IIT Delhi
Institute of Eminence

Research Impact, 2018 - 2024

भारतीय प्रौद्योगिकी संस्थान दिल्ली
Indian Institute of Technology Delhi

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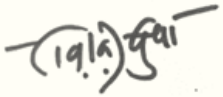
INDIAN INSTITUTE OF TECHNOLOGY DELHI

PREFACE

We take great pleasure in bringing out this compilation showcasing glimpses of the impact of IIT Delhi's ideas, research, and innovations on society. Our efforts go beyond the traditional metrics of publications, patents, and products. The selected stories reflect the breadth and diversity of our Institute's efforts and impact in the seven years since we were elected as an Institute of Eminence in 2018. We hope these narratives give you a flavor of the Institute's activities and will encourage new partnerships. We welcome your feedback and suggestions towards enhancing the impact of our education and research.

Prof. Rangan Banerjee (Director)



Prof. Vivek Buwa (Dean, Planning)

ACKNOWLEDGEMENTS

We gratefully acknowledge the efforts of the faculty colleagues who have contributed their research stories to this report. Several offices and individuals contributed to the compilation of this research impact report. These include the Planning Office, Industrial Research & Development (IRD) Unit, Foundation of Innovation and Technology Transfer (FITT), Office of Dean (Academics), and the Central Library. In particular, we gratefully acknowledge the efforts of Mrs. Suchitra Bhatnagar and staff members of the Planning Office for their arduous efforts in compiling the stories for this research impact report in a short span of time. Finally, we appreciate the efforts of Integral World in elegantly designing this report.

SUCCESSFUL STARTUPS

The entrepreneurial efforts of IIT Delhi faculty and students touch all our lives through their focus on areas like AI/ML/Cybersecurity, automotive healthcare, biotechnology, sustainability and many more.


FEC
TECHNO PARK

Intelligent Water Level and Water Quality Monitoring

Building a smart sustainable future with innovative IoT solutions for water quantity and quality monitoring

Aquasense delivers state-of-the-art water sensors, particularly for monitoring ground water, surface water, and water quality. It targets reaching the forefront of the water monitoring industry, providing unparalleled expertise and solutions for private, public, and other organizational entities by harnessing the power of IoT platforms and real-time data analytics.

Its first innovation was a contactless device for monitoring ground water levels. The team approached the Central Ground Water Board (CGWB) with a request to use the device on some of their existing wells and received the CGWB's certificate of satisfaction.

Besides real-time measurement of groundwater fluctuation, Aquasense provides sensors for quantifying rainwater harvesting, conducting impact assessments, monitoring hand pump water utilization, studying groundwater flow, preparing a groundwater atlas, and mapping aquifers.

AQUASENSE

Monitoring Every Drop !

- **Monitoring devices are very important for handling water security and furthering sustainable development to enhance social resilience in coping with the implications of climate change.**

Prof. A K Gosain
Department of Civil Engineering

Making Every Breath More Sustainable

Enabling society to overcome air pollution

Nanoclean Global (NCG) Pvt Ltd, a startup venture of IIT Delhi, addresses challenges posed by air pollution with innovative products like Nasofilters (nanofiber-based filters that can be placed on the nostrils), Pollution nets (nanofiber-based window nets that allow fresh airflow into our homes), AC filters (which turn an air conditioner into an air purifier) and Cigibud (a novel nanofiber-based cigarette filter), all of which utilize award-winning nanotechnology developed at SMITA Research Lab, a Centre of Excellence in Smart Textiles, IIT Delhi. Nasofilters have proven to be a lifeline for those suffering from allergies and the latest innovation, Cigibud, filters harmful substances, such as nicotine and tar from the cigarettes, protecting the health of smokers and enabling them to quit smoking with ease. With aggregate revenues of over INR 20 crore and a valuation of INR 40 crore, Nanoclean Global continues to expand its market presence in India and abroad.

- **NCG currently exports to more than 12 countries and generates over 20% of its revenues from exports.**
- **A 60% repeat order rate for Cigibud and its wide distribution network across all Tier 1 and Tier 2 cities through Q-com has rendered NCG operationally profitable.**
- **NCG has successfully raised over INR 6 crore in venture funds and even featured on Shark Tank India.**

As Seen On SHARK TANK INDIA

Prof. Ashwini K Agrawal and Prof. Manjeet Jassal
Department of Textile and Fiber Engineering

Wiom: Building the Airbnb for the Internet

Bridging the data access divide for 500 million Indians

Broadband Internet penetration in India is under 10% and, at the current rate of growth, it will take over 10 years to catch up with other developing nations like Indonesia and Brazil.

Wiom takes advantage of a platform model to create a highly scalable and efficient business model - an Airbnb or Uber for the Internet. It unlocks broadband access to the approximately 100 million households who have access to cable television services but not broadband Internet.

These households are largely serviced by a network of more than 1 lakh cable operators who have the operational expertise to service a wired network while still being profitable at a monthly price point of approximately INR 300. However, they lack market creation and technical expertise, while high fixed costs and low asset utiliz ation keeps their price points high, resulting in slow growth rates.

Wiom provides these operators with technical and logistical support and access to confirmed customers, which allows them to expand their services at low marginal costs while simultaneously reducing the access barriers for customers through zero upfront costs, byte-sized and flexible plans, and roaming Internet.

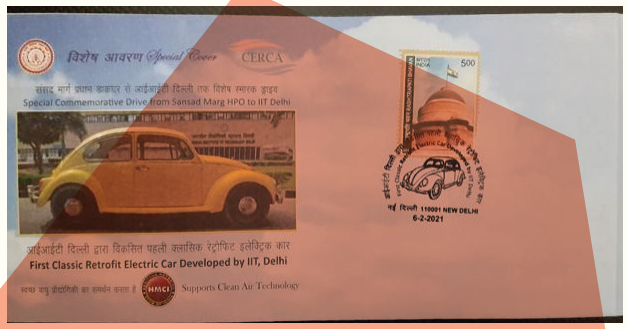
- **Fastest growing player in India with the highest number of new connections / month.**
- **More than 70% of our customers are first-time Home Broadband Internet buyers.**
- **Over 700,000 monthly active users.**

Satyam Darmora
Alumnus

Making Electric Vehicles without Adding New Vehicles

Providing sustainable solutions by extending the life of old ICE vehicles

Tadpole Projects, incubated through FITT at IIT Delhi, leads in EV research and development (R&D), offering efficient, affordable, and sustainable electric mobility solutions by converting the existing Internal Combustion Engine (ICE) vehicles into electric vehicles (EVs). Through this process, we convert four-wheelers into EVs with efficient power trains and battery packs. We retain the original transmission which results in better torque while preserving the originality of the vehicle and making it user friendly. Our solutions extend the vehicle's life, lower the cost of conversion, and reduce maintenance costs while fostering an EV ecosystem. Given our commitment to social impact, this solution leads to a sustainable transportation system. Vehicles we have retrofitted are in operation for the past year and half with considerable success and much customer satisfaction. These vehicles are located in places like Tadoba National Park, Pench National Park, Ranthambore National Park, Chandimandir Cantonment, Delhi Cantonment, etc. and save the equivalent of 150 tonnes of carbon dioxide emissions.



- **Provided mobility solutions to defence establishments and National Parks by converting the iconic Maruti Gypsy into an electric vehicle.**
- **Received a specially issued postcard and stamp for converting a vintage car into an electric vehicle for the first time in India.**
- **Conferred with the Aspiring Start-up Award at the India Circular Economy Forum 2023, through IIM Bangalore.**

Prof. Bijaya Ketan Panigrahi
Department of Electrical Engineering

An Indigenous Technology for Drone Swarming

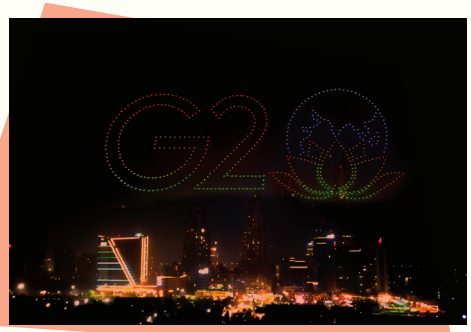
BotLab dynamics is setting new milestones in using drone swarms

BotLab Dynamics is known for its in-house drone designs, Real-time kinematic positioning (RTK-GPS), and flight controllers with exceptional reliability and flawless functionality. We develop hardware and software for drone light shows and have executed some of the most iconic shows in India, including:

- Setting a record with 1,000 drones at Rashtrapati Bhawan for the Beating Retreat ceremony, launching the first drone light show vertical and making India the fourth nation to host a drone show on such a scale.
- Creating India's first QR Code in the sky over Mumbai.

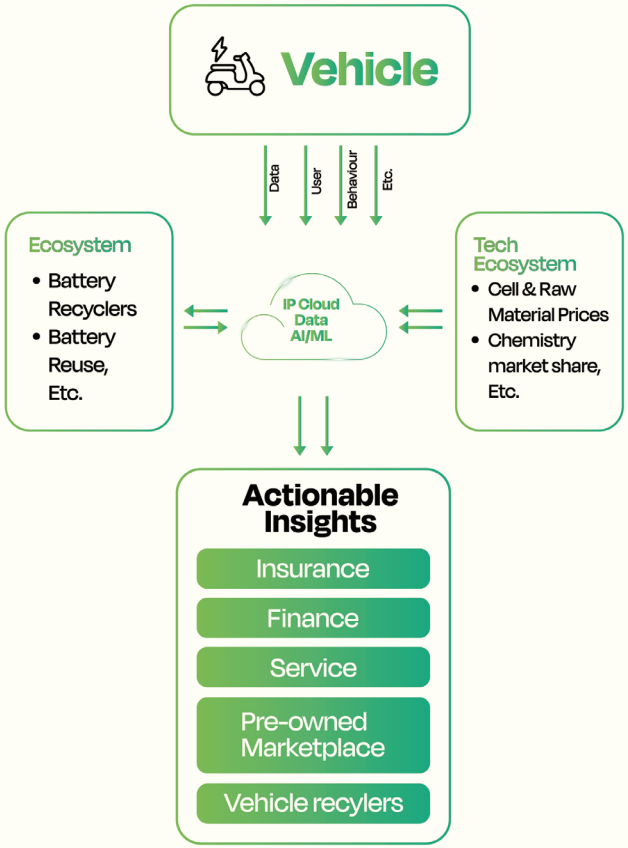
We registered a new global milestone by setting 5 Guinness World Records in a single drone light show with 5,500 drones at the Amaravati Drone Summit 2024. With recently-secured significant funding for further research and development, BotLab Dynamics is primed to expand its presence in the global drone light show market and continue shaping the future of this transformative industry.

- **India's largest drone fleet of over 7,000 drones**
- **250,000 cumulative flight hours**
- **Over 200 projects delivered**
- **A more-than-180-member strong team**



Prof. Ratnamala Chatterjee
Department of Physics

Vecmocon's EV Ecosystem Data Play



Prof. Amit Kumar Jain
Department of Electrical Engineering

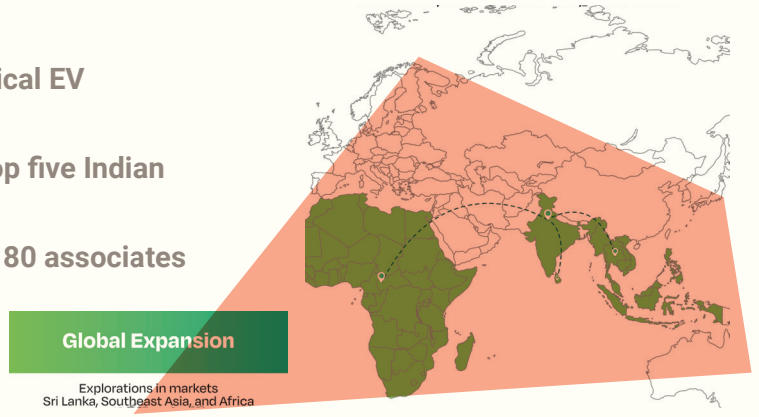
Vecmocon: Driving Innovation in Electric Vehicle Technology

Leading the charge in EV component innovation with advanced engineering and deep tech

Peeyush Asati (CEO), Adarshkumar Balaraman (COO), and Shivam Wankhede (CTO) incubated Vecmocon in 2016 at IIT Delhi. The company has now established its presence in major cities like Delhi, Bangalore, Chennai, and Lucknow with a passionate team of more than 180 associates. It is at the forefront of advanced computing solutions for electric mobility, specializing in safety-critical components such as Battery Management Systems (BMS), EV chargers, Vehicle Intelligence Modules (VIM), and secure Firmware Over the Air (FOTA) for electric vehicles. Vecmocon is also working with two of the top five EV players in India, besides various leading battery manufacturers, ensuring a high level of reliability and safety and delivering robust performance for the next generation of intelligent and smart EVs.

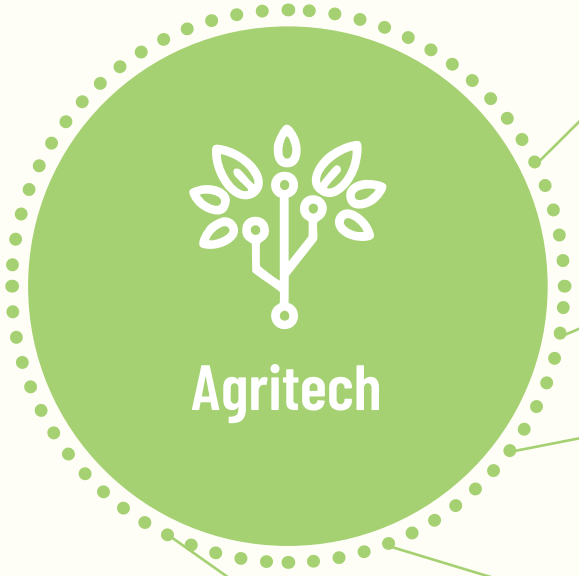
With a vision to develop the most reliable, robust, and cost-efficient systems, Vecmocon aims to drive the mass adoption of electric vehicles globally.

- **Specializing in safety-critical EV components**
- **Working with two of the top five Indian EV players**
- **Passionate team of over 180 associates**




WLS Laboratory
iWAY+
iWayPlus Private Ltd.
PRENISHQ
Novae Avenue™
NANO SAFE
SRAMJA™
PaiByTwo
VIKASH GEOSENSING PVT LTD
Nirmalaya
FRAGRANCE OF GOD
SWATRIC.
bmt
Aqua Synthesis
AEGION
nano clean
3rd iTech
MachPhy SOLUTIONS
THE STRUCTURAL EXPERTS
SANRACHNA PRAHARI
FRUVETECH
AGRI WASTE PVT LTD
Hexon
LABORATORIES PVT. LTD
INTELLICON
inGO
Chakr Innovation
QuantEon
SYNERGY QUANTUM
MATISOFT
CYBER SECURITY LABS
Dash Dynamic
Technology Curator
tadpole
efundu
FLEXMO
VECROS
BRAVECORE
SURVEILLANCE AND TACTICALS
COMPILERAI
Rhythm for Life
Raised Lines Foundation
NEO RISERS
EnthuDes
ZERODRAG

STARTUPS



Blendmest Technologies Pvt. Ltd.

Crafting "Made in India" drones tailored for agriculture and surveillance, besides offering custom, small- and large-scale drone manufacturing solutions to both industry players and government entities.

Aquasynthesis Pvt. Ltd.

Innovating saffron farming through adopting hydroponics techniques.

Agriwaste Pvt. Ltd.

Designed a bio-charcoal machine which converts every kind of agricultural waste into charcoal without requiring an external source, and costs INR 9,000 (market price ranges from INR 7 lakh to INR 1 crore).

PaiByTwo Pvt. Ltd.

Developed a Biped Agricultural Robot equipped with state-of-the art technologies.

Fruvetech Pvt. Ltd.

Developing a device to enhance the shelf life of fruits and vegetables using energy-efficient, high-quality storage solutions adjustable to specific needs and conditions

CYRAN Ai Solutions Pvt. Ltd.

Building advanced hardware-software technology solutions in the domains of Artificial Intelligence (AI) and Cyber-Physical Security.

Compiler AI

Specializes in software verification tools, based on sophisticated AI-based algorithms, that automatically generate correctness proofs and/or counterexample traces to validate both software code and binary executable code.

PlusQO Corportation Pvt. Ltd.

Developing and improving the reliability of Digital System IPs, Subsystem IPs, Communication IPs, Processing IPs, Security IPs, and SoCs.

Synergy Quantum India Pvt. Ltd.

Delivering post-quantum encryption, quantum key distribution (QKD), random number generation, and quantum communication infrastructure.

Matisoft Cyber Security Labs Pvt. Ltd.

Offers an Advanced Malware Scanner which is one of the most advanced AI-based Advanced Threat Protection (ATP) antivirus developed from the combined experience of ethical hackers, virus researchers, and AI experts.

HyperX Energy Pvt. Ltd.

Working on Smart Lithium-ion battery packs along with in-house, modular, and stackable Smart BMS.

Createra Mobility Pvt. Ltd.

Developed the world's 1st adaptive modular platform in the electric 2-wheeler (E2W) segment, with ground-up vehicle design encompassing innovative battery UX and unparalleled safety features.

Tadpole Projects Pvt. Ltd.

Aims to provide affordable and clean energy conveyance solutions simultaneously focusing on waste management and power efficiency, via adding electric vehicles without increasing on-road vehicle population.

inGO Electric Pvt. Ltd.

Engineered an effective micro-mobility solution (e-scooter) to help people travel anywhere faster, more safely, and seamlessly, with the target of serving factories, airports, hotels, and apartment complexes.

Dash Dynamics

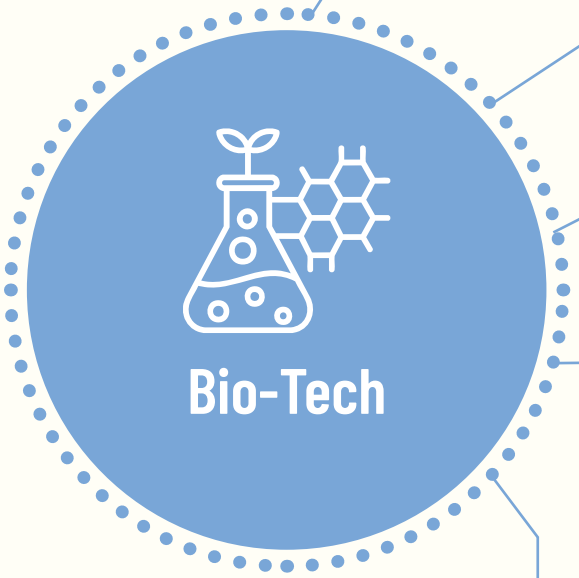
Developing wireless charging technology for EVs.

inGO

CREATARA

tadpole™

Dash Dynamic
Technology Curator



Flexmotiv Technologies Pvt. Ltd.

Specializing in assistive technologies that incorporate automation in healthcare.

Redroom Technology Pvt. Ltd.

Created Sanfe, India's revolutionary feminine hygiene and period care brand striving to build a better world for women, with products that are comfortable, rash-free, natural, organic, and safe for the body and the environment.

Incipient Materials Pvt. Ltd.

Facilitates the development of smart textile materials for various applications.

Asvin Tech Biodent Pvt. Ltd.

Developed Dentra, an AI-powered, cost-effective, and scalable intraoral dental 3D scanner.

Enthudes Design Pvt. Ltd.

Developing portable, minimally invasive devices to treat Pneumothorax, Hydropneumothorax, and Hemothorax.

Quanteon Powertrain Pvt. Ltd.

Offers powertrains for automobile OEMs and enables them to replace friction pads-based brakes and gearbox with a simple axial-flux-in-wheel-motor-hub in EV wheels for new (P4 level) or retrofitted models.

Chakr Innovation Pvt. Ltd.

Creates pioneering, sustainable, and scalable technologies to combat the grave threat posed by pollution, such as Chakr Shield - an innovative emission control device.

Intellicon Technologies Pvt. Ltd.

Working on indigenous e-mobility technology development.

Hexense Labs Pvt. Ltd.

Focuses on connected cars and modular smart car devices.

Zerodrag Technology Pvt. Ltd.

Envisions becoming a leader in the drone tech ecosystem by manufacturing the electronics hardware - including flight controllers, electronic speed controllers, receivers, and propulsion systems - needed for Unmanned Aerial Vehicles (UAVs) through a Make in India approach to fulfill local and global demands.

Vecros Technologies Pvt. Ltd.

Develops hardware and software enabling aerial robots to operate in GPS-denied environments without human control, prior information, or preexisting infrastructure, such as no motion capture systems.

Technit Space and Aero Works (TSAW) Pvt. Ltd.

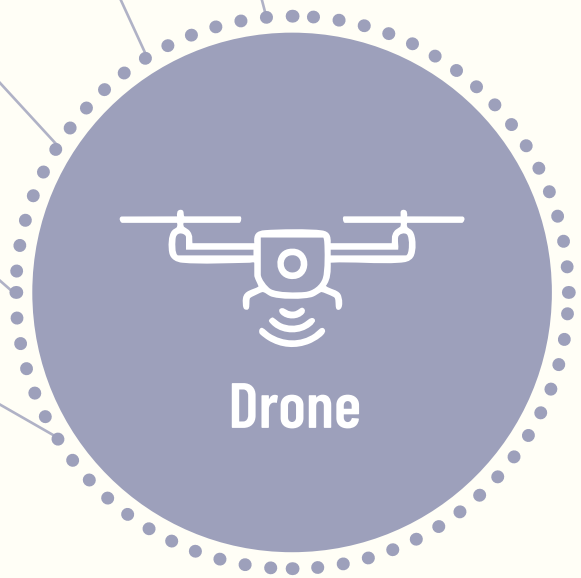
Provides logistics services using drones.

Hawaiadda Aerial Innovations Pvt. Ltd.

Develops drones for precision data solutions including GPS navigation, obstacle avoidance systems, autonomous flights, and indigenous UAV products for agriculture and smart infrastructure.

Bravecore Pvt. Ltd

Provides cable-based terrestrial surveillance systems.

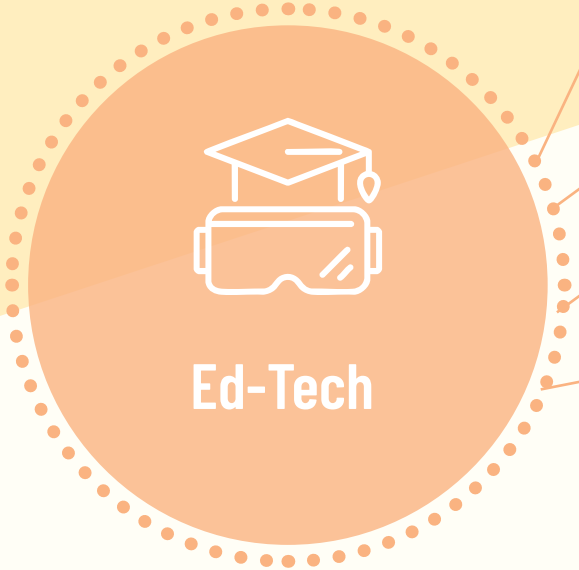


Raised Lines Foundation

INAVANTAGE SOLUTIONS PRIVATE LIMITED

efundu
Creative Learning with Tech & Toons

NEO RISERS



Raised Lines Foundation

Provides textbooks in accessible format with tactile diagrams for visually impaired students.

Neo Risers Pvt. Ltd.

Neo Risers enables developing skills, applying learnings, and cultivating an innovator mindset through engaging play-learning kits and learning models.

Ains Peopletech Pvt. Ltd.

Helping companies find and retain front-line talent by providing technology-based Skill Match and Skill Development solutions.

Hapilipi Tech Pvt. Ltd.

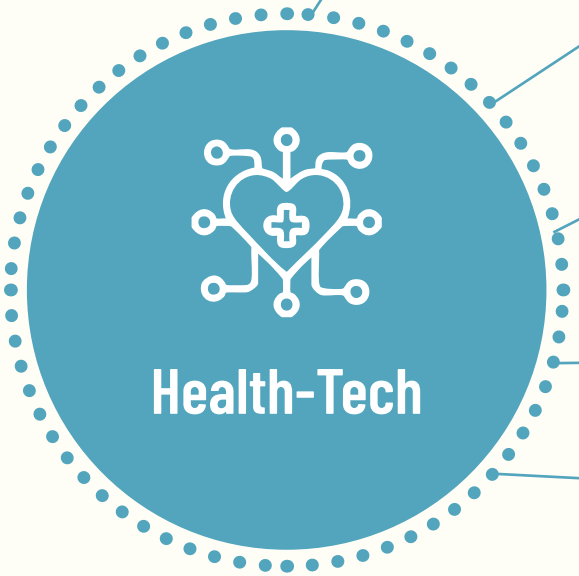
Drives creative learning with scholastic content like Environmental Studies as well as real world life skills content like Financial Literacy and Mental Health. The content is delivered through comics and films in primary education starting with bilingual comics about EVS, an Assessment App, and a YouTube Channel.

Invitante Solutions Pvt. Ltd.

Developed a vending machine to provide fresh, healthy, and hygienic fruit juices and salads.

Rusicaa Beverages Pvt Ltd

Developing organic and low-cost, value-added products like biscuits, cakes, candies, and cookies from Mahua flowers.



Ramja Genosensor Pvt. Ltd.

Building a novel device to detect gram-negative bacterial infections and antibiotic resistance in patients with Acute Leukemia.

Machphy Solutions Pvt. Ltd.

One of the fastest-growing cold chain providers in India preserving the shelf life of healthcare biologics, and fruits and vegetables, and used in retail industries.

NanoSafe

Developing functional materials imbibed with antimicrobial properties for improved health and hygiene.

Genelek Technologies Pvt. Ltd.

Developing exoskeletons for specially-abled people.

Carditek Medical Device Pvt. Ltd.

Introduced Sydantek, the world's first and smallest wireless, wearable 12-lead ECG with no learning curve and reusable sensors that are clinically and electrically equivalent.

Tensor Dynamics Pvt. Ltd.

Enabling climate and weather-affected industries with cutting-edge solutions using core concepts of atmospheric sciences and deep learning techniques.

Prenishq Pvt. Ltd.

Manufacturing components to advance quantum technology, including External Cavity Diode Laser (ECDL), temperature and current controller, laser locking module, Magneto Optical Traps (MoTs), and qubits.

iWayPlus Pvt. Ltd.

Offers a solution to generate geocoded indoor maps and positioning signatures for large spaces like hospitals, airports, academic campuses, and malls. The technology helps businesses in tracking and managing staff, assets, and crowds while enhancing visitors' experience with personalized way-finding assistance.

Papli Labs Pvt. Ltd.

An AI-based real-time road analytics system that delivers intelligence for safety and security in mobility.

Wireless 4 Scale Labs Pvt. Ltd.

Developing communication technology-based products and solutions leveraging 5G and more advanced networks.

Green Aero Propulsion

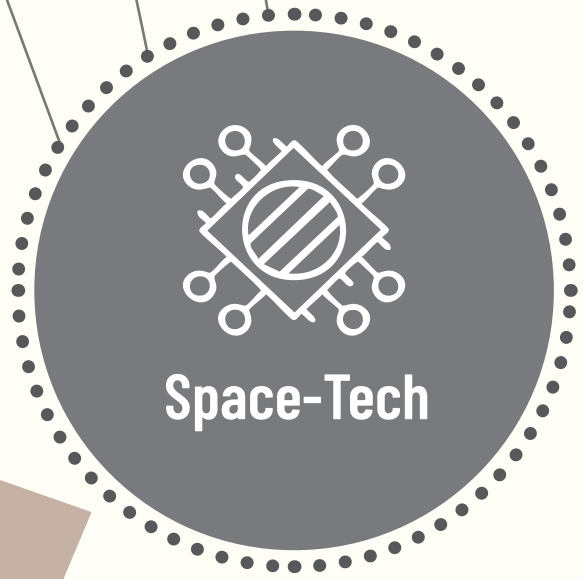
Innovating hydrogen-based gas turbines.

DV2JS Innovation LLP

Developing products for defense services under iDEX including blue-green lasers for underwater applications.

Aegion Aerospace Pvt. Ltd.

Crafting advanced coatings for high-performance metals and materials, developing blockchain-powered virtual simulation tools for military training, and manufacturing precision aerospace components.



M/s. Vikash Geonensing Pvt. Ltd.

Developed a machine to sense the precursor seismic waves arising from below the Earth's surface due to tectonic plate movements.

Sanrachna Prahari Pvt. Ltd.

Facilitates structural health monitoring to maximize structural integrity.

Nanoclean Global Pvt. Ltd.

Makes Naso95, Nasofilters, Cigibud, Nanoclean AC filters, and Pollution nets.

Nirmalaya Wellness Pvt. Ltd.

Manufactures incense products by recycling flower waste.

Swatric Pvt. Ltd.

Focuses on researching and developing state-of-the-art technologies to revolutionize Indian domestic textile and garment industries and enable commercializing new and competitive categories of smart and functional products.

VIKASH GEOSENSING PVT LTD

THE STRUCTURAL EXPERTS SANRACHNA PRAHARI

nano clean

Nirmalaya FRAGRANCE OF GOD

SWATRIC.

TECHNOLOGIES COMMERCIALIZED

As an incubator of critical technologies, IIT Delhi plays a vital role in developing and commercializing these, often with industry partnerships.

STRIDE: Empowering Independent Mobility in Parkinson's Disease Patients

Revolutionizing mobility for Parkinson's disease patients using a customized wearable and personalized data-based feedback

Parkinson's disease, a neurodegenerative disorder, can significantly impact a person's quality of life. One of its most debilitating symptoms is freezing of gait, in which the patient is temporarily unable to move while walking or turning. Such freezing can lead to falling, inducing anxiety, and facing social isolation. STRIDE utilizes customized wearables installed on the shoe and advanced data processing techniques to predict and mitigate this freezing of gait. It continuously monitors a user's gait patterns and provides real-time, personalized vibrational feedback. By anticipating and interrupting freezing of gait, STRIDE empowers individuals with Parkinson's disease to regain their mobility, confidence, and independence.

- **Predictive Technology: Predicts freezing of gait.**
- **Personalized Feedback: Tailored vibrational feedback for every individual.**
- **Improved Quality of Life: Enhanced mobility, reduced anxiety, and increased independence.**

Prof. Deepak Joshi
Centre for Biomedical Engineering

RoboExo^{SMART}: An Innovative Indian Exoskeleton for Distal Upper-limb Recovery in Stroke Rehabilitation

An affordable and portable new hope enabling stroke-affected patients to make functional gains towards greater independence

RoboExo^{SMART}, a robotic exoskeleton, is an innovative rehabilitative device developed over a decade of research at IIT Delhi, in collaboration with AIIMS, New Delhi. The device improves Activities of Daily Living by synchronizing the extension and flexion of wrist and finger by facilitating inter-joint coordination, which is often affected after a stroke, making patients dependent and degrading their quality of life.

The device has undergone rigorous clinical validation and testing on more than 75 patients with stroke in the past couple of years, with a month of therapy for each patient. Patients experienced significantly greater improvements in muscle control, movement range, and hand function, compared to conventional physiotherapy. Notably, brain excitability measurements revealed reorganization and recovery, indicating neuroplasticity. The device offers hope for affordable effective rehabilitation in improving hand function and promoting brain recovery. It can be used at home, or in peripheral settings, making it a practical solution for patients.

The device has received patents in India, the USA, and the EU.

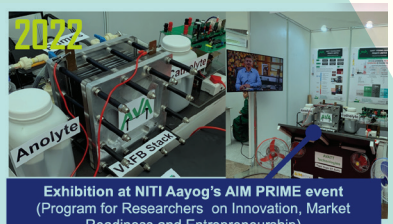
- **Over 75 patients have successfully used the exoskeleton with motor recovery and functional gains.**
- **RoboExo^{SMART} achieves the same outcomes in just 4 weeks of intervention as 6 months of conventional physiotherapy.**
- **It has reduced rigidity or hand spasticity in 100% of patients tested so far.**
- **In one patient's words: *"simple therapy which has made my wrist softer".***

Prof. Amit Mehndiratta
Centre for Biomedical Egineering

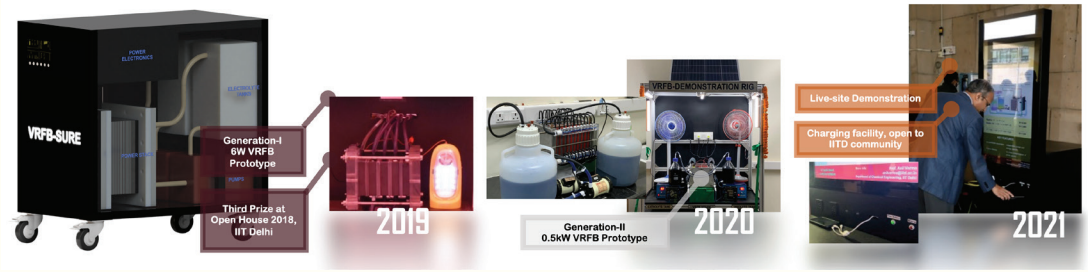
Development of Vanadium Redox Flow Battery (VRFB) for Large Scale Renewable Energy Storage

VRFB is a potential candidate for large-scale sustainable and cost-effective renewable energy storage

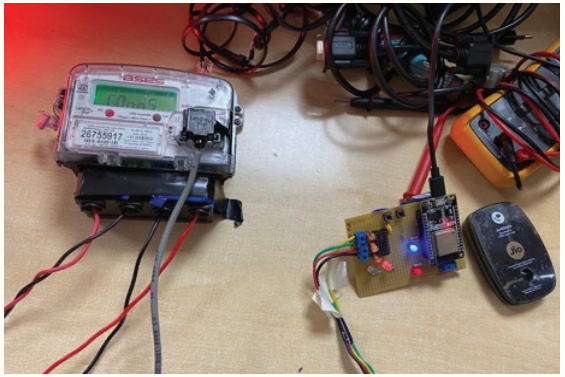
VRFB, a large-scale energy conversion and storage battery, has a life of over a decade. It requires very low maintenance, presents no potential fire hazard, and is green and safe for the environment. VRFB has a low levelized cost of energy (LCOE) given its ultra-long life. The team led by Prof. Anil Verma has been actively involved in the development of VRFB to a multi-kW level. They have tried to cover every aspect of the technology including the materials (electrolyte, electrode, bipolar plates, and membrane), the scaling up (industrial design, containerization, and maintenance techniques), and the development of dedicated power electronics (battery management system, sensors for battery health monitoring, and IoT-enabled data acquisition). At present, the team is working on developing 2 kW and 5 kW VRFB systems with dedicated power electronics. The 2 kW system will be installed at the Transport Unit, IIT Delhi, to power an e-Vehicle charging station for three-wheelers plying in the campus, whereas the team is developing the 5 kW system as a replacement for an industrial unit's diesel generator, thus taking the battery to Technology Readiness Level 7 (TRL-7).



- **The team has filed 6 patents (4 granted) and published over 12 high-impact research articles.**
- **They have incorporated a start-up, and demonstrated kW-level VRFB prototypes at various exhibitions such as IIT R&D Fair 2022, Industry Day 2022, and NITI Aayog's AIM-Prime 2022.**
- **The team has received National Innovation Challenge Award (NICA) from the Deparment of Science and Technology, Ministry of Science and Technology, Government of India.**



Prof. Anil Verma
Department of Chemical Engineering



A Low-Cost Smart Metering Solution

A low cost, IoT-based retrofitting solution to enable data acquisition and analysis for demand side energy management using previously installed meters

- **This low cost IoT-based smart metering retrofit offers a sustainable energy solution eliminating the need to replace existing metering infrastructure and thereby also saving the energy required to create new infrastructure.**

The developed product is a low cost retrofit to existing energy meters enabling data analytics for demand side management. It was initially tested in the Lecture Hall Complex (LHC) at IIT Delhi. Later discussions with Delhi's distribution company BSES Rajdhani Power Limited (BRPL) led to further improvements while implementing the product on two types (single phase and three phase) of meters. The device has been showcased at various platforms within and outside IIT Delhi. It has since been transferred to a start-up company EVI Technologies Pvt. Ltd., through the Foundation for Innovation and Technology Transfer (FITT). EVSI is working on commercializing the solution while integrating it with their EV charging infrastructure. We have also partnered with Tata Power Delhi Distribution Limited (Tata Power-DDL) to deploy this solution on one of their microgrids, with test for further scaling up ongoing.

Prof. Ashu Verma
Department of Energy Science and Engineering

Prof. B.K. Panigrahi
Department of Electrical Engineering

A High-Efficiency Shadowless Solar Photovoltaic Tower with Mirror Reflection Concentration

i. Non-mechanical tracking solar tower with mirror reflection: Capacity: 4 kW-10 kW.
ii. Mechanical tracking solar tower with mirror reflection: Capacity: 2 kW-5 kW

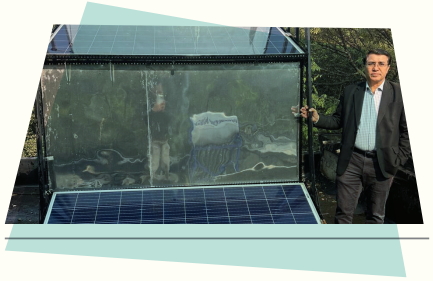
Solar photovoltaic (PV) flat panels are mainly used for converting sunlight into electricity. The efficiency of these solar panels is around 20% between 11:00 am and 2:00 pm. During morning and evening hours, and in the winters, the efficiency drops significantly because of low value of solar irradiance incident on the solar panels.

We have developed a shadowless, cascaded solar PV panel tower with mirror reflection concentration for high-efficiency power generation throughout the day. Solar panels are mounted vertically in a staircase style to form a tower which requires approximately 30% less area compared to a conventional mounting. To improve the maximum solar irradiance incident on the solar panels during morning and evening hours and in the winters, large low-cost, light weight mirrors are mounted between two solar panel layers. As a result, the solar panels receive both direct and reflected sunlight, which increases the incident solar irradiation by approximately 50%, compared to conventional solar panels. The electrical output generated is higher by 15% - 25% without tracking the sun and by 25% - 35% when tracking the sun. This technology is now transferred to an Industry EP, Sunsol Pvt. Ltd. from Bangalore.

Prof. Dalip Singh Mehta and Coworkers
Department of Physics

Targeted applications for this high efficiency solar tower include:

- **High-efficiency rooftop solar power generation for independent houses, schools, hospitals, shops, and IT enterprises.**
- **Electric Vehicle (EV) Charging Stations.**
- **Vehicle-mounted Solar Tower with Sun Tracking to generate power for Agriculture applications like solar water pumps, tractor battery charging, and e-rickshaws.**
- **Military applications.**



Tactile Diagrams for Making STEM Books Accessible to Visually Impaired Individuals

Absence of tactile diagrams in Braille books results in the exclusion of visually impaired people from pursuing Science, Technology, Engineering, and Mathematics (STEM) subjects

"We wish that these books would have come in our study time also so that our study would have been made easy as well as interesting and we could opt for our favourite subjects instead of going for an option which was not of our interest. We really like these books and thank you so much for providing them for our students."
–A visually impaired teacher from Rajasthan Netraheen Kalyan Sangh School, Jaipur

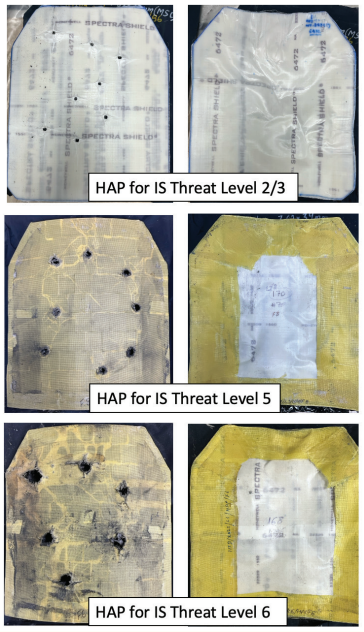
India has invested in high-capacity Braille books production units but not in designing and producing tactile diagrams. Braille, being a script, can only be used for text. Diagrams are an essential part of STEM textbooks whether the subject be biology, chemistry, geometry, geography, or economics.

To address this gap, IIT Delhi with support from the Ministry of Electronics and Information Technology (MeitY), set up a Centre of Excellence in Tactile Graphics in 2014. We developed an end-to-end process for producing tactile diagrams, and were the first to use 3D printers for making masks for these diagrams. This effort included software packages' integration as well as understanding the learning process of visually impaired people through the tactile route. We also worked closely with the National Council of Educational Research and Training (NCERT) in producing school-level tactile textbooks.

In 2018, we incubated a non-profit named Raised Lines Foundation, which has thus far supplied tactile books to over 75 schools, covering more than 10 schools each year. This has made a significant difference to the education of thousands of visually impaired students in over 20 states across India. Even today, RLF is the only entity producing tactile books in India.

Prof. M. Balakrishnan
Department of Computer Science and Engineering

Prof. PVM Rao
Department of Design and
Department of Mechanical Engineering



Advanced Ballistics and High-Energy Defeat (ABHED) Body Armor for Indian Armed Forces

Lightweight body armor to defeat 7.62 mm armor piercing (AP) projectiles from AK-47s and Sniper rifles

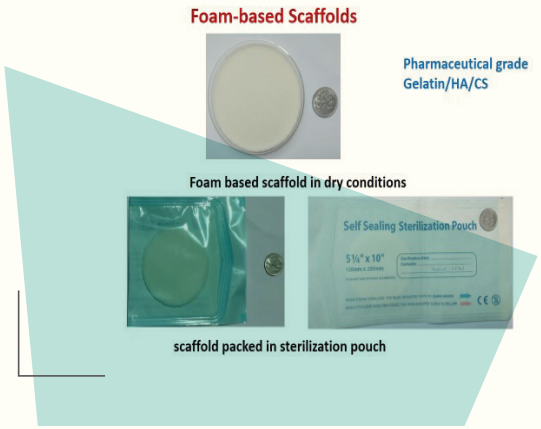
An armor's performance depends upon its design and subsequent manufacturing. The ABHED body armor was designed using explicit-dynamics finite element analysis (FEA) simulations. The ABHED armors were fabricated and tested in-house at manufacturing and experimental facilities created in IIT Delhi.

A lightweight armor designed to defeat AP projectiles consists of a strike face material and a back face material. Boron carbide tiles (B4C) were chosen as strike face material, given their low density and high hardness, after careful evaluation of various hard materials. The tiles' configuration used for ABHED BPJ improved the multi-hit withstanding capability of the armor. Ultrahigh molecular weight polyethylene (UHMWPE) fiber-reinforced composites were selected as the armor's back face material due to their low density and high strength. All the materials used in ABHED were characterized and their manufacturing process optimized using carefully designed experiments.

The ABHED BPJ have modular configurations and provide all around (360˚) torso protection along with throat and groin protection. More than 500 armor panels of various types and sizes have been ballistically tested during development to arrive at ABHED design. The ABHED armor qualified after stringent tests, as per IS 17051:2018 and GSQRs, at the Terminal Ballistics Research Laboratory (TBRL-DRDO), Chandigarh. The technology was transferred to three industries for production.

- **IS Threat Level 6/GSQR 1707/NIJ Level IV compliant armor weight: 9.5 kg.**
- **IS Threat Level 5/GSQR 1438/NIV Level III+ compliant armor weight: 8.2 kg.**

Prof. Naresh Bhatnagar
Department of Mechanical Engineering



Artificial Skin (Bio-Inspired Bilayer Polymeric Hybrid Scaffold) for Treating Burn Injuries and Trauma Care

Wound healing is a complex and dynamic process of rebuilding native skin and tissue. The wound can become chronic or impaired if the tissues fail to progress through the necessary stages of healing. This significant clinical problem affects 5.7 million patients every year

The team fabricated a porous, foam-based bilayer hydrogel scaffold using gelatin, hyaluronic acid, and chondroitin sulfate (G-HA-CS) in an appropriate proportion. They characterized the fabricated scaffold physiochemically for pre- and post-sterilization efficacy. Its therapeutic efficacy in rodent and swine second degree burn models in comparison to the marketed product Integra™ proved its clinical translation capability. The team also conducted biocompatibility studies such as Skin sensitization test, Acute systemic toxicity test, Implantation study, Intracutaneous reactivity test, ***In vitro*** cytotoxicity test, and Genotoxicity test under ISO-10993, to prove the product's safety. The proposed scaffold will become part of the skin and will act as a skin substitute. This technology has already received an Indian patent.

- **The scaffold developed will be used as skin substitute and will replace the imported scaffold Integra currently used worldwide for burn Injuries.**
- **The team has already transferred this technology to Dr. Reddy's Laboratories, Hyderabad.**

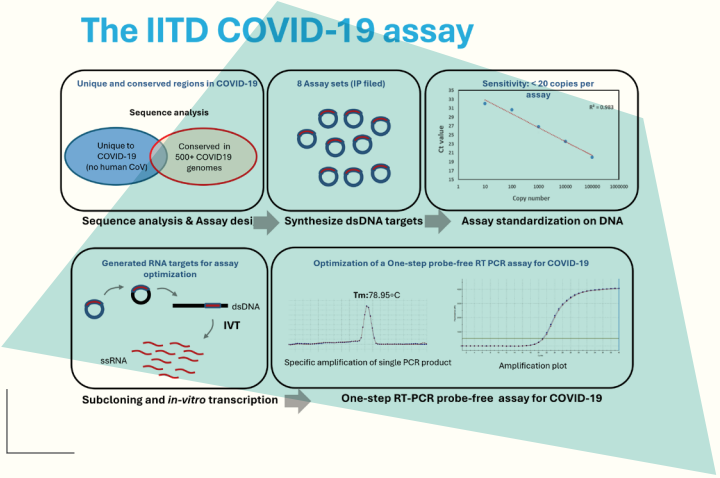
Prof. Veena Koul
Centre for Biomedical Engineering

Prof. Maneesh Singhal
Burns and Plastic Surgery, AIIMS, New Delhi

A Probe-Free RT-PCR for SARS-CoV-2

The team identified unique regions absent in other human coronaviruses, permitting a highly discriminatory assay for COVID-19

Using synthetic DNA constructs and ***in vitro*** transcribed RNA fragments, the team optimized the assay rigorously to achieve a lower detection limit of ~20 copies per reaction. It is a probe-free, cost-effective, one-step, real-time PCR assay for detecting SARS-CoV-2 in clinical samples. The assay functions effectively in a one-step RT-qPCR process, requiring about 80 minutes from RNA extraction to result. The technology is user-friendly and requires manual verification of sigmoidal curves. The team also developed a graphical user interface (GUI) that enables untrained users to interpret the results. The assay is easily scalable and is highly discriminatory against other human infecting coronaviruses. SYBR Green-based technology represents the fundamental variant of real-time PCR and is compatible with all models of real-time PCR instruments across the country. The cost per test is less than USD 5. The kit was the first among such kits developed by Indian academic institutions to obtain approval from ICMR. IIT Delhi transferred the technology to over ten companies, some of which obtained CDSCO licenses and commercialized the assay.



- **Developed a single-step, probe-free assay for COVID-19 that is easily scalable, affordable (less than USD 5 per test), and exhibits 100% specificity and sensitivity for the virus. The ICMR has approved this kit and IIT Delhi has commercialized it.**

Prof. Vivekanandan Perumal, Prof. Manjo B Menon, Prof. Bishwajit Kundu, and Prof. James Gomes
Kusuma School of Biological Sciences

The *Gram Urja Swaraj* Initiative: A CBG Enrichment and Bottling Technology

Empowering energy transition and self-reliance through Compressed Biogas (CBG) technology and waste management

- **Executed 11 technology transfers empowering industries and rural enterprises.**
- **Studied the potential use of Compressed Biogas (CBG) as an alternative automotive fuel.**

IIT Delhi installed a 20 cum/day cow dung-based Biogas plant in 1995 to research alternative fuels for internal combustion engines. Through this approach, we are studying emissions, mileage, engine performance, derating, etc. to create a Biomethane standard in India (IS 16087-Biomethane standard). We developed a low-cost, small-scale biogas enrichment and bottling technology with a 20 cum/hour biogas flow rate using a water scrubbing column for vehicular application.

We patented this technology in 2006 and licensed it to 11 industries, many of which are rural enterprises, and cow shelters (Goshalas). The Biogas plant now operates on kitchen waste such as vegetable peels collected from nearly 200 households, hostel messes, and juice centres located on the IIT Delhi campus.

The 11 industries include:

- M/S Indian Compressors Ltd, New Delhi
- M/S Tech Zone, Bhavani, Tamil Nadu
- M/S Excel Electrical Pvt Ltd, Valsad, Gujarat
- M/S Swasth Sewa Maitry Charitable Trust, Delhi
- M/S Ashoka Bio green Pvt. Ltd., Nasik, Maharashtra
- M/s Raghunath Bioenergy Pvt Ltd, New Delhi
- M/S Green Bric Eco Solutions, New Delhi
- Mahindra and Mahindra, Mahindra Research Valley
- M/S Praj Industries Ltd, Pune, Maharashtra
- S.S. Gas Ltd., New Delhi
- M/S KIS Group, Bangalore, Karnataka

Prof. Virendra Kumar Vijay
Centre for Rural Development and Technology

Prof. PMV Subbarao
Department of Mechanical Engineering

HIGH IMPACT PUBLICATIONS

The research work carried by IIT Delhi faculty and students are published in leading journals of international repute in different areas of science & technology, management, social sciences, policy, etc.


ACS NANO


ADVANCED COMPOSITES AND HYBRID MATERIALS


ADVANCED ENERGY MATERIALS


ADVANCED MATERIALS


Advances in Optics and Photonics


Angewandte Chemie
International Edition


BIOACTIVE MATERIALS


CATALYSIS
APPLIED
B: ENVIRONMENTAL


Chem Soc Rev


CHEMICAL REVIEWS


Energy & Environmental Science


International Journal of
Information Management


JMA


nano energy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COMMUNICATIONS


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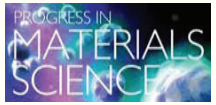
nature electronics


nature climate change


Nucleic Acids Research


PROGRESS IN
MATERIALS
SCIENCE


Science


Signal Transduction and Targeted Therapy


THE LANCET

Engineered Plasmonic Gold Electrodes for Efficient Photoelectrochemical Energy Harvesting

Nanophotonics-enhanced charge harvesting: A game-changer for Plasmon-driven water oxidation through superior photoelectrochemical performance in gold electrodes

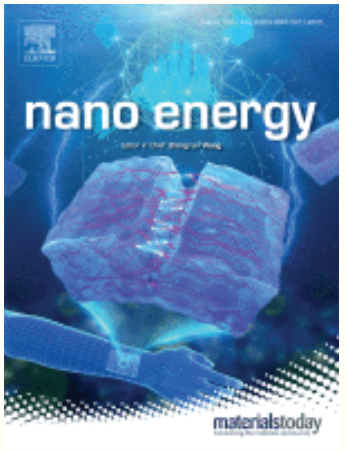
Sustainable energy production demands innovative approaches that go beyond material composition and bandgap engineering. The optical properties of photoelectrodes—specifically, their ability to harvest and sustain light interactions—play a critical role in solar energy applications, including water splitting and photovoltaic devices. Traditionally, electrodes serve as passive electrical contacts, but what if they could actively enhance light-matter interactions and charge generation?

To answer this, we engineered a gold nanoparticle grating on an indium tin oxide (ITO) base electrode and demonstrated enhanced solar water splitting through extended spectral absorption. By leveraging nanophotonic strategies, we coupled photonic resonances with plasmonic excitations to amplify charge transfer and boost catalytic performance.

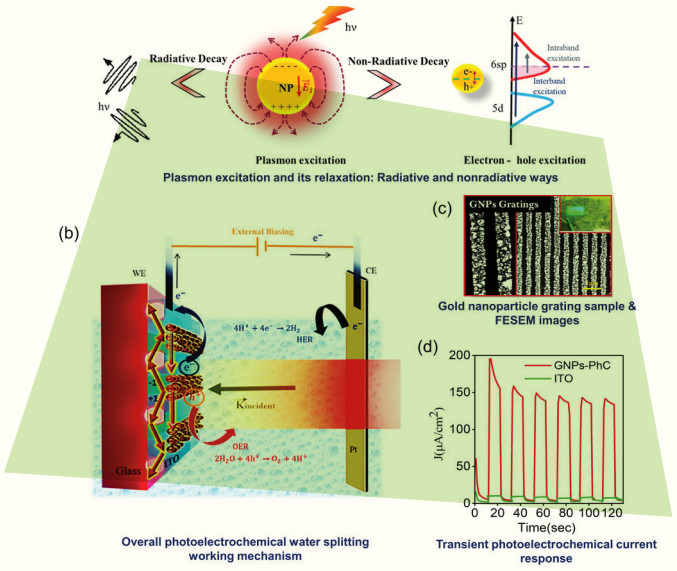
Plasmon resonances in gold nanoparticles generate localized electromagnetic fields, enabling strong light absorption and non-radiative decay pathways that produce energetic "hot carriers." These carriers accelerate charge transfer to adsorbed water molecules, minimizing overpotentials and reaction barriers. Compared to conventional gold films or randomly dispersed nanoparticles, our design can reduce hysteresis losses and enhance redox kinetics by mitigating charge trapping and recombination. Such nanophotonic-driven photoelectrodes present a promising route for visible-light-driven energy storage by water splitting and sustainable catalysis.

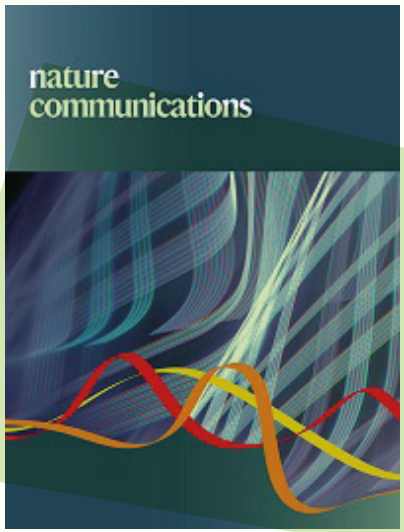
Prof. Joby Joseph
Optics & Photonics Centre

Prof. Suddhasatwa Basu
Department of Chemical Engineering



■ **Pandey, Saurabh; Joseph, Shereena; Devinder, Shital; Singh, Aditya; Basu, Suddhasatwa; Joseph, Joby; Hybrid photonic-plasmonic photoelectrode for enhanced photoelectrochemical current generation, 2023; Nano Energy, 108307.**



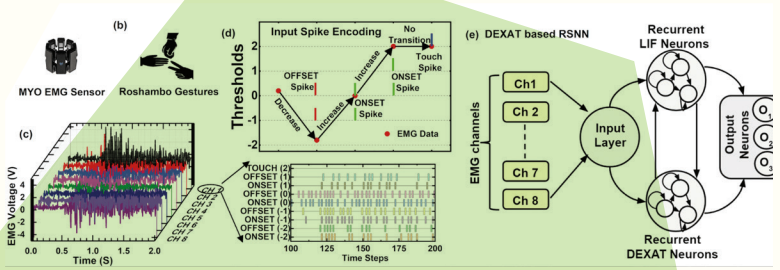


A Human Brain-inspired Artificial Neuron for Efficient Neuromorphic AI Systems

Developing a novel adaptive spiking neuron model and implementing its hardware for enhancing the performance of neuromorphic networks on spatio-temporal tasks

The human brain is one of the most powerful natural computers known to mankind. Neurons and synapses are important computational building blocks giving rise to intelligence inside our brains. Short-term memory characteristics give the mammalian brain extraordinary cognitive capabilities for processing information that varies with space and time (i.e. spatiotemporal data). This study proposed and demonstrated a novel artificial spiking neuron model 'DEXAT' that delivers extended short-term memory, higher accuracy, faster convergence and greater flexibility in hardware implementation compared to other state-of-the-art adaptive threshold spiking neurons. We also demonstrated efficient hardware realization using a hybrid nanodevice, and achieved a SOTA classification accuracy of 91% on Google Spoken Commands (GSC) dataset. Our findings were further validated by implementing the proposed DEXAT neuron on industry-grade hardware, viz. Intel's neuromorphic Loihi chip. We performed the industry chip-based demonstration for efficient Electromyograph (EMG) gesture recognition, which achieved significant energy/latency benefits of ~983X/19X compared to conventional GPUs.

■ **Shaban, Ahmed; Bezugam, Sai Sukruth; Suri, Manan; An adaptive threshold neuron for recurrent spiking neural networks with nanodevice hardware implementation, 2021; Nature Communications; 12 (1).**



Prof. Manan Suri
Department of Electrical Engineering

Unveiling the Biophysical Profiles of Exon-Intron Junctions

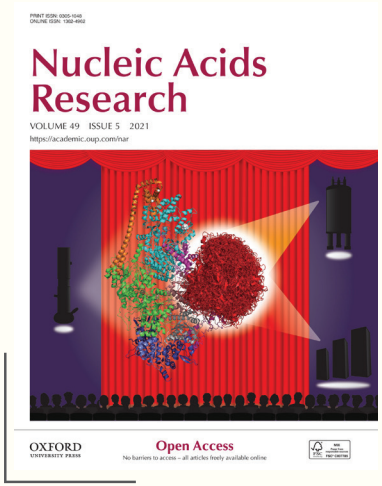
A breakthrough study unveiling the hidden structural and energetic fingerprints at exon-intron boundaries in the human genome

The journey from DNA to protein is central to life, with genes providing the instructions for making proteins. However, in eukaryotic genomes, genes are often fragmented into exons and introns, making accurate identification of these boundaries a major challenge in molecular biology. Understanding how cells precisely distinguish between these regions is critical for decoding gene function and regulation.

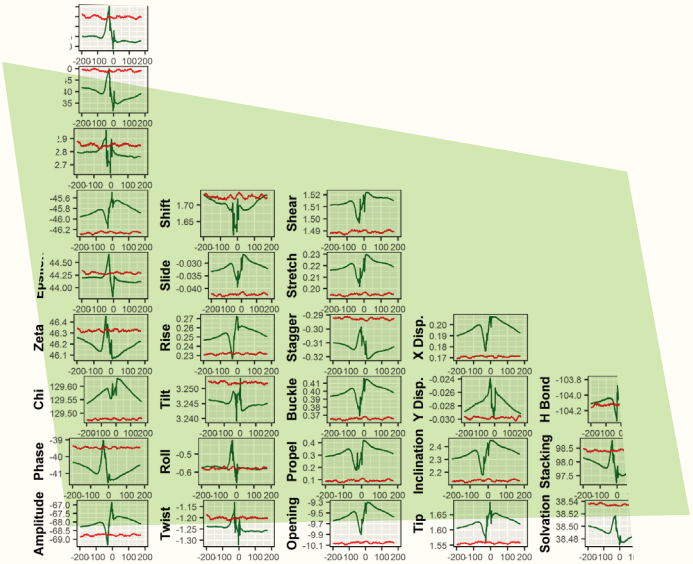
Our recent study conducted at SCFBio, IIT Delhi, sheds light on this complex process by exploring the structural and energetic properties of exon-intron junctions. Going beyond traditional sequence-based methods, the research analyzed over 650,000 exon-intron sites to reveal distinct physicochemical fingerprints at these boundaries. These findings provide a new perspective on how DNA's structure and energetics guide the splicing machinery, addressing fundamental challenges in gene annotation.

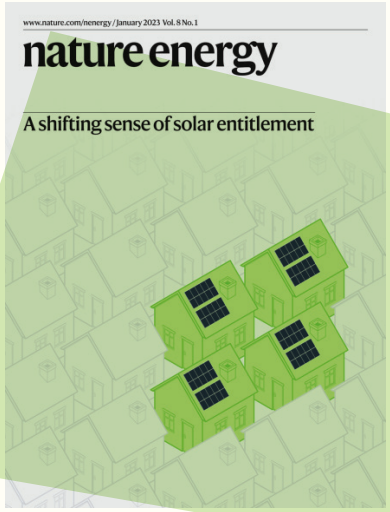
Building on earlier successes in using DNA's biophysical properties for gene and promoter prediction in prokaryotes, this study on eukaryotic genomes offers promising implications for improving genome annotation tools and understanding genetic disorders linked to splicing errors.

Prof. B. Jayaram
Department of Chemistry and
Kusuma School of Biological Sciences



- **Mishra, Akhilesh; Siwach, Priyanka; Misra, Pallavi; Dhiman, Simran; Pandey, Ashutosh Kumar; Srivastava, Parul; Jayaram, B; Intron exon boundary junctions in human genome have in-built unique structural and energetic signals, 2021; Nucleic Acids Research, 49 (5), 2674-2683.**



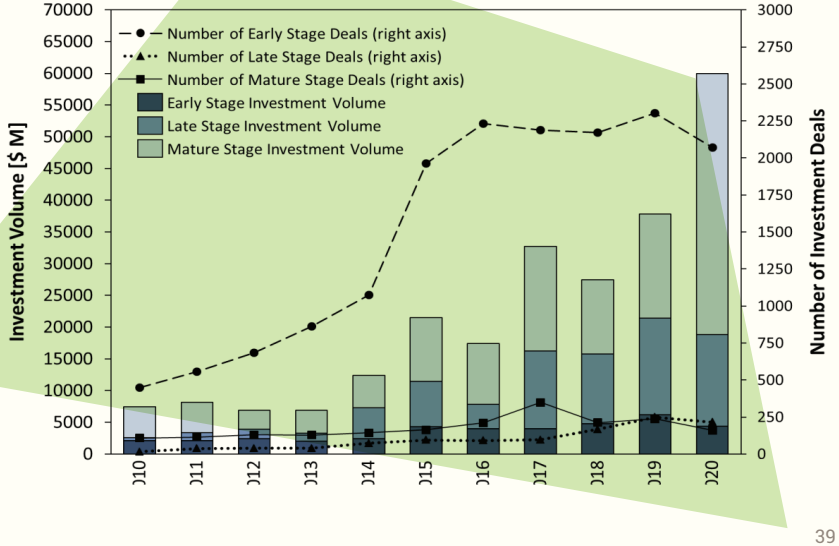


Analysis of the Low-Carbon Energy Technology (LCET) Startup Landscape in India

Analyzing the role of startups in India's clean-energy transition

Low-carbon energy technology (LCET) startups are likely to play a key and increasing role in India's clean-energy transition. Yet, we have only a limited understanding of the Indian LCET startup landscape and the factors shaping it. This paper provides the first-ever analysis of this landscape and shows that the investment and patenting activity in this space has increased substantially in recent years, particularly after 2017. The primary drivers for this growth are the market-creation policies put in place by the Indian government. However, the activity is concentrated in a few sub-sectors and a few value-creating activities, reflecting the technological capabilities in these areas. These results suggest that along with market-creation policies, the Indian government also needs to invest in complementary strengthening of energy technology capabilities. This can help enhance LCET startup activity in India and accelerate the country's clean-energy transition.

■ **Krishna, Harilal; Kashyap, Yash; Dutt, Dwarkeshwar; Sagar, Ambuj D.; Malhotra, Abhishek; Understanding India's low-carbon energy technology startup landscape, 2023; Nature Energy; 8(1), 94-105.**

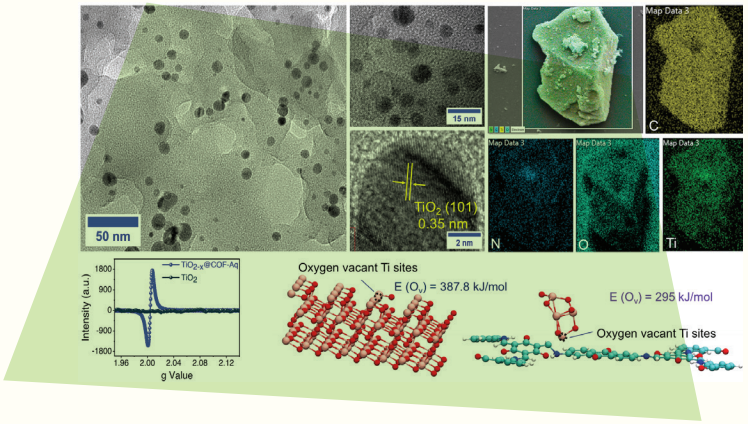


Prof. Ambuj Sagar
School of Public Policy

A Next-Generation Electrocatalyst for Green Ammonia Production

Electrocatalytic reduction of nitrogen to ammonia by TiO_2 nanoparticles with oxygen vacancy stabilized over anthraquinone-linked covalent organic framework

The Functional Materials and Membranes Laboratory at DMSE, IIT Delhi, achieved a significant breakthrough in electrocatalytic ammonia synthesis. The team leveraged the synergistic interplay of metal-support interactions to design an advanced electrocatalyst. By stabilizing TiO_2 nanoparticles on an anthraquinone-linked covalent organic framework (COF), we achieved substantial particle size reduction and oxygen vacancy enrichment, resulting in exceptional nitrogen reduction selectivity and catalytic efficiency. This pioneering work highlights the transformative potential of crystalline porous materials such as COFs in stabilizing small nanoparticles and augmenting their functional attributes, thereby establishing a new benchmark in nanocatalysis. The electrocatalyst facilitates ammonia production under ambient conditions, delivering an impressive yield of ~30 μg h^{-1} mg^{-1} with a Faradaic efficiency of 16%, significantly surpassing conventional methodologies and addressing the energy-intensive limitations of the Haber-Bosch process. Furthermore, its robustness, scalability, and insights into electron transfer dynamics and oxygen vacancy formation provide a strategic pathway for advancing the design of next-generation sustainable catalysts.



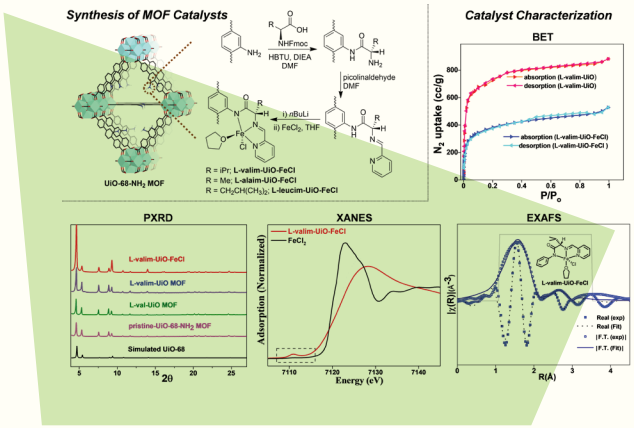
- **Mishra, Biswajit; Biswal, Swayamprakash; Ussama, Mohd.; Ali Haider, M.; Tripathi, Bijay P.; Rationally designed oxygen vacant TiO_2 decorated with covalent organic framework for enhanced electrocatalytic nitrogen reduction to ammonia, 2024; Applied Catalysis B: Environmental; 342.**

Prof. Bijay Prakash Tripathi
Department of Material Science & Engineering

Sustainable and Economic Synthesis of Enantiomerically Pure Chiral Compounds

Developing heterogeneous metal-organic framework catalysts using amino acids and earth-abundant metals for enantio-selective chiral molecule synthesis

Chiral Active Ingredients are essential building blocks for producing pharmaceuticals, agrochemicals, and biologically active molecules. The industrial synthesis of enantiomerically pure chiral compounds relies on solvent-intensive optical resolution methods or expensive and toxic late-transition metal-based homogeneous catalysis. We developed a new catalytic technology that enables the sustainable and cost-effective synthesis of chiral molecules. Our team utilized Metal-Organic Frameworks (MOFs) as tunable molecular materials for designing novel chiral heterogeneous catalysts using inexpensive, naturally occurring amino acids and abundant-but-less toxic metals such as iron, cobalt, and nickel. The study showed that grafting amino acids or amino alcohols within the pores of an easily synthesizable porous MOF and following it up with metalation generates highly active and enantioselective metal catalysts for various organic transformations. The MOF-based catalysts efficiently produce chiral alcohols in either enantiomeric form, achieving up to 99% enantiopurity by reducing carbonyl substrates. These heterogeneous catalysts also exhibit excellent recyclability, maintaining their performance over multiple cycles, which helps lower the overall cost of producing chiral molecules. This innovation has significant potential for the cost-effective and environmentally friendly domestic production of chiral APIs.



■ **Newar, Rajashree; Akhtar, Naved; Antil, Neha; Kumar, Ajay; Shukla, Sakshi; Begum, Wahida; Manna, Kuntal; Amino Acid-Functionalized Metal-Organic Frameworks for Asymmetric Base–Metal Catalysis, 2021; Angewandte Chemie - International Edition; 60 (19), 10964-10970.**

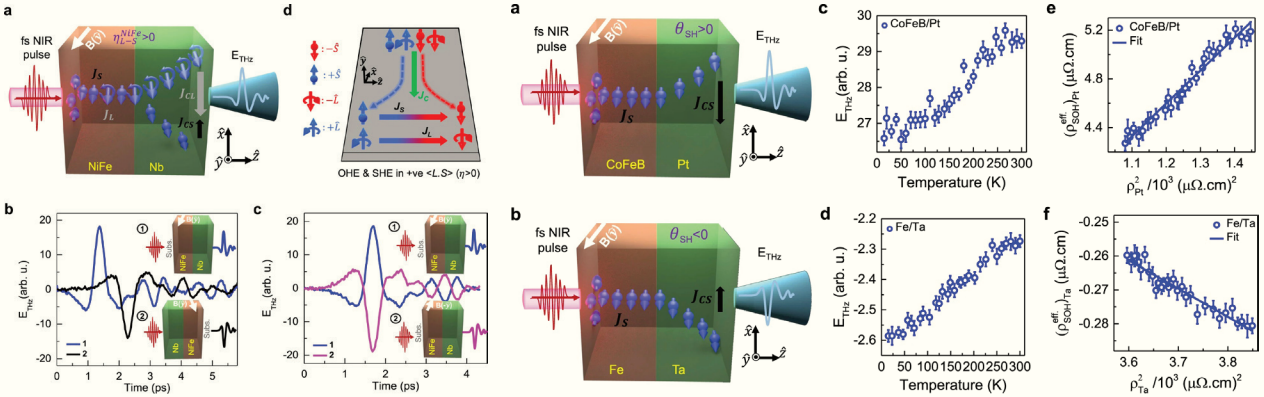
Prof. Kuntal Manna
Department of Chemistry

Broadband THz Emission by Femtosecond Orbital Current

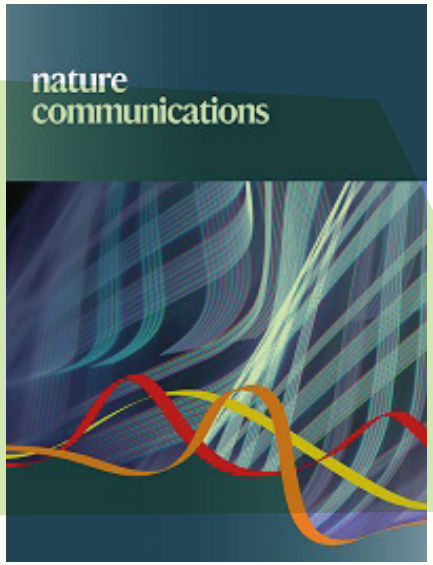
Ultrafast spintronics and orbitronics: THz probing of nonlocal orbital current in ultrathin metallic film heterostructures

The generation, manipulation, and detection of spin current have been of prime interest among researchers keen on developing efficient devices for spintronics applications. The speed of transporting quantum information using this degree of freedom has already touched the THz scale. Thus far, no one could explore or exploit the orbital degree of freedom of information carriers in this context. The need is for suitable materials and multifunctional combinations, along with the techniques for directly measuring and manipulating them.

Access to the ultrafast triggering of the orbital phenomena can lead to high-speed orbitronic devices. In the current work, we demonstrated thin film heterostructures-based orbitronic THz emitters. The emitted THz electromagnetic radiation manifested as ultrafast orbital current formation and subsequent conversion to the transient charge current in femtosecond laser-excited FM/NM heterostructures composed of FM:CoFeB, NiFe and NM: Ta, W, Pt material layers.



Prof. Sunil Kumar
Department of Physics



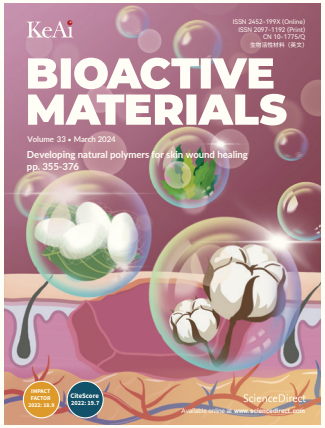
■ **Kumar, Sandeep; Kumar, Sunil; Ultrafast THz probing of nonlocal orbital current in transverse multilayer metallic heterostructures, 2023; Nature Communications; 14 (1).**

MicroRNA Therapeutics and Nanomedicine for Brain Tumor Treatment

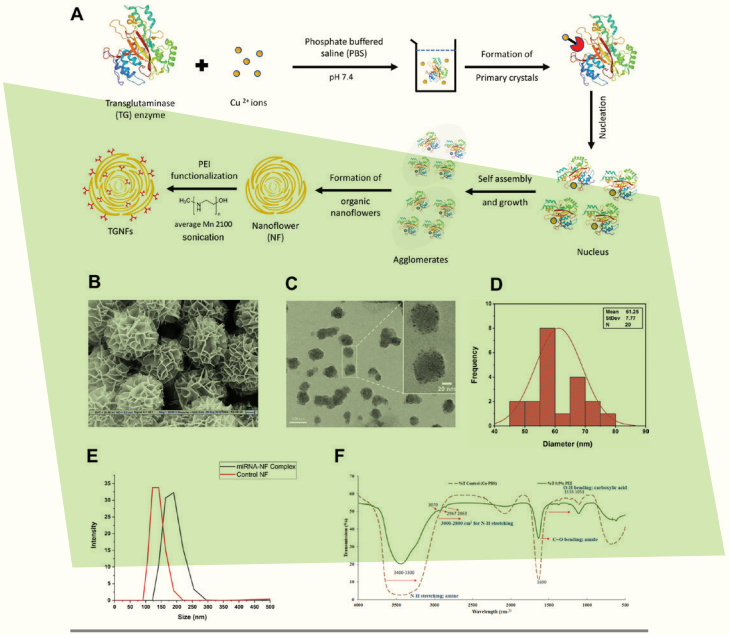
Engineering nanocarrier-mediated co-targeting of dysregulated microRNAs using Antisense Oligonucleotides (ASOs) to treat Glioblastoma (GBM)

Glioblastoma (GBM) is an aggressive malignancy of the central nervous system (CNS) that remains incurable despite the improvements in cancer therapeutics. The conventional chemo- and post-surgery radiotherapy have only been able to improve the prognosis slightly; however, the development of resistance and/or tumor recurrence is almost inevitable. Thus, there is a pressing need for adjuvant molecular therapies that can successfully and efficiently block tumor progression. Research has validated the therapeutic potential of several types of ncRNAs, including miRNAs, lncRNAs, and circRNAs, in both ***in vitro*** and ***in vivo*** models of GBM, and shown microRNAs such as miR-210 to be a prognostic marker regulating different hallmarks of gliomagenesis. However, the delivery of these RNA-based therapeutics is highly challenging, especially to the tumor of the brain, as the blood-brain barrier (BBB) poses a major obstacle, among others. Also, since RNA is extremely fragile in nature, designing a delivery agent requires meeting careful considerations. Smart nanomaterials such as transglutaminase nanoflowers (TGNF) and surface-modified ultra-small mesoporous materials can aid in the safe and targeted delivery of nucleic acids to treat GBM, overcoming the limitations of conventional therapy.

Prof. Ritu Kulshreshtha
Department of Biochemical Engineering and Biotechnology



- **Singh, Ravi Raj; Mondal, Indranil; Janjua, Taskeen; Popat, Amirali; Kulshreshtha, Ritu; Engineered smart materials for RNA based molecular therapy to treat Glioblastoma, 2024; Bioactive Materials, 33, 396-423.**



Peptide Catalyzes New Molecular Synthesis with Unprecedented Precision and Selectivity

Organocatalytic reaction for single enantiomers of bioactive fulvenes

Inspired by nature's prowess for synthesizing small molecules and our goal of developing a sustainable synthetic route towards medicinally important small molecules, our team manipulated amino acids to design an organic catalyst for engineering a variety of chiral small molecules without using toxic, unnatural metal catalysts. The organocatalysts developed from amino acid t-Leucine can carry out reactions that yield elusive chiral fulvenes in a single step.

The new catalysts and the synthetic procedure described opens up options for quicker and more affordable chemical synthesis, especially of a scaffold such as fulvene, which is of huge significance in biology and medicine. The method developed yielded new molecules, which were all in single enantiomers reflecting the high selectivity achieved in product formation. Importantly, at present,, single-enantiomer compounds are painstakingly synthesized as building blocks for drugs, agrochemicals, and functional materials.

We demonstrated these molecules' utility in cellular labelling as they possessed excellent fluorescent properties and were non-cytotoxic making them apt for bio-imaging. Interestingly, the catalysts we developed can be used directly as organocatalysts or in combination with transition metals to form new transition-metal catalysts by complexation. The options realized are virtually endless and greatly impact the discovery of new agrochemicals, pharmaceuticals, and other fine chemicals.

■ **Singh, Sanjay; Saini, Ravi; Joshi, Akshay; Singh, Neetu; Singh, Ravi P.; Desymmetric homologating annulation to access chiral pentafulvenes and their application in bioimaging, 2024; Nature Communications; 15(1).**

Prof. Ravi P Singh
Department of Chemistry

Prof. Neetu Singh
Centre of Biomedical Engineering

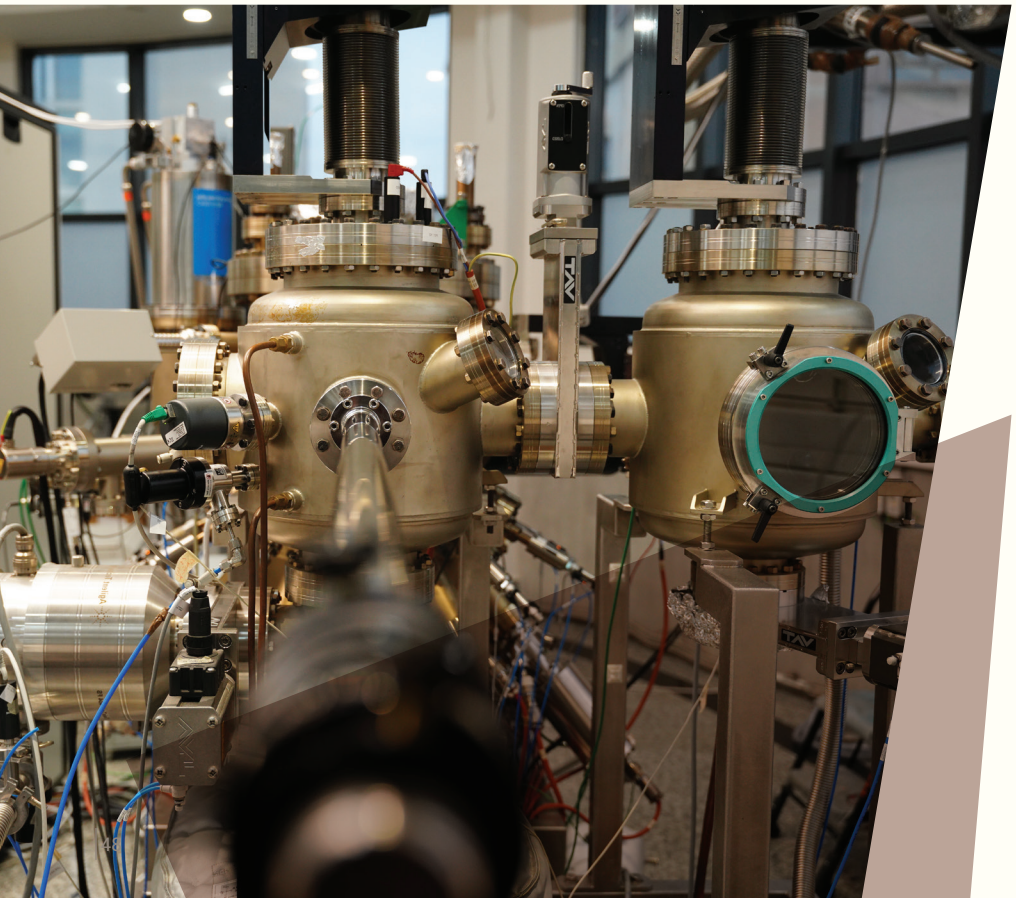

ACADEMIC COMPLEX EAST

INTERNATIONAL RESEARCH NETWORK

Highlights of our research collaborations with universities across the globe including joint PhD programs with University of Queensland (Australia) and NYCU (Taiwan).

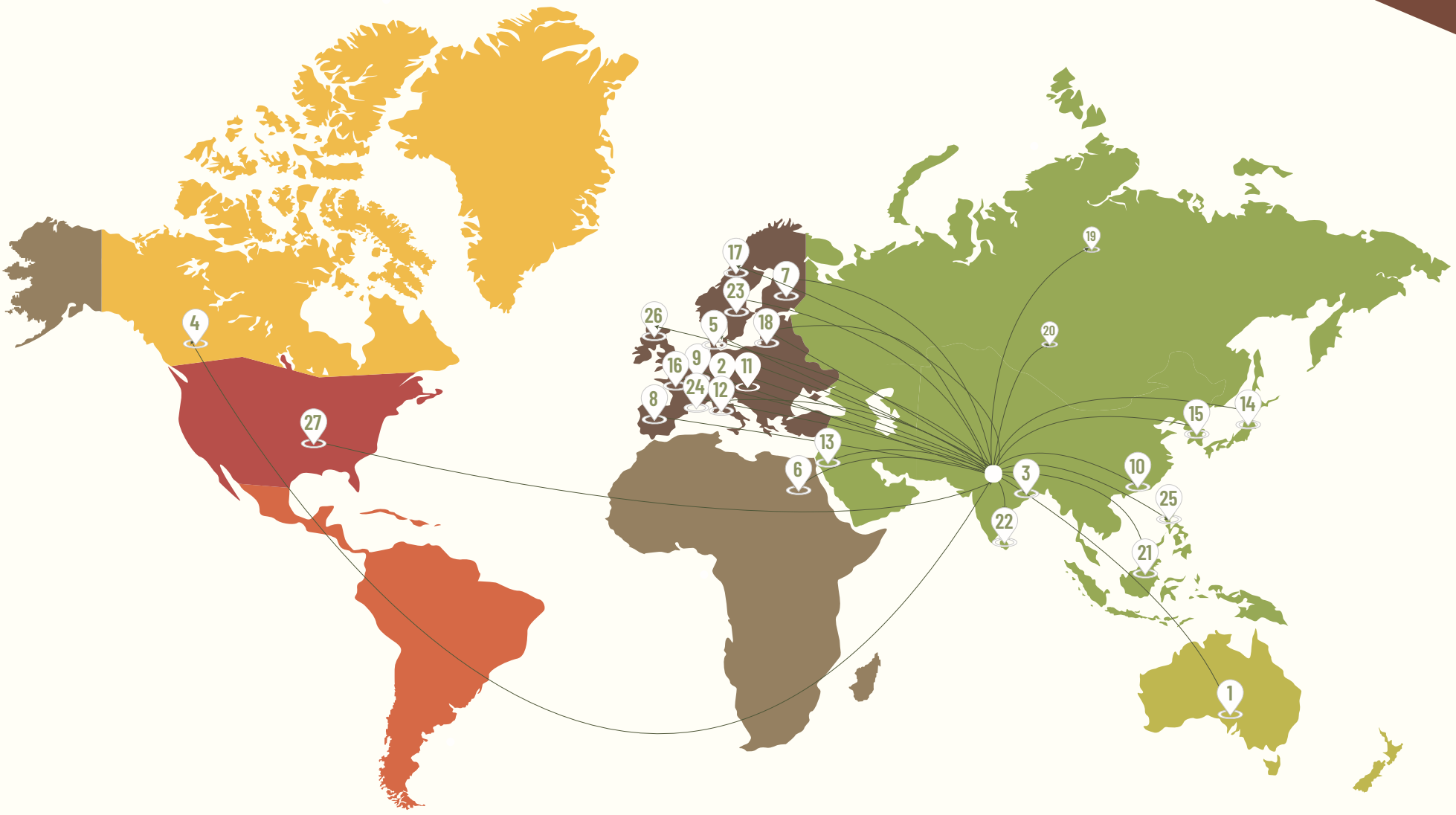
INTERNATIONAL RESEARCH PROJECTS

Summary of international research projects undertaken by IIT Delhi during 2018-2024



S. No.	Name of the Country	Total Projects
1	Australia	1
2	Austria	3
3	Bangladesh	1
4	Canada	11
5	Denmark	9
6	Egypt	1
7	Finland	5
8	France	10
9	Germany	19
10	Hong Kong	1
11	Hungary	1
12	Italy	2
13	Israel	14
14	Japan	8

S. No.	Name of the Country	Total Projects
15	South Korea	2
16	Netherlands	16
17	Norway	1
18	Poland	2
19	Russia	3
20	Russia & China	2
21	Singapore	11
22	Srilanka	1
23	Sweden	4
24	Switzerland	2
25	Taiwan	38
26	UK	54
27	USA	49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JOINT SEED FUNDING PROGRAM FOR INTERNATIONAL RESEARCH COLLABORATIONS

University of Waterloo
Canada

Delft University of Technology
Netherlands

5

14

University of Southern Denmark
Denmark

6

14

Hebrew University of Jerusalam
Israel

University of Sorbonne
France

5

35

National Yang Ming Chiao Tung University
Taiwan

3

10

University of Clemson
USA

New Zealand Universities
New Zealand

31

11

University College of London (UCL)
UK

University at Buffalo
USA

CMOS-MEMS Pirani Gauges for Vacuum Sensing

CMOS back-end-of-line (BEOL) integrated Pirani gauges achieve high sensitivity, broad dynamic range, and reliable vacuum detection for packaged microsensors

This project focuses on developing an advanced monolithically integrable MEMS-based Pirani gauge for precise vacuum pressure monitoring. By integrating the gauge directly into CMOS technology (the standard platform for modern electronics), it creates a compact and cost-effective solution that fits seamlessly into existing devices.

The innovative multi-heat-sink design and use of titanium nitride (TiN) as a heating element improves the gauge's sensitivity and extends its measurement range, enabling the detection of even the smallest change in vacuum levels. This advancement ensures reliable performance for critical systems like sensors and chips, which require precise vacuum conditions to function properly.

The impact of this innovation is significant:

Smaller, smarter devices: The compact gauges (360 μm^2) enable the creation of smaller, more efficient electronics.

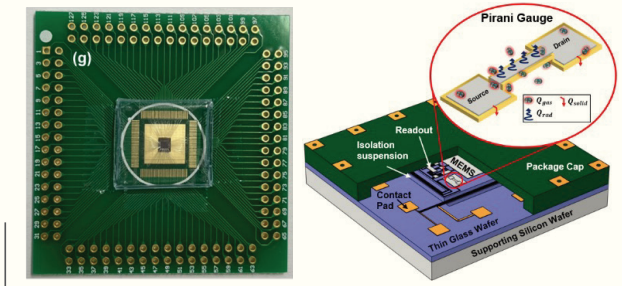
Improved reliability: Real-time, accurate monitoring enhances the durability and performance of delicate systems.

Cost-efficiency: Direct integration simplifies manufacturing, reducing production costs and time.

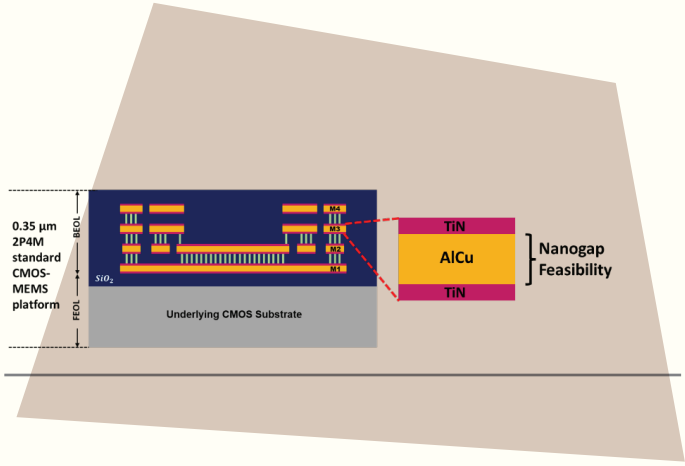
This innovation paves the way for more reliable and efficient electronics, benefiting industries like healthcare, aerospace, and advanced manufacturing, where maintaining precise vacuum conditions is essential.

Prof. Pushpapraj Singh
Centre for Applied Research in Electronics (CARE), IIT Delhi

Prof. Yi Chiu
Department of Electronics and Electrical Engineering, NYCU Taiwan



- **Precision Monitoring: Achieves a broad vacuum detection range from 8.3 Pa to 106 Pa with high sensitivity and reliability.**
- **Compact Integration: Fully integrated into CMOS technology, enabling smaller, smarter, and cost-efficient devices.**
- **Repeatability: Experimental data shows exceptional reliability with a maximum measurement error of only 0.2%.**

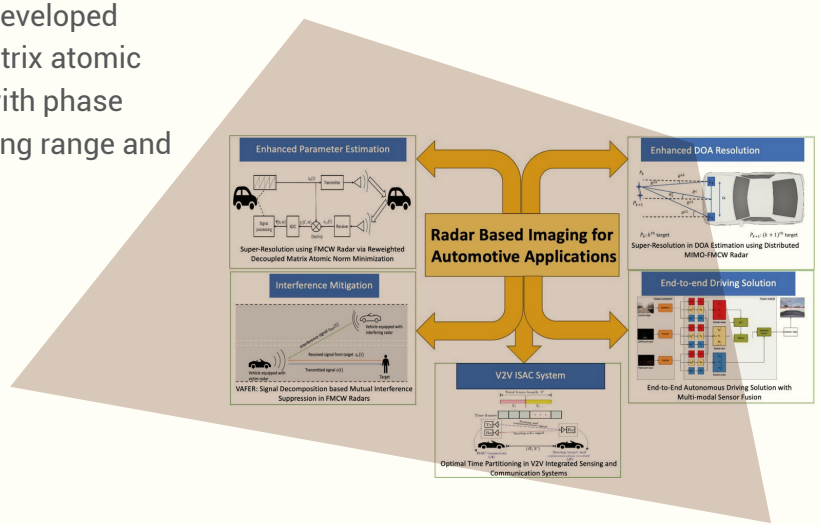


Radar-Based Imaging for Automotive Applications

Identifying the challenges and limitations in employing radar for automotive applications

- **Enhanced resolution compared to well-known frequency estimation methods employed in commercial FMCW radar modules.**
- **Computationally efficient and real-time interference mitigation solution.**
- **Cost effective signal processing solution to improve the direction of arrival (DOA) resolution.**
- **Provides insights into the sensing and communication design parameters for integrated sensing and communication (ISAC) systems.**

The primary objective of this research is to identify the challenges and limitations in employing radar for automotive applications and to develop strategies for mitigating them. The main challenges and limitations of automotive radar are low resolution, performance degradation in the estimation of target parameters due to range-Doppler coupling, and interference. Using radar in coordination with other sensors can help develop a realistic framework for an end-to-end autonomous driving solution. By and large, automotive applications leverage Frequency-Modulated Continuous-Wave (FMCW) Radar for localizing targets by estimating their ranges and velocities in 2-D space. We developed an reweighted decoupled 2-D matrix atomic norm (RMAN)-based algorithm with phase compensation for jointly estimating range and velocity for a wideband FMCW radar. In addition, we designed mutual interference suppression algorithms for this radar. To enhance the DOA resolution, we engineered a distributed multiple input multiple output (MIMO)-FMCW radar system. Next, our multi modal attention-based network fuses data from the camera, lidar, and radar sensors. Lastly, this research highlights the inherent tradeoffs associated with sensing and communication design parameters and obtaining optimal sensing and communication time durations in vehicle-to-vehicle (V2V) ISAC systems.

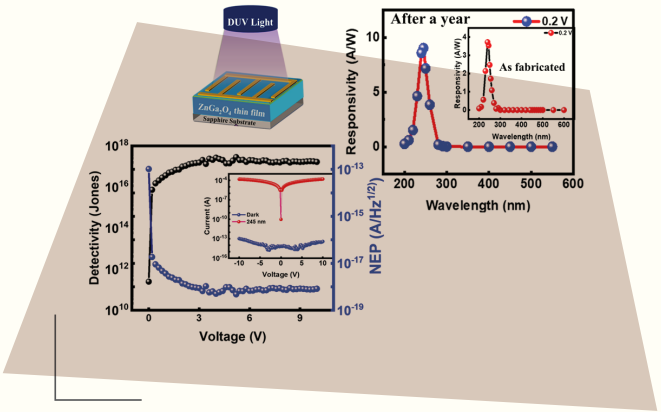


Prof. Seshan Srirangarajan
Department of Electrical Engineering, IIT Delhi

Prof. Kai-Ten Feng
Department of Electronics and Electrical Engineering, NYCU Taiwan

Deep Ultraviolet Photodetector Based on a MOCVD-Grown $ZnGa_2O_4$ (111) Facet on a Sapphire Substrate

Orienting a deep ultraviolet photodetector utilizing MOCVD-grown $ZnGa_2O_4$ epilayers along the (111) facet on a sapphire substrate offers enhanced performance, high thermal stability, and excellent sensitivity for deep ultraviolet detection applications



- **Produced Zinc gallate ($ZnGa_2O_4$) epilayers on sapphire substrates using Metal-Organic Chemical Vapor Deposition**
- **Gadget detects deep ultraviolet light with outstanding sensitivity and stability**

We developed a cutting-edge deep ultraviolet (DUV) photodetector employing superior material engineering. To create this unique device, we produced Zinc gallate ($ZnGa_2O_4$) epilayers on sapphire substrates using Metal-Organic Chemical Vapor Deposition (MOCVD). The gadget detects deep ultraviolet light with outstanding sensitivity and stability due to $ZnGa_2O_4$'s unique characteristics and optimum orientation.

Deep ultraviolet light, undetectable to the human eye, is essential for water purification, environmental monitoring, and advanced electronics. This photodetector works well at high temperatures, unlike ordinary detectors, which makes it ideal for demanding industrial and space applications.

This innovation greatly improves an ultraviolet detection system's accuracy and durability, benefiting public health, environmental safety, and energy efficiency technologies. Our study addresses material design difficulties, paving the path for the next generation of durable and dependable ultraviolet sensors.

Prof. Rajendra Singh
Department of Physics, IIT Delhi

Prof. Ray Hua Horng
Institute of Electronics, College of Electrical and Computer Engineering, NYCU Taiwan

Thermal vs. Electrical Energy Storage Performance in Renewables

Integrating high-temperature latent heat storage with renewable energy systems can mitigate the discrepancy between energy supply and demand

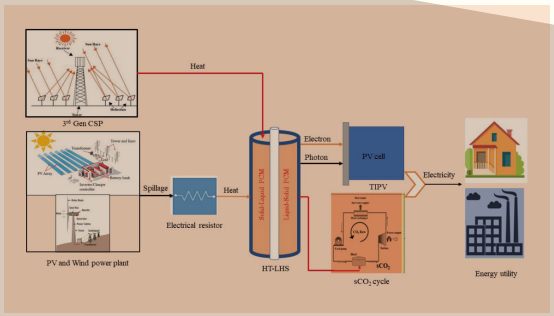
The ever-increasing demand for energy and heightened concern for environmental security has attracted considerable attention from researchers seeking to switch from fossil fuel technology to renewable energy (solar energy, wind energy, etc.) technology. However, spatial and temporal intermittency is the major hindrance to the effective deployment of renewable energy technologies. Hence, energy storage technologies are paramount for the wide scale deployment of renewable energy systems. Among storage technologies, high-temperature latent heat storage (HT-LHS) can be integrated with concentrated solar thermal systems and Thermionic photovoltaic (TIPV) systems.

The present study explores the potential of high-temperature latent heat storage (HT-LHS) using metallic phase change materials (PCM). We identified metallic silicon as a suitable high-temperature PCM. We also developed a Python model to evaluate the performance of an advanced supercritical CO_2 recompression cycle integrated with HT-LHS. The efficiency we observed was upwards of 50% at an operating temperature range of 700-750 °C, which resulted in higher overall solar-to-power conversion efficiency. We designed a lab scale HT-LHS prototype and conducted experiments to evaluate the charging and discharging performance. Further, we conducted a comprehensive techno-economic comparison between HT-LHS and a Li-Ion battery, which showed that silicon-based HT-LHS can perform better.

Prof. Dibakar Rakshit and Prof. K. RaviKumar
Department of Energy Science and Engineering,
IIT Delhi

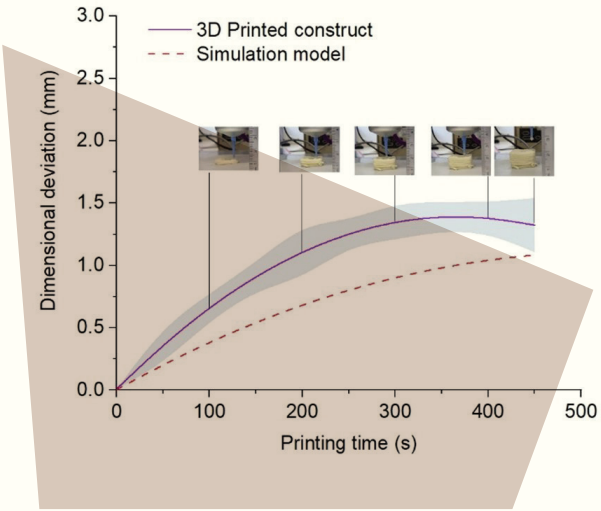
Prof. Hal Gurgenci
School of Mechanical and Mining Engineering,
University of Queensland

- **Silicon-based high-temperature latent heat storage can be a potential alternative to Li-ion battery storage**
- **Charging and discharging performance of high-temperature latent heat storage is predominantly sensitive to Rayleigh number compared to Reynold's number.**
- **The gravimetric and volumetric energy densities of silicon-based thermal cells are significantly higher compared to specific Li-ion cells.**



Designing Functionalized Sweetmeats Through 3D Food Printing

Leveraging 3D printing for developing novel dairy sweets with programmable textures and high-quality manufacturing precision



This project reimagines the production of dairy sweetmeats, a cherished part of Indian culture, by introducing 3D printing technology. People love traditional dairy sweets for their flavors but maintaining their consistency, hygiene, and customization is a challenge. Using heat-acid coagulated milk as the primary material, this innovation optimizes formulations and printing processes to create high-quality, ready-to-eat dairy sweets with customizable textures, shapes, and sizes.

The project delivers impactful outcomes: precision in production, reduction in food waste, and the ability to meet evolving consumer preferences for personalized nutrition and textured sweets. By leveraging advanced 3D printing parameters, the process ensures structural stability, smooth extrusion, and programmable textures, paving the way for sweets that are not only nutritious but also tailored to individual needs.

This innovation benefits small-scale sweet manufacturers, ensuring consistent quality, hygiene, and efficiency in production. It also opens doors for personalized nutrition, allowing creation of healthier versions of traditional sweets for health-conscious consumers. Ultimately, this work combines cultural heritage with cutting-edge technology to modernize a traditional food sector while promoting sustainability and innovation.

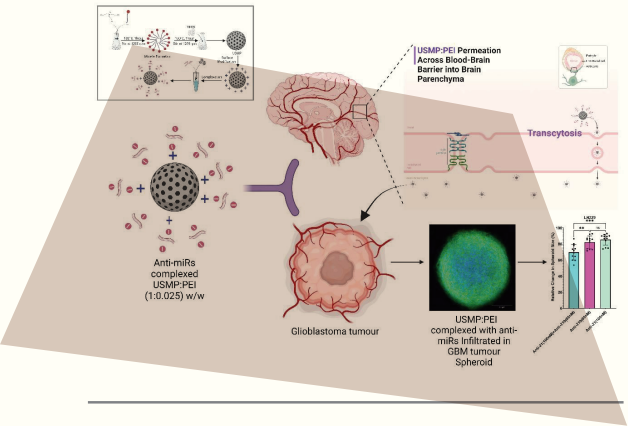
- **Nutritional Customization: The project enabled the development of healthier dairy sweets with reduced fat and sugar content, meeting the needs of health-conscious consumers while retaining traditional flavors.**

Prof. Jatindra Kumar Sahu and Prof. Satya Narayan Naik
Centre for Rural Development and Technology, IIT Delhi

Prof. Sangeeta Prakash and Prof. Bhesh Bhandari
School of Agriculture and Food Sustainability,
University of Queensland

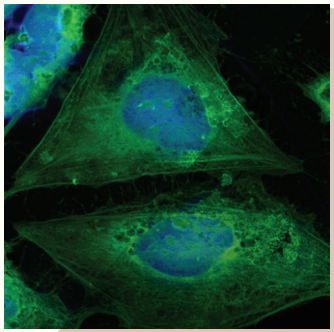
Nanomedicine and Gene Therapy to Treat Glioblastoma

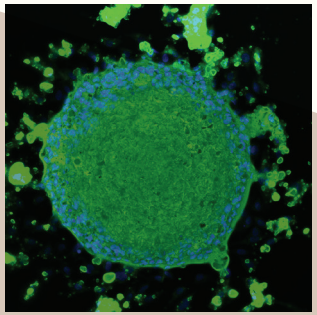
Treating Glioblastoma using ultrasmall mesoporous silica nanoparticles for co-delivery of therapeutic antisense oligonucleotides



- **Targeting smart and notorious criminals like GBM needs cops like antisense oligonucleotides with smart strategies such as ultra-small nanocarriers to hit them to their core.**
- **With the help of these molecular cops, we were able to arrest criminals like GBM and put them behind bars with a ~40% reduction in GBM tumor spheroid growth and tumorigenesis potential.**

Glioblastoma (GBM) is one of the most lethal and malignant forms of cancer affecting the central nervous system, with a very poor prognosis and high post-diagnosis mortality. Global statistics indicate that it affects, on average, 3-4 people/100,000 population with a median survival of not more than ~15 months following surgery, chemotherapy, and radiation therapy. Conventional treatment options have failed to help clinicians eradicate the tumor and provide relief and comfort to GBM patients and their loved ones. New gene therapy treatment options such as co-targeting oncogenic microRNA known to promote cancer progression can help target the GBM at the molecular level. However, oligonucleotide therapy comes with its own challenges, such as degradation by enzymes in blood serum and off-target effects. We sought to address such challenges by engineering ultra-small delivery carriers. These nanomachines can safely transport cancer-killing oligonucleotides, keeping them safe, hidden, and wrapped till they reach the targeted location within the tumor core and disrupt them from within their engineered safe zone.



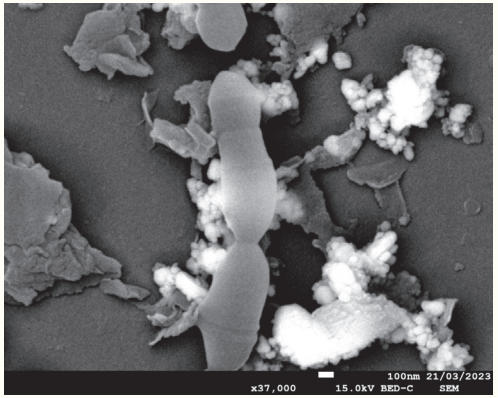


Prof. Ritu Kulshreshtha
Department of Biochemical Engineering and Biotechnology, IIT Delhi

Dr. Amirali Popat
Professor and Director of Research, School of Pharmacy, University of Queensland

Revolutionizing Water Treatment with Green Nanotechnology

A sustainable approach for water disinfection and pollutant degradation using green-synthesized silver nanomaterials



- **Clean Water Innovation: Eco-friendly silver nanoparticles for water purification.**
- **Waste to Value: Agricultural waste transformed into sustainable nanomaterials.**
- **Broad Impact: Tackles pollutants, detects heavy metals, and prevents biofilm formation**
- **Energy-Efficient: Scalable, low-energy solution for clean water access**

Access to clean water remains a global challenge due to increasing pollution and the limitations of conventional water treatment methods. This project focuses on the development of biobased silver nanoparticles (AgNPs) and nanocomposites synthesized using fruit peel waste, a green and sustainable alternative to chemical methods. This innovative green synthesis method eliminates the need for toxic chemicals, aligning with sustainable and cost-effective water treatment practices.

We engineered the biobased AgNPs for **multifunctional applications** in water treatment, including:

- **Pollutant Degradation:** The nanomaterials catalyzed the breakdown of 4-nitrophenol and parabens, including removal of 97.6% methylparaben under visible light using reduced graphene oxide-supported AgNPs.
- **Heavy Metal Detection:** The nanoparticles enabled selective and visual detection of mercury ions, addressing contamination concerns.
- **Microbial Biofilm Inhibition:** The nanocomposite significantly reduced microbial biofilms by up to 70%, tackling waterborne pathogens that evade conventional treatment methods.

This research paves the way for sustainable, cost-effective, and energy-efficient technologies to improve access to clean water. By transforming agricultural waste into functional nanomaterials, this project addresses emerging pollutants and waterborne pathogens while advancing global sustainability efforts. The scalable solutions developed are particularly impactful for regions with limited resources, offering an innovative approach to ensure safe and clean water for all.

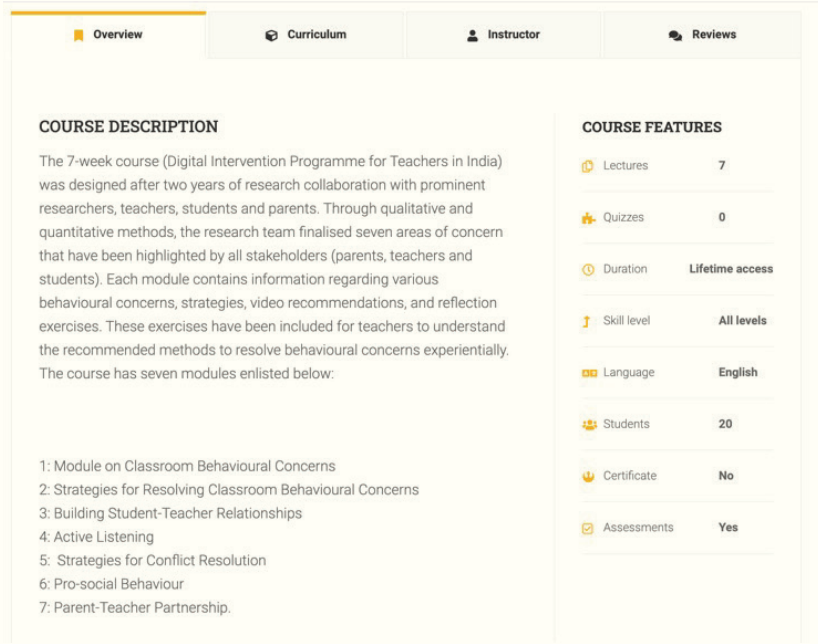
Prof. Kamal Kishore Pant
Department of Chemical Engineering, IIT Delhi

Prof. Mark Blaskovich and Dr. Zyta Ziora
Institute for Molecular Biosciences, University of Queensland

Digital Intervention Programme for Teachers in India to Address Behavioral Concerns in Classrooms

Overcoming logistical and personal barriers to seek help for classroom management while optimizing teacher self-efficacy

This project tackled the everyday challenges teachers face with student behavior in classrooms across different types of schools—private, public, and government—in Delhi NCR. By working closely with teachers, we co-created a practical and accessible digital tool (website) to make it easier for them to seek support and feel more confident in managing their classrooms. This intervention not only reduced disruptive behaviors among students but also empowered teachers to become more compassionate and champion student mental health. Our initiative is a meaningful step toward building healthier, more supportive school environments and ensuring that both students and teachers thrive.



- **Improved self-efficacy in teachers from rural schools.**
- **Reduced incidences of disruptive behaviors in students across rural and urban schools**
- **Reduced incidences of negative teaching behavior in the classroom, by teaching conflict resolution strategies**

Prof. Purnima Singh
Humanities and Social Sciences, IIT Delhi

Prof. Matthew Bambling
School of Medicine, University of Queensland

Unlocking Mechanisms of Development and Regeneration

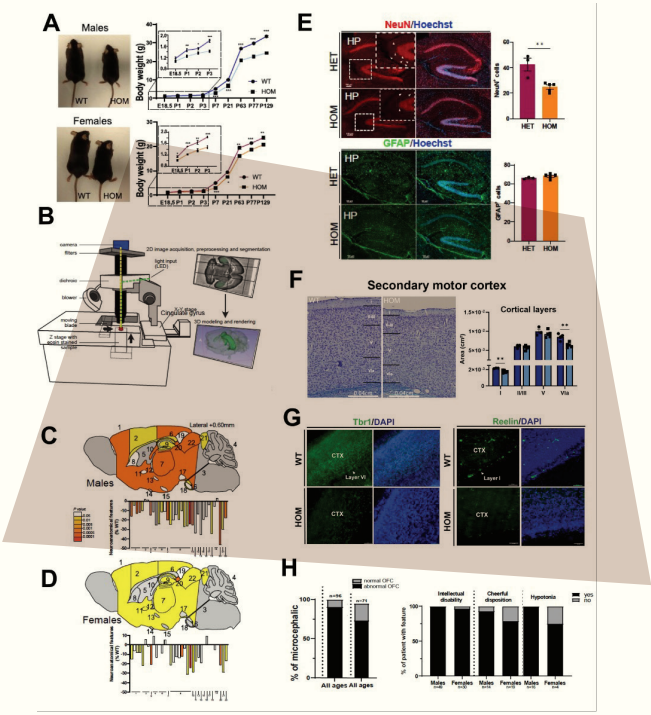
Exploring neural repair, genetic regulation, and transcriptomics through zebrafish and mice models

Our research is centered on understanding development and regeneration, with a focus on the repurposing of developmental processes during regeneration and leveraging these insights to enhance our understanding of disease conditions. By investigating the molecular and cellular mechanisms underlying these processes, we aim to identify gene expression networks and signaling the pathways that drive them.

One of our key findings is the identification of VPS13B as a crucial player in neurodevelopment. This discovery provided significant insights into Cohen syndrome, a rare neurodevelopmental disorder, by linking the molecular changes in VPS13B -mutant mice to patient phenotypes. Similarly, we mapped dynamic gene expression assemblies in specific organs, creating a foundation to explore conserved genetic pathways. These findings are instrumental in bridging the gap between model organisms like zebrafish and humans and opening new avenues for studying development, disease, and potential biomarkers for diagnostics and therapeutics.

To extend these discoveries into regeneration, we are using our standardized telencephalic stab wound injury model in zebrafish to investigate the reuse of developmental mechanisms in neural repair. This model enables us to study gene expression networks and signaling pathways in action, providing a holistic view of regeneration at the molecular and cellular levels.

Ultimately, our work aims to connect the dots between development, regeneration, and disease by using the unique strengths of model organisms like zebrafish and mice. We hope these efforts will contribute to a deeper understanding of human biology and encourage innovative approaches to regenerative medicine and disease intervention.



Prof. Shilpi Minocha
Kusuma School of Biological Sciences, IIT Delhi

Prof. Binnaz Yalcin
University Bourgogne Franche-Comté

Reconfiguring Post-Consumer Textile Fibre-to-Fibre Recycling Value Chains

Mitigating the environmental impacts of the textile supply chain by valorising post-consumer textile waste into products, conducting life cycle assessments, and developing a decision support system for optimized textile recycling value chains

The textile industry is intensively resource dependent and it also generates huge amount of waste which is either incinerated or sent to landfill. It generates an estimated 92 million tons of waste globally every year. A circular economy based on fiber-to-fiber recycling can potentially offer solutions to this problem. However, some critical barriers hinder the adoption of circular economy in the textile industry. These include technological limitations as well as the complexity of designing a circular supply chain. Our research seeks to solve these issues. It optimizes post-consumer textile recycling for improving material quality and encourages sustainable product development using recycled fibers. We also employed a Life Cycle Assessment to evaluate the sustainability of the developed products. Given that the current valorisation of circular textiles is hindered by challenges at product-process-supply chain levels, tackling such challenges requires data-driven decision-making. Thus, decision support tools can guide industry stakeholders like sorters, recyclers, manufacturers, and brands on managing the circular textile value chain more effectively, maintaining their recycling operations, and improving economic returns. We are now making efforts with the help of industry partners to develop such a dynamic decision- making platform


Waste denims


Cutting machine


Opener & cleaner


Recycled fibres


Open end spinning

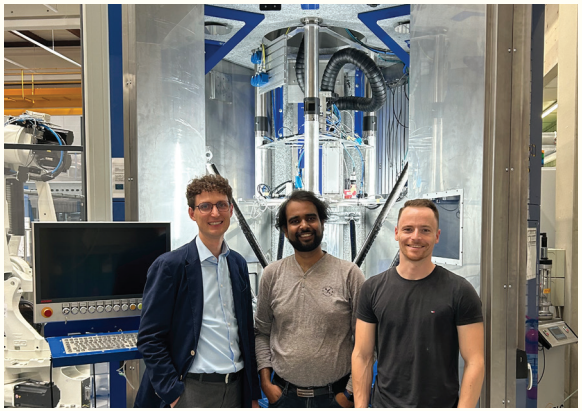

Recycled yarns

Prof. Abhijit Majumdar
Department of Textile and Fibre Engineering, IIT Delhi

Prof. Rudrajeet Pal
The Swedish School of Textiles, University of Boras

Development of Mandibular Implants Using Biotechnology-Inspired Functional Lattice Structures

Patient-specific, additively-manufactured Temporomandibular Joint (TMJ) implants with lattice structures to support osseointegration



Patients suffering from disorders of the Temporomandibular joint (TMJ) can have the joint replaced by an implant. However, commercially available TMJ implants are not ideally suited for Indian patients due to fit discrepancy and lower efficacy. This project aims to develop patient-specific TMJ implants that can potentially promote osseointegration, besides circumventing existing issues. We analyzed Indian patients with terminal TMJ disorders to understand the morphometric variation from healthy subjects (Indian and Caucasian population) for developing suitable TMJ implants.
We also developed and studied virtual 3D models representing mandibles implanted with existing TMJ implants. To support osseointegration in TMJ implants, we chose optimal biotechnology-inspired functional lattice structures (porous-based) and analyzed their mechanical performance. Then we compared the biomechanical performance of the implants having these lattices with existing TMJ implants. We observed significant morphometric variations between patients suffering from TMJ disorders and healthy subjects. Notably, implants with lattice structures performed better than existing TMJ implants. These modified, additively-manufactured mandibular implants with lattice structures have the potential to enhance the quality of life of patients having TMJ disorders.

Prof. Kaushik Mukherjee, Prof. Sudipto Mukherjee, and Prof. Anoop Chawla
Department of Mechanical Engineering, IIT Delhi

Prof. Ajoy Roychoudhury and Prof. Ongkila Bhutia
Centre for Dental Education and Research, AIIMS

Dr. Kingshuk Poddar
Head, Medical Material and Devices, Tata Steel

Prof. Frederik Zanger
Institute of Manufacturing and Materials Technology
wbk Institute for Production Technology (Karlsruhe Institute of Technology)

Lukas Göhler
Head of Process Development, OTEC Präzisionsfinish GmbH

Project EPIC: Operationalizing "Equity" in the Distribution of Irrigation Water

Developing new knowledge and tools to transform irrigation water management for fair and sustainable distribution of water

Irrigation systems play a crucial role in enhancing agricultural productivity and farmer resilience. However, increasing inequity in the distribution of irrigation water is a challenge. Irrigation policies are dominated by concerns of efficiency and productivity, but concerns of equity are rarely foregrounded. How can we assess (in)equity in the distribution of irrigation water (ground or surface water) among different users, and how can this assessment help in designing more just irrigation programs? This question is central to our project.

Our team of eight partners (representing academia, NGOs, and government) across four countries (India, Tanzania, Ethiopia, and the Netherlands) is creating new knowledge based on diverse perspectives of equity in irrigation water distribution. We are actively engaging with stakeholders such as the irrigation bureaucracy, water-user associations, and women and marginalized farmers in different case study contexts. Based on these grounded perspectives, our multidisciplinary research team aims to apply mixed methods (ethnographic, modelling, remote-sensing) to develop protocols and tools for mapping and measuring (in)equity. Through games, workshops, and new courses for irrigation professionals, we aim to mainstream equity concerns in irrigation policy and practice.

Dr. Pooja Prasad
Assistant Professor, School of Public Policy, IIT Delhi

Dr. Seleshi Yalew
Senior Researcher, IHE Delft Institute for Water Education

Prof. Hans Komakech
Nelson Mandela African Institute of Science and Technology

Prof. Seid Hussein
Wollo University

Dr. Sachin Tiwale
Fellow, Ashoka Trust for Research in Ecology and the Environment (ATREE)

Mr. Subrata Singh
Foundation for Ecological Sustainability

Mr. Lucas Kapama
Irrigation Engineer, Pangani River Basin Water Board

Dr. Abebe Kibret
Wollo Development and Entrepreneurship Trust

Aptamer-Based Rapid Testing Kits (RTKs) for Analyzing Micronutrients and Mycotoxins in Fortified Food and Feed Samples

Aptamer-based RTKs facilitate real-time detection of mycotoxins, saving time and cost. They are stable at room temperature and highly sensitive and specific

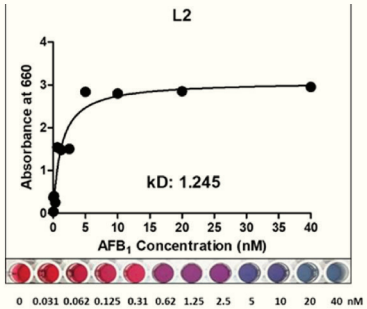


Figure represents the higher affinity of Aptamer L2 to aflatoxin. The colour changes from red to blue – indicting different concentrations of Aflatoxin B1 (LOD is 5 nM)

Demonstration of Aptamer based RTKs

More than four hundred types of mycotoxins exist in nature. AFB_1, AFB_2, AFG_1, and AFG_2 are commonly found in contaminated agro-food and feed. When ruminants digest feed contaminated by AFB_1 and AFB_2, their hydroxylated metabolites, namely AFM_1 and AFM_2, are subsequently excreted in the milk of lactating ruminants. Through this medium, mycotoxins enter the food supply chain during the storage and handling of agro-produce.

Similarly, recent universal food fortification programs implemented across the world have primarily focused on Vitamins B9 and B12, particularly when it comes to the fortification of rice. Therefore, maintaining and monitoring their concentrations at each stage of the supply chain is crucial to ensure QA and QC, which, as a result, leads to the effectiveness of the food fortification program.

The present intervention leverages nucleic acid aptamers for detecting micronutrients (vitamins) and mycotoxins in fortified foods and animal feeds. Aptamers are single-stranded DNA or RNA molecules (20-100 nucleotides) that can bind to specific target molecules with high affinity and specificity. They are more stable than antibodies and can retain their binding ability across various environmental conditions and sample types. They are cost-effective and can be produced in large quantities via chemical synthesis. The real-time kits (RTKs) developed using aptamers are cheaper, more accurate, and user-friendly.

Prof. Jatindra K Sahu and Prof. Hariprasad P.
Centre for Rural Development and Technology

Dr. Ruchika Chugh Sachdeva
Nutrition Lead, India Count, Bill & Melinda Gates Foundation

Policy Analysis to Meet India's Energy and Climate Challenges

Supporting India's climate change mitigation and adaptation efforts

This project takes a multi-pronged approach to develop policy insights that can enhance the country's efforts toward climate change mitigation and adaptation. One aspect of the project explored the ways in which climate science can inform climate adaptation policy. A second aspect analyzed India's low-carbon energy technology (LCET) startup landscape, as a way to develop insights into how startups can better support the country's clean-energy transition. A third aspect focused on developing a capacity-building agenda to strengthen climate policy research and action. Last, a fourth aspect examined just transition approaches in different parts of the world with a view to developing a framework to engage more systematically with this issue. All these analyses of the climate problem contributed to evolving and presenting insights that can help policy makers and practitioners engage more effectively with the various dimensions of the climate challenge.

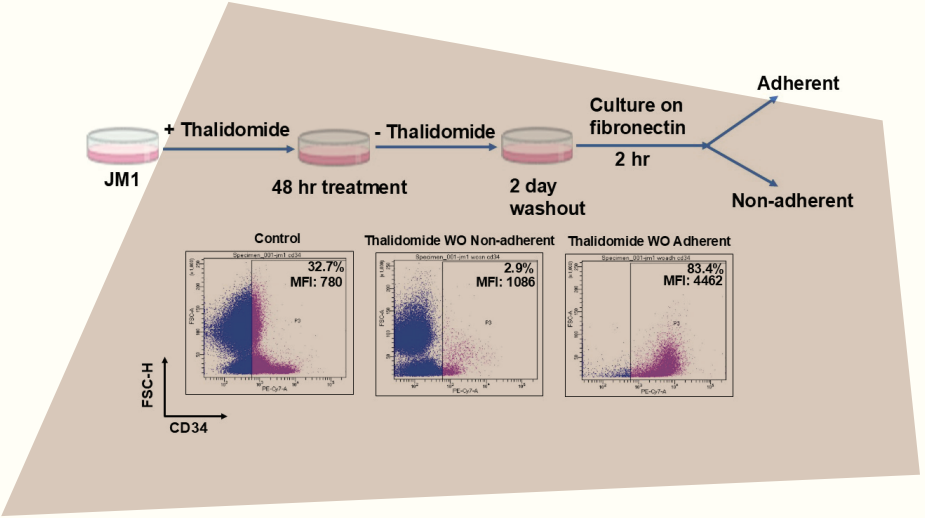
Prof. Ambuj Sagar
School of Public Policy

Dr. Shirish Sinha
Director, Climate, CIFF

A Chemotherapy Drug Turns Rogue

Lenalidomide therapy in multiple myeloma patients leads to the development of a different blood cancer, B cell acute lymphoblastic leukemia

Doctors have used Lenalidomide as a supportive chemotherapy for patients suffering from a particular type of blood cancer called Multiple Myeloma. Recent worldwide reports indicated that long-term treatment with this drug can cause patients to develop a second type of blood cancer called B-cell acute lymphoblastic leukemia (B-ALL), although the reason for this development is not clear. In our research, sponsored by IIT Delhi and the Indian government's Department of Biotechnology and the Wellcome Trust India Alliance, we showed that the long-term Lenalidomide use interfered with the nuclear localization of Ikaros, a protein that acts as a turn on switch for B cell development. Moreover, it led to the arrest of these cells in a stem-cell like state resembling the blasts of B-ALL. Thus, our study uncovered the mechanism for the development of B-ALL. We are in the process of designing improved lenalidomide derivatives that do not cause such a stem-cell like state.



Prof. Anita Roy
Kusuma School of Biological Sciences

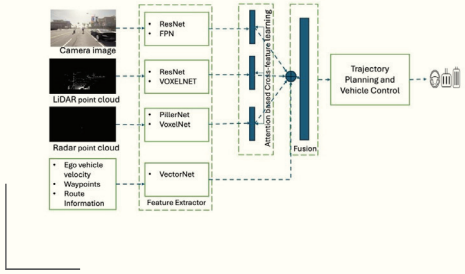
Dr. Divya Tiwari
Grants Adviser, India Alliance

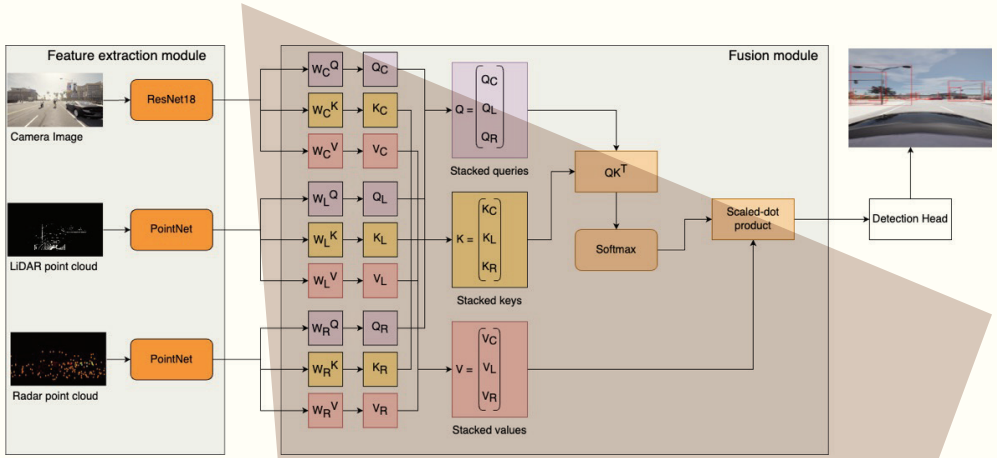
Multi-Modal Sensor Fusion for Autonomous Driving

Multi-modal sensor fusion strategies for an end-to-end driving model to maneuver an autonomous vehicle in dense and complex traffic scenarios

Semiconductor Research Corporation

Various sensors like radar, lidar, and camera can help derive the necessary perception capabilities for end-to-end driving of autonomous vehicles. While these sensors have their strengths and shortcomings, a single sensor framework is unlikely to cater sufficiently to the needs of autonomous vehicle control systems and could restrict the implementation of autonomous driving technology. We are developing, testing, and implementing perception tasks such as object detection, tracking, route planning, and control decisions for autonomous driving individually, as sub-problems of a driving model. The outcome of a sub-problem impacts the execution of the next sub-problem in the processing chain, which may lead to accumulating errors. The primary objective of this research is to develop multi-modal sensor fusion strategies to enhance the perception capability of an autonomous vehicle (AV) and develop an end-to-end driving model for maneuvering an AV (point-to-point navigation) in dense and complex traffic scenarios. To address this, we developed a multi-modal attention-based network (MMA-Net) to fuse data from the camera, lidar, and radar sensors.





Prof. Seshan Srirangarajan
Department of Electrical Engineering

Dr. Marcus Pan
Research Program Director,
Semiconductor Research Corporation

Bolstering the India-UAE Partnership in Scientific Research

IIT Delhi – Abu Dhabi: An international campus building a strong research and innovation ecosystem in the Middle East

IIT Delhi - Abu Dhabi (IITD-AD), the international campus of IIT Delhi, aims to establish itself as a premier research institution in the Middle East, with a strong focus on science and technology. To achieve this vision, IITD-AD is building a comprehensive research and innovation ecosystem that covers the spectrum from basic and applied research to commercialization. This ecosystem is closely aligned with the institution's mission of advancing technology and innovation, while addressing both global and local challenges in the UAE and the wider region.

The research and innovation strategy at IITD-AD is designed to contribute to key international frameworks, such as the United Nations Sustainable Development Goals (SDGs), while also aligning with local strategic priorities, including the UAE's National Innovation Strategy (NISA) and the "Next 50 Years" plan. Developed through consultations with faculty, industry leaders, and relevant stakeholders, the strategy outlines clear research directions, defines key focus areas, sets measurable objectives, and establishes timelines for implementation. IITD-AD is leveraging its expertise and the strength of its faculty to focus its efforts on the following key research areas:

- Sustainable and Clean Energy, Energy Planning, and Technologies for Energy Transition
- Technologies for tackling Environment, Water Resources, and Climate Change-related issues
- The Future of Carbon Resources
- Computational Sciences for engineering applications: Data Science, Artificial Intelligence, Computational Fluid and Solid Mechanics, Computational Chemistry, Materials Modeling, Optimization and Scheduling, Bioinformatics
- Technologies for Healthcare, including Digital Health
- Advanced Materials Research

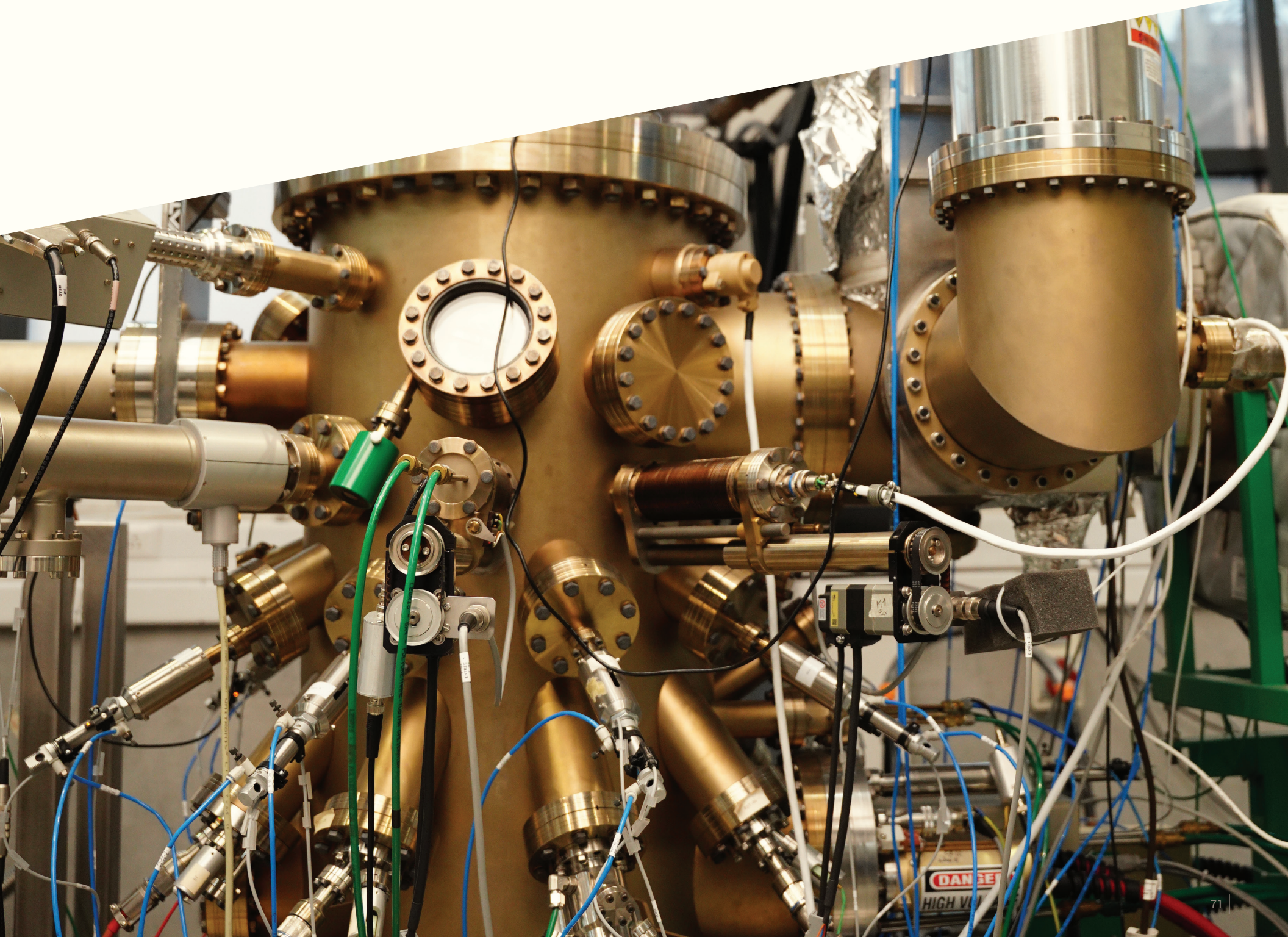
Faculty from IIT Delhi are actively engaged at the IITD-AD campus, participating in research discussions, workshops, training programs, and collaborative projects. IITD-AD is committed to providing world-class research training to doctoral students and industry professionals, fostering an ecosystem for high-impact research and innovation.

Prof. Mohammad Ali Haider
Vice Provost for Research and External Engagement
Indian Institute of Technology (IIT) Delhi - Abu Dhabi


formlabs
formlabs
Account
Log in for remote printers and groups
Printer
ValiantQuagga
Job Settings
Print Validation
Model List (1)
Job Uploaded Successfully
Upload to Queue

IMPACTFUL RESEARCH

Snapshots of the pathbreaking research that underpins IIT Delhi's contributions to cutting-edge science, technology development, and solutions to societal problems.

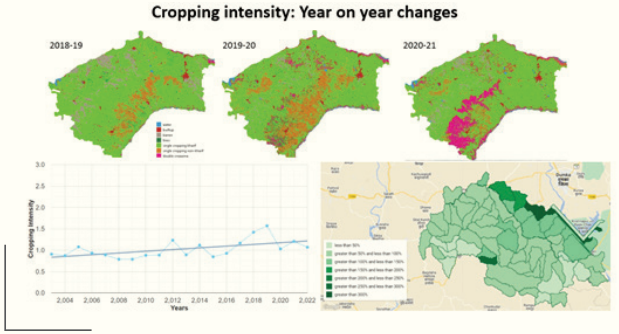

DANGER

Empowering Rural Communities to Build Climate Resilience

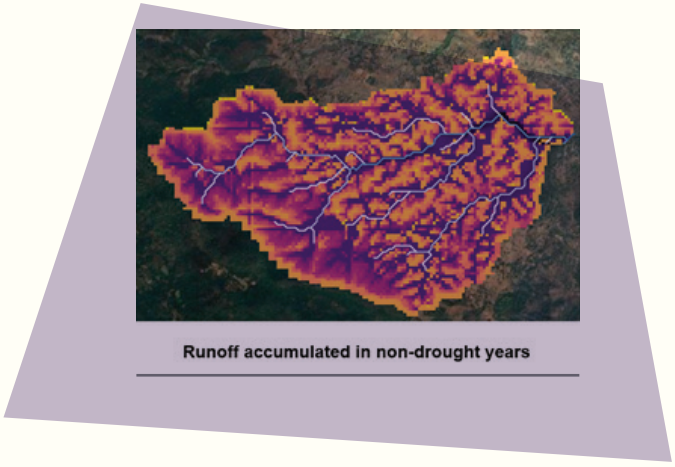
CoRE Stack: A collaborative effort to build a digital public infrastructure for climate change adaptation

The Commoning for Resilience and Equality (CoRE) Stack is a digital public infrastructure consisting of datasets, pre-computed landscape-level indicators, and tools that rural communities and other stakeholders can use to improve their local landscapes' sustainability and resilience. It enables innovators to build upon and contribute their datasets, use APIs for third-party apps, and track and monitor socio-ecological sustainability through a systems approach. The CoRE stack broadly comprises four layers. First, using ML on satellite imagery we produce novel geospatial layers on changes in cropping intensity, water table levels, health of waterbodies, forests and plantations, and welfare fund allocation, among others, over the years. Second, these layers help generate rich analytics on diverse socio-ecological indicators. Third, tools that use the underlying datasets and analytics enable communities to build a shared understanding of their landscape, align on informed actions to improve its resilience and sustainability, monitor its progress, and report insights. Fourth, these tools have relevant plugs to integrate their outputs, including community demands, for public and private funding mechanisms that can support community stewardship of landscapes.

Our goal is to leverage the CoRE stack to accelerate bottom-up action by rural communities in building climate resilience, guiding government departments to develop evidence-based policy, and channeling climate finance for sustainable landscapes.



- **Number of geospatial layers: 20**
- **Number of civil society organizations using the datasets and tools: 10**
- **"As a Village Resource Person (VRP) in our rural community, explaining the complexities of groundwater stress, changes in land-use pattern, and their impact, used to be a challenge. With CoRE Stack, I now have comprehensive data insights at my fingertips through intuitive tools and interactive maps."**



Prof. Aaditeshwar Seth
Department of Computer Science and Engineering; School of Information Technology

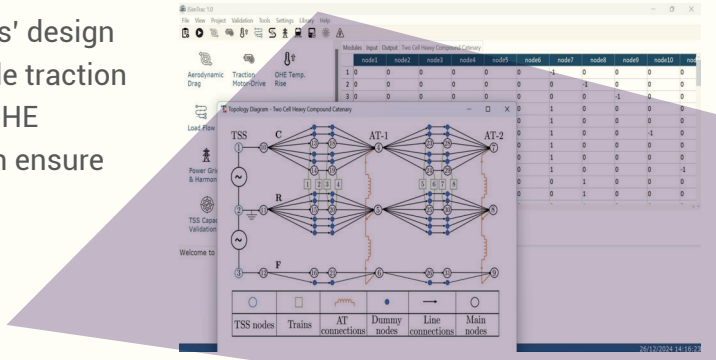
iSimTrac: Power Supply Simulation Package for a Bullet Train

A steady-state simulation software (iSimTrac) for robust design validation and informed operational decision-making in traction power supply systems

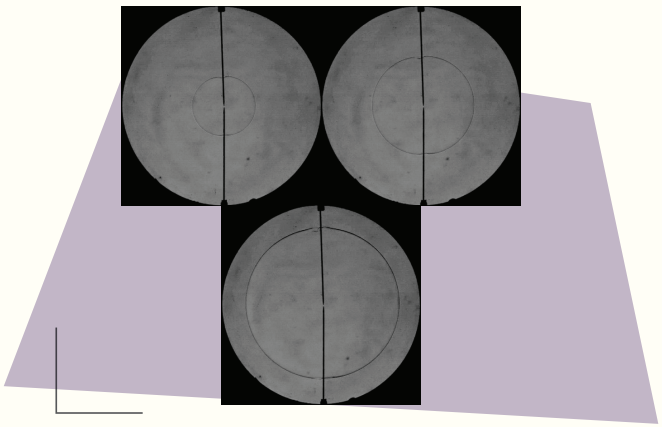
- **The first open-source Indian simulation software for designing and validating high-speed traction power supply systems**
- **Modular, robust, easy to scale, and user-friendly design**
- **iSimTrac has won several prestigious awards in the power systems domain (PPSA/GIPSA), showcasing its innovation and impact.**

Simulation studies for traction power systems in India, including Metro and high-speed railways, are often outsourced, leading to high costs and reliance on foreign software. Through iSimTrac, we address these challenges by offering an indigenous, cost-effective, and efficient solution for self-reliant simulations, reducing dependency, and enabling streamlined design and validation of traction power supply systems.

Designed for high-speed railway operations, iSimTrac features ten interconnected modules for comprehensive system analysis. At its core, the software performs load flow and short-circuit analyses, which form the foundation for electric traction power supply systems' design validation. Supporting modules include traction motor-drive, aerodynamic drag, and OHE temperature rise functionalities, which ensure accurate simulation of system conditions. Further, iSimTrac's capabilities encompass advanced analyses such as harmonics, contingency planning, induced voltage, rail potential, train operation, and TSS capacity validation. Dedicated modules for these functions are seamlessly integrated into the software. Validated against the EN50641:2020 standard for railway applications, the Python-based software ensures precise and efficient performance analysis, making iSimTrac a versatile and reliable tool for traction power supply system design validation and operational planning.



Prof. Abhijit R. Abhyankar, Prof. N. Senroy, and Prof. Anandarup Das
Department of Electrical Engineering



A Study of the Combustion Characteristics of Multi-Component Alternative Fuels

Analyzing today's fuels for the future

- **We obtained the combustion properties of various multi-component gaseous fuels using different experimental setups. We also determined the laminar burning velocity values computationally and compared them with the experimentally obtained values. This data is useful in validating and tuning the chemical mechanisms of combustion reactions.**

Previous researchers have mostly focused on single-component fuels for applications in engines, gas turbines, and combustors of various kinds. However, fuels like syngas, obtained from the gasification of coal, contain multiple combustible components like hydrogen and carbon monoxide. Nowadays, hydrogen is added to natural gas to enhance its combustion properties. In our experimental setups, developed by the Combustion Laboratory of the Department of Mechanical Engineering, we determined the combustion properties of such complex fuels for a range of mixture conditions. One such property we obtained is the laminar burning velocity, which is related to the burning rate of the mixture. We centrally ignited a combustible mixture in a rigid vessel and photographed the spherically expanding flame using a high-speed camera. On processing the resultant images, we arrived at the radius of the flame as a function of time, using which we computed the laminar burning velocity. We also used a heat flux burner, which produces a flat flame, to determine this laminar burning velocity.

Prof. Anjan Ray and Prof. M R Ravi
Department of Mechanical Engineering

Designing Novel Glasses Using Artificial Intelligence and Machine Learning

Advancing the discovery of materials through data-driven modeling, simulations, and high-throughput experiments

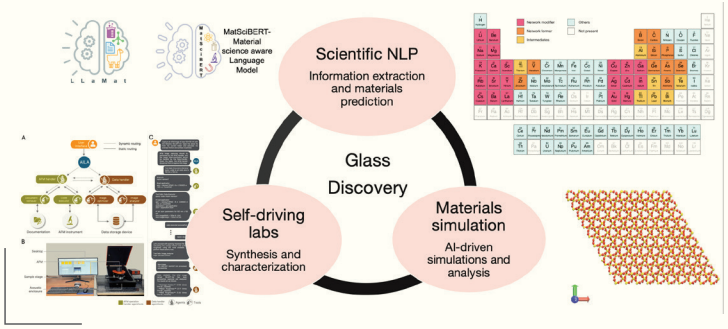
- **Enabled technology transfer transfer of a software package named Python for Glass Genomics, (PyGGi) to enable AI-driven glass design.**

Glass is everywhere in our modern world - from the screen on which you are reading this to the windows in your home; from the fiber optic cables that underpin the Internet to the containers in which you store your medicines. Despite glass's ubiquitous presence and critical importance, colleagues have before spent countless frustrating hours and resources in the lab mixing different ingredients to create new types of glass through trial and error.

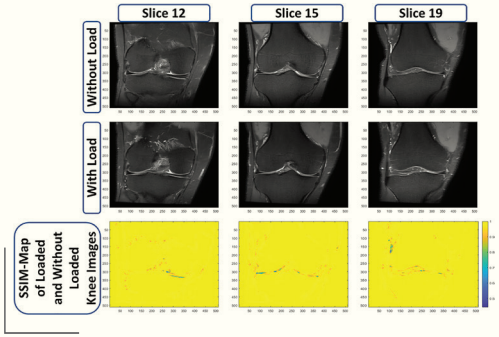
To circumvent this traditional approach, our team developed an AI system designed to be a master glass recipe book, learning from thousands of previous experiments documented in scientific literature. Our digital brain can suggest the precise ingredient combinations required to create glass with specific properties such as extra strength, heat-resistance, or crystal-clear transparency.

Our system first automatically reads through existing scientific papers to gather information about different glass compositions. Then, it uses this knowledge to design new glass formulas for specific uses. Finally, we test these AI-suggested formulas in our laboratory to confirm that they work as intended.

Notably, we have already successfully created new types of glass tailored for storing medicines, spacecraft components, and safely containing nuclear waste. To help advance this field further, we have made our technology freely available through our software package Python for Glass Genomics, (PyGGi), to allow other researchers to develop specialized glass for their own needs. This open approach means our innovation can benefit the entire scientific community and accelerate glass development across multiple industries.



Prof. N. M. Anoop Krishnan
Department of Civil Engineering, Yardi School of Artificial Intelligence

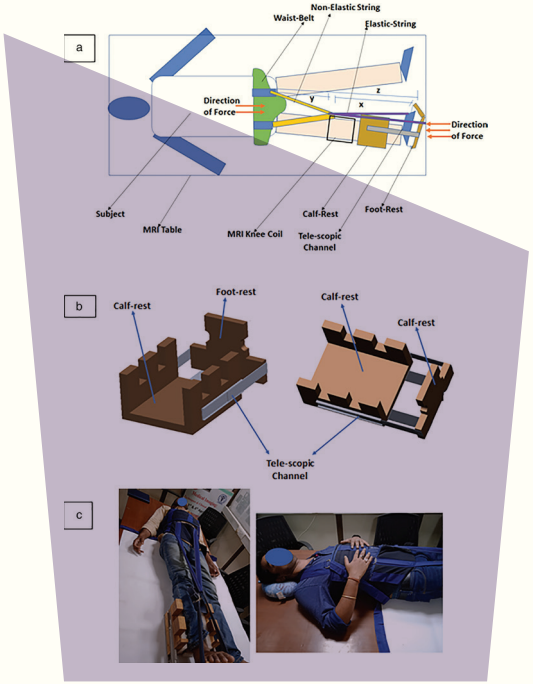


Device for Assessing Knee Joint Dynamics During MR Imaging

The proposed device is conditional-MR-safe, low-cost, portable, and effective in loading the knee joint with up to 50% of body weight

Conducting knee assessments with and without load using magnetic resonance imaging (MRI) can provide information on knee joint dynamics and improve the diagnosis of knee joint diseases. Performing such studies on a routine MRI scanner requires deploying a load-exerting device during the scanning. In this study, we have designed and developed a portable and easy-to-use axial loading device to evaluate knee joint dynamics during the to an MRI scan. The novel loading mechanism of the device reduces the potential of motion artifacts and facilitates studies related to osteoarthritis, sports, and other knee joint-related research.

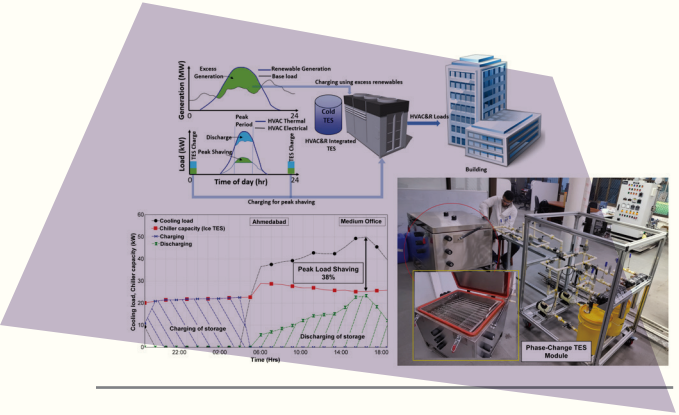
Subjects can tolerate the device's applied load for up to 15 minutes with minimum unease and up to 25 minutes with moderate unease. We tested the device on 1.5T and 3T MRI scanners and found that it does not introduce any artifacts that impact clinical evaluation. Radiologists have qualitatively assessed the quality of MRI images with and without the loading device. We also assessed the images quantitatively using a structural similarity index metric. We observed significant changes in the bone gap and cartilage thickness in the knee joint images of healthy volunteers with and without the loading device.



- **The developed knee joint loading device can be used for inducing 50% of body weight load, mimicking the load when standing, on conventional MRI scanners.**

Prof. Anup Singh
Centre for Biomedical Engineering

Prof. Amit Mehndiratta
Centre for Biomedical Engineering

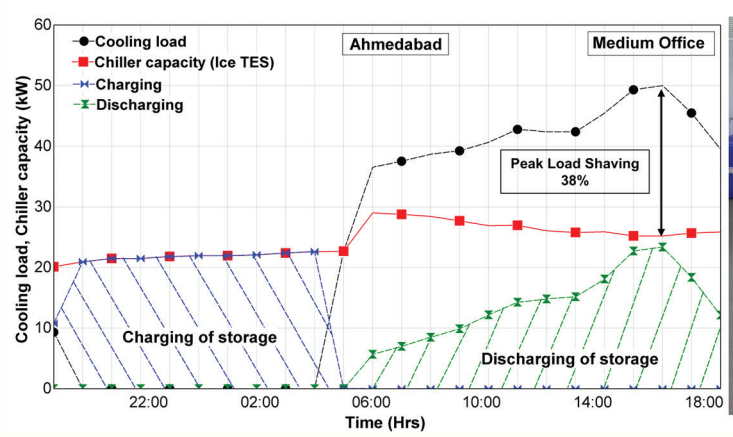


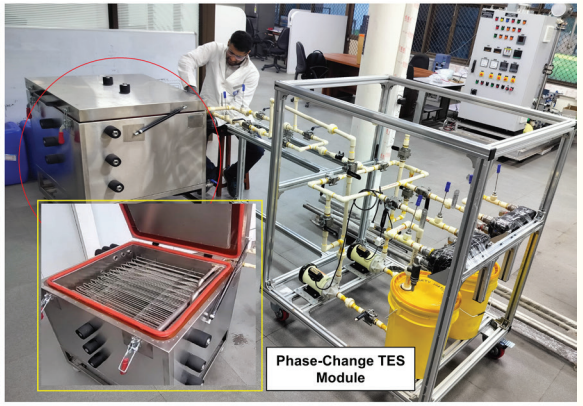
Thermal Energy Storage Technologies for Buildings

Thermal energy storage, like batteries, enables efficient cooling and heating solutions for diverse applications while maximizing the utilization of renewable energy

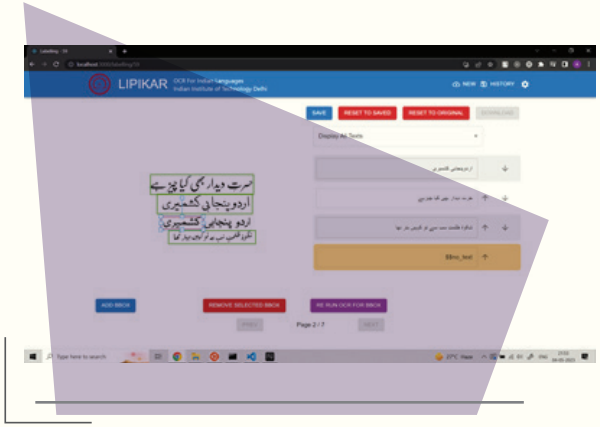
- **Developed optimized phase-change thermal energy storage modules integrated with commercial building HVAC systems to reduce peak load by 25% - 40%**
- **Heat pumps with TES in cold climates can reduce peak load by ~25% and improve energy efficiency by ~10%.**
- **The levelized cost of storage (LCOS) for TES is significantly lower than that of battery systems.**

Effective energy storage methods are crucial for continuous clean energy supply considering the inherent intermittency of renewable power sources. Thermal energy is ubiquitous, and heating and cooling account for a significant fraction of the total energy consumed in our economy. We routinely see news about the record-breaking peak electric load in summer months mainly driven by the large demand for air-conditioning. In our research, we have shown the potential of thermal energy storage (TES) in reducing such peak electric loads in buildings. We used phase-change materials (paraffin waxes and salt hydrates) with optimized heat exchanger designs to develop high-energy density storage modules that are easily retrofittable into the existing central cooling systems in commercial buildings. We demonstrate a peak load-shaving potential of 25% - 40%, which lowers the cost of operation and improves the operational efficiency, in addition to improving grid resiliency. Our TES designs are modular and easily scalable and can be used for heating too, enabling the electrification of building heating and reducing the carbon footprint of HVAC systems.





Prof. Anurag Goyal
Department of Mechanical Engineering



Optical Character and Hand-Written Text Recognition for Indian Languages

The development of a reliable OCR system is key to developing digital scholarship in the humanities involving Indian languages and for heritage preservation

- **The development of an Urdu OCR system paves the way for further research into Indian language OCR solutions. Our LIPIKAR platform would make OCR solutions accessible to both humanities scholars and wider audiences.**

We have developed a novel Urdu Optical Character Recognition (OCR) technology based on modern deep neural network techniques. The proposed model has established a new state-of-the-art system for Urdu printed text OCR. We have also curated a new Urdu printed text dataset and released it publicly for the wider research community.

We have also developed a web application named LIPIKAR to apply the OCR system. Along with providing the OCR output for a given page, LIPIKAR also allows users to fix any errors in it. After any manual correction of the automated OCR results, one can download the results in '.pdf', '.json', or '.txt' formats. LIPIKAR's history page also allows the user to keep a record of previously uploaded files.

Prof. Arjun Ghosh
Department of Humanities and Social Sciences

Prof. Chetan Arora
Department of Computer Science and Engineering

Fiber-Based Quantum Secure Communication

Quantum cyber security is the need of the hour to secure data exchange

With the development of quantum computers, existing security solutions are at risk of hacking and data breaches. Provable security technologies are urgently needed, and the principles of quantum physics, viz. quantum secure communication can help us develop these. Quantum Key Distribution (QKD) is one such method, which relies on a key exchange using quantum principles. Our project aims to develop QKD technology using optical fibers for securing key exchange. We demonstrated the first 100 km intercity fiber QKD between Prayagraj and Vindhyachal in 2022, which was extended to 380 km (fiber) in 2023. This long-distance exchange does not require any trusted relay in between, making it safer for deployment. More recently, in 2024, we demonstrated a quantum entanglement-based QKD for 50 km using an optical fiber deployed within the IIT Delhi campus. Leveraging quantum entanglement offers an extra layer of security and the quantum key can be set up even when the source is held by an adversary. This method is thus one of the safest forms of QKD for strategic applications, unhackable even by quantum computers. Quantum security is of paramount importance for digital transactions, securing telecom, banking, strategic, and diplomatic information exchanges. Our technology demonstrations were covered by the media in the respective years.

- **First intercity 100 km fiber quantum communication between Prayagraj and Vindhyachal in 2022**
- **Trusted, node-free fiber quantum communication extended to 380 km in 2023**
- **Quantum entanglement-based unhackable quantum key distribution over 50 km in 2024**
- **Coexistence of entanglement-based QKD with live internet traffic in same fiber at telecom C band for 50 km in 2025**

Prof. Bhaskar Kanseri
Department of Physics and Optics and Photonics Centre

A Clean and Green Cooking Device

A forced-draft pellet stove as a clean, efficient, and sustainable cooking solution for healthier homes

We developed a forced-draft pellet domestic cookstove that is a cleaner, more efficient alternative to traditional biomass cookstoves. This innovative cookstove addresses two critical issues: low thermal efficiency and harmful emissions. With a thermal efficiency of 48% (four times higher than traditional stoves) and CO emissions of just 2 g/kg-fuel and PM2.5 levels of 119 mg/kg-fuel, it performs on par with LPG stoves in terms of emissions while offering a more affordable and sustainable cooking solution.

The stove uses 6 mm biomass pellets as fuel, a renewable energy source that reduces dependency on firewood and other polluting fuels. Its forced-draft mechanism ensures complete combustion, minimizing smoke and harmful pollutants. This characteristic makes it ideal for households where indoor air pollution from cooking is a significant health concern.

By combining efficiency, cleaner emissions, and affordability, this cookstove provides a practical solution for clean cooking, improving the quality of life for families, especially in rural areas. Our innovation bridges the gap between traditional cooking methods and modern clean energy solutions, contributing to better health, reduced fuel costs, and environmental sustainability.

- **Efficiency Boost: Achieves 50.4% thermal efficiency, significantly higher than traditional cookstoves (12%) and comparable to LPG stove (60%) as per BIS & ISO standards.**
- **Ultra-Low Emissions: CO: 2 g/kg-fuel, PM2.5: 119 mg/kg-fuel, matching LPG standards for cleaner air.**
- **Impact: Reduces indoor air pollution and fuel costs, and promotes sustainable cooking by using biomass pellets mostly made of agro-waste.**

Prof. S.K. Tyagi
Department of Energy Science and Engineering

Crash Analysis, Vehicle Crashworthiness, and Injury Biomechanics

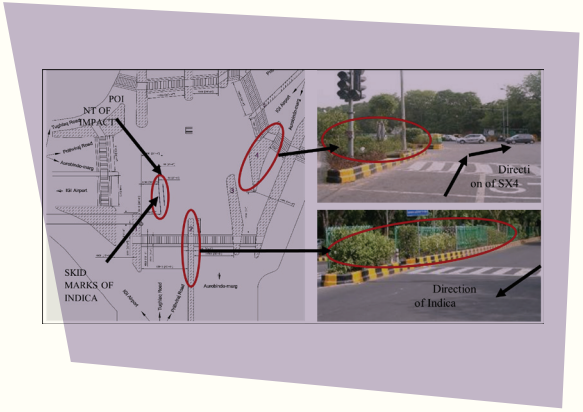
TRIPC has been working to reduce crash-related injuries and fatalities in the country by conducting crash data collection, crash analysis, vehicle structural analysis, and injury estimation through biomechanical analysis

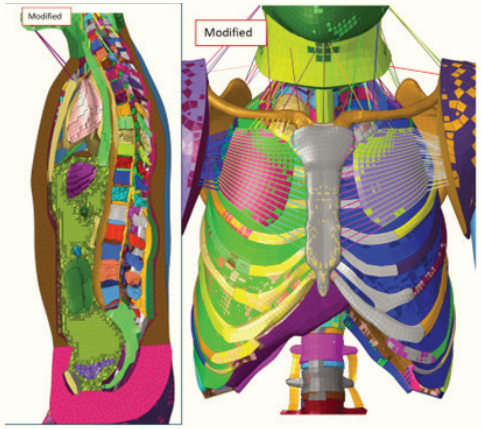
- **Engaging with MoRTH in the CMVR-TSC and the Bharat NCAP 2.0 committee.**
- **Development of the first ever Human Body Finite Element Model for the 50 percentile Indian population for use in crash research**

TRIPC recognized early on that the nature of crashes, and injury modes are different in India as compared to OECD countries. The large proportion of fatalities in pedestrian and two-wheeler riders has driven our innovations in methods for crash reconstruction relevant to the Indian context. We have partnered with a consortium, Sweden-India Transport, Innovation, and Safety Partnership, focussed on road traffic and safety studies. The roadmap for in-depth crash data collection and crash safety research prepared jointly with them is with the Ministry of Road Transport and Highways (MoRTH) and may lead to setting up the first Center of Excellence (COE) in India for crash analysis and research.

We focus on data-driven interventions, often using advanced simulation tools, including human body models. Our long-running collaboration with AIIMS led to the development of the first ever Human Body Finite Element model for the 50 percentile Indian population. This included dynamic testing and characterization of human tissues for their impact response. We have supported SIAM, among others, in evaluating the effect of proposed regulations involving new technologies in road safety. Some noteworthy contributions have been the safety evaluation of oversized vehicles on Indian roads, a safety evaluation of vehicle carrier tractor-trailer combinations, and the ongoing evaluation of Acoustic Vehicle Alerting Systems for pedestrian safety from EV two-wheelers.

We actively engage with national efforts for safer transport including MoRTH standing committees like the Central Motor Vehicle Rules-Technical Standing Committees (CMVR-TSC) and the Bharat New Car Assessment Program (Bharat NCAP) 2.0 committee.

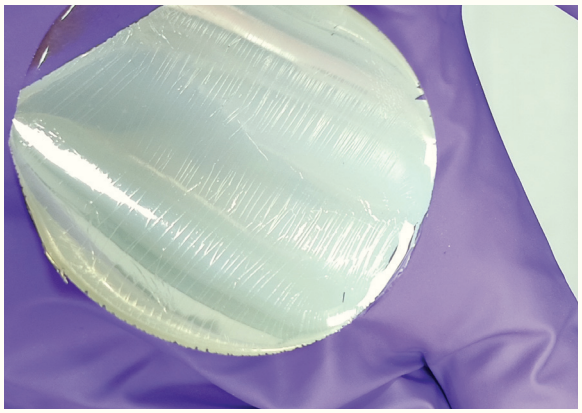




Late Prof. Dinesh Mohan, Prof. Anoop Chawla, Prof. Sudipto Mukherjee, and Prof. Kaushik Mukherjee
Transportation Research and Injury Prevention Centre

A Portable ECG Device with Flexible Silvernanorods PDMS Electrode

A smartphone-based rapid, portable Electrocardiogram (ECG) monitoring device using flexible gel-less antibacterial Ag nanorods PDMS electrode



Cardiovascular diseases (CVDs) are a leading global health concern, affecting more than half a billion people worldwide. According to the World Health Organization (2023), CVDs accounted for approximately 20.5 million deaths in 2021. The development of portable ECG devices with high-quality electrodes is crucial for early detection and timely intervention, especially in remote areas where access to medical facilities is limited.

We have developed a portable ECG device integrated with flexible dry silver nanorod (AgNRs) electrodes embedded in a polydimethylsiloxane (PDMS) matrix for long-term ECG monitoring. The silver nanorods offer antibacterial properties and a high surface area, ensuring superior ECG signal quality and lower skin-to-electrode interface impedance. Unlike traditional gel-based electrodes, these gel-free electrodes are reusable and ideal for long- term monitoring.

The AgNRs-PDMS electrodes, combined with the portable ECG monitoring device, enable real-time ECG signal acquisition and display via a mobile application. The recorded data can be transmitted over Wi-Fi to medical practitioners for prompt analysis and medical advice, making it a valuable tool for efficient and accessible cardiovascular health management.

- **The developed AgNR-PDMS electrodes have been clinically tested on CVD patients at AIIMS Rishikesh.**
- **The AgNR-PDMS electrodes successfully captured all ECG morphologies associated with specific heart conditions, demonstrating comparable accuracy to traditionally used ECG electrodes.**

Prof. J. P. Singh
Department of Physics

Technology Development for a Flex-fuel Automotive Vehicle with DME-Diesel

Researchers at IIT Delhi, IOCL R&D, and Ashok Leyland developed a Flex-fuel Vehicle technology to run either on 100% diesel or DME-Diesel

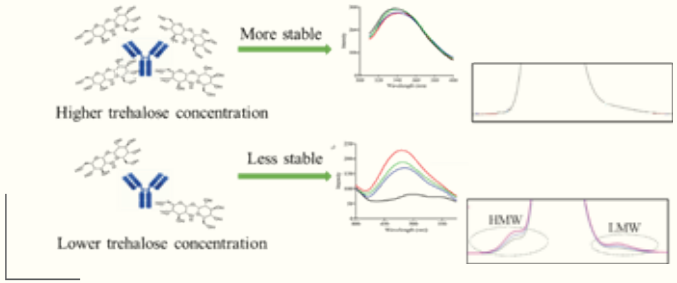
IIT Delhi developed the flex-fuel engine technology for using Dimethyl Ether (DME), while IndianOil Corporation Ltd.'s Research and Development Center (IOCL R&D) undertook the endurance and field trials tests and developed the dedicated engine oil with technical support from Ashok Leyland. The Department of Science and Technology, Government of India, funded this project.

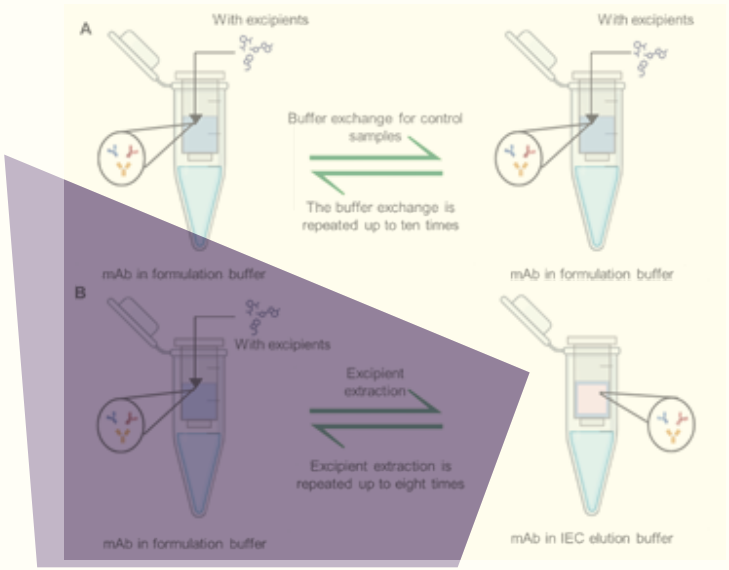
DME is one of the alternative fuels for compression ignition engines and vehicles as it has a higher cetane number (~58) compared to conventional diesel (51). DME is produced from Biomass, Coal, Industrial Wastes, Municipal Solid wastes, and Black liquor (a by-product of pulp) through gasification and the Fisher-Tropsch synthesis process. We can also produce it via the catalytic dehydration of methanol. DME is generally stored in the liquid state and the phase change from liquid to vapor or gas can easily occur at ambient temperature and pressure.

As a fuel, DME is injected into the intake manifold of the engine, but diesel is directly injected into the engine cylinder. The Common Rail Direct Injection (CRDI) system controls the load in both diesel and DME fuel injections. The engine or vehicle operates with the optimum DME energy share without a knock.

Prof. K. A. Subramanian
Department of Energy Science and Engineering

- **When using Flex-fuel Vehicle Technology, the vehicle can run on both modes, viz. either using 100% diesel or DME-Diesel.**
- **It requires transitioning diesel trucks from conventional diesel to leveraging DME as an alternative fuel.**
- **It emits negligible smoke, soot, and Particulate Matter (PM) emissions.**
- **It promotes a sustainable environment through substantially reducing emission of Greenhouse Gases.**





Biotherapeutic Drug Product Comparability Assessment in Formulations

A platform for reliably characterizing and evaluating the comparability of biosimilar drug products in lyophilized and liquid formulations

The stability of protein biotherapeutics and their biosimilars is highly influenced by the formulation's excipients and drug product design. Demonstrating the analytical and functional similarity of a biosimilar product to the respective innovator products is the foundation for a biosimilar manufacturer's regulatory filing. A key challenge when performing these activities is that the excipients and species in the formulation interfere with the typical set of analytical and functional tools that are otherwise routinely used for characterizing the comparability of drug substances. Through this project, we offer an analytical platform that allows us to reliably characterize and evaluate the comparability of biosimilar drug products in both lyophilized and liquid formulations. Our approach involved unraveling the impact of excipients on the typically used analytical and functional methods. For methods where the interference was significant, we created alternative methods that do not suffer such interference. We expect the findings of this project to be of significant value to regulators as well as to the Indian biopharmaceutical industry.

- **Repeated buffer exchange and isolation of excipients impacted the charge heterogeneity and tertiary structure of innovator and biosimilar drug products.**
- **A higher concentration of trehalose excipient improves the stability of innovator and biosimilar drug products under forced stress conditions.**
- **Identified methods where we observed significant interference from excipients and proposed alternative tools.**

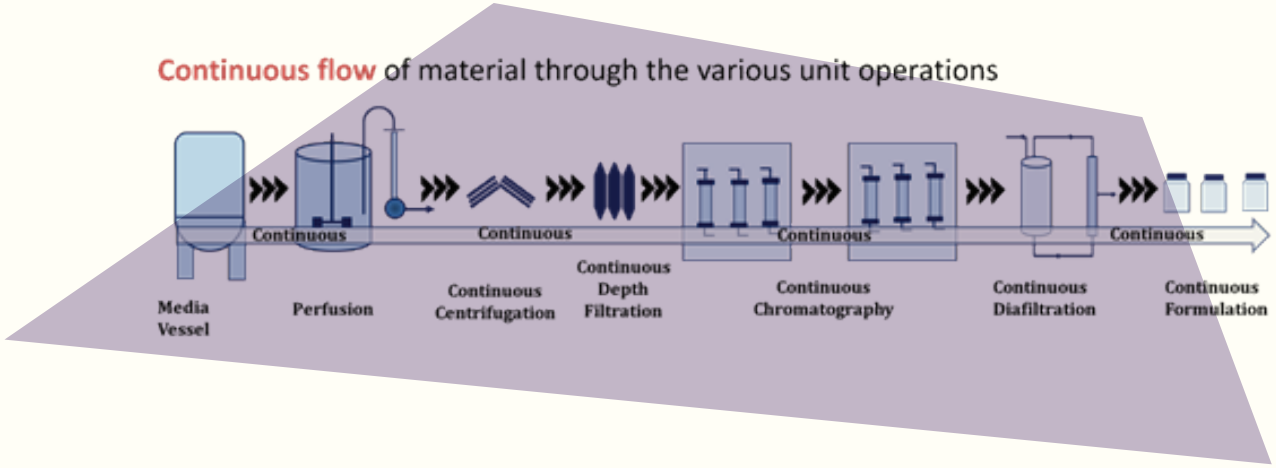
Prof. Anurag S. Rathore
Department of Chemical Engineering

- **Developed end-to-end continuous training for the purification of mammalian as well as microbially derived products.**
- **Demonstrated platforms for 4 commercial products viz. GCSF, Lucentis, Trastuzumab, and Itolizumab.**
- **Realized a reduction in manufacturing cost of up to 75%, along with a productivity increase of up to 10X.**

Continuous Processing for the Economical Production of Biotherapeutics

Establishing enablers and process control tools that facilitate continuous manufacturing of biopharmaceutical products

Biotherapeutics represent a significant breakthrough in medical history, harnessing the body's inbuilt defense mechanism to treat infections and diseases like cancer. Their targeted actions offer hope to patients worldwide, particularly in high-income countries. Personalized medical approaches have revolutionized treatment strategies, leading to improved patient outcomes and societal well-being. However, despite their effectiveness, their affordability is a challenge, especially in low- and middle- income countries. We established India's first and only state-of-the-art continuous processing facility and have successfully produced several biotherapeutics with an estimated 50% - 75% reduction in the cost of manufacturing. Accomplishing this endeavor required creating an amalgam of expertise in widely disparate areas such as process development, analytical characterization, data analytics, process modeling, and artificial intelligence approaches like machine learning. We demonstrated, at our facility at IIT Delhi, the creation of integrated process platforms and real-time monitoring of product quality, dealing with any deviations effectively to prevent any process disruptions. We are now transferring these technologies to major Indian biopharmaceutical manufacturers such as Biocon and Ipca Laboratories.



Prof. Anurag S. Rathore
Department of Chemical Engineering

Moisture Management Finish for Sports Textiles

Absorbs, wicks, and dries away perspiration to keep sportswear and activewear users comfortable

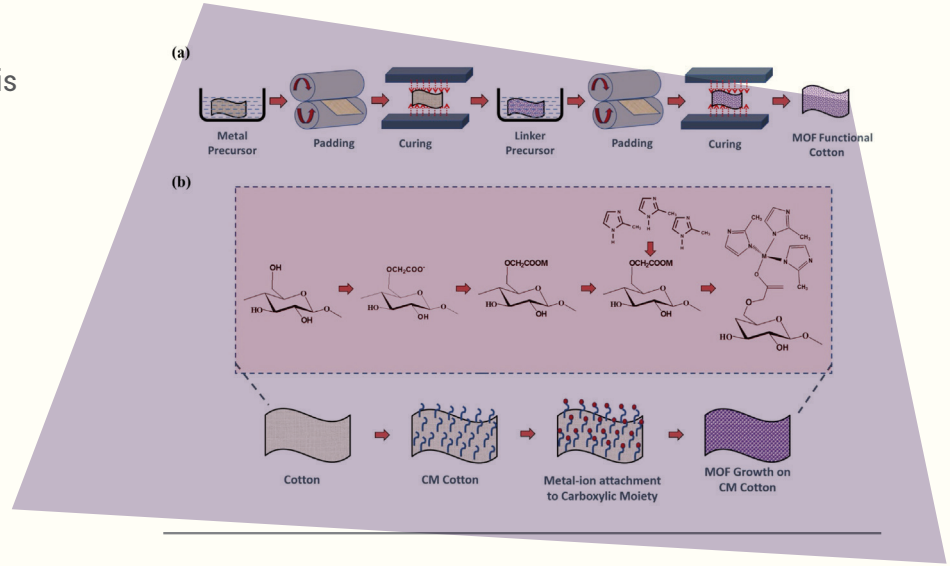
In high-performance sports wear, microdenier polyester knitted fabric is used to wick away the wearer's sweat and keep their body dry. However, the fabrics used currently are not adequately comfortable to wear as they do not readily absorb, wick away, and dry the sweat.

SMITA Research Lab has developed a nanotechnology-based finish for sportswear that can significantly enhance the moisture management properties of their fabric. It not only improves the absorption and wicking (i.e. spreading) of perspiration but also helps dry it faster to keep the sportsperson's body cool and comfortable. This is crucial in maintaining the performance of a sportsperson in the field.

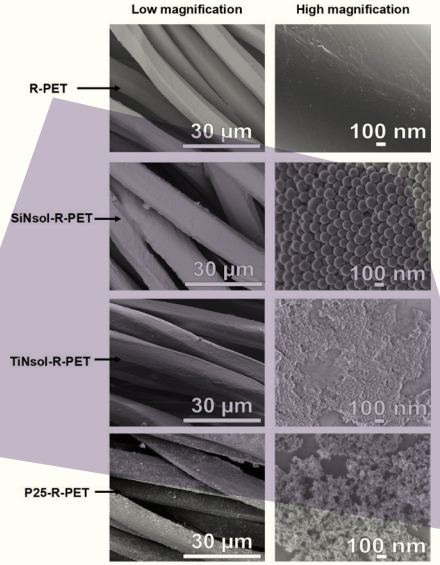
This finish is also durable to multiple washes and exceeds performance parameters compared to any commercial finish available today. The Department of Science and Technology (DST), Government of India, and Resil Chemicals Private Limited, Bengaluru jointly funded this technology's development. We have since successfully transferred the technology to the company.

A sportswear textile finish that

- **Significantly improves moisture management of sports textiles**
- **Removes sweat from the skin and dries it quickly**
- **Is durable to multiple washes**
- **Keeps fabric cool and comfortable during high activity**



Prof. Ashwini K. Agrawal and Prof. Manjeet Jassal
Department of Textile and Fibre Engineering



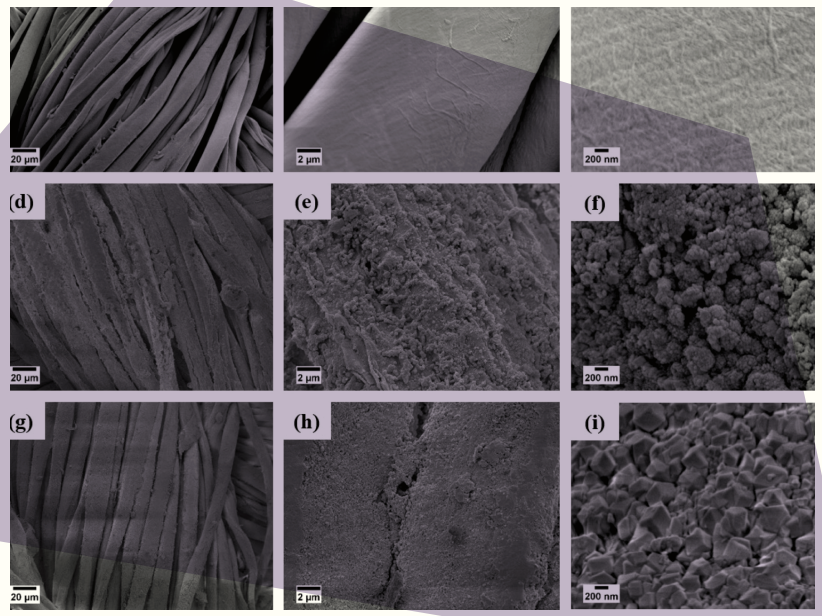
Toxic Gases (Pollutants) Adsorbing Smart Textiles

A textile that removes toxic aromatic gases and bad odors from closed homes and workplaces

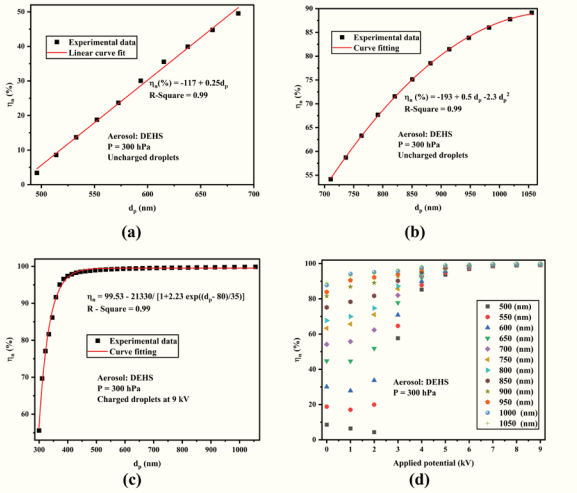
Smart Cotton fabrics, developed using nanotechnology, can readily adsorb various aromatic pollutants present in the environment. These pollutants, which are mostly aromatic compounds, are generated by burning fossil fuels in vehicles and are present in toxic concentrations inside our homes and workplaces. The technology involves modifying fabric surfaces by anchoring metal-organic framework layers, which are highly porous and can capture these gases in high amounts. These smart fabrics can be regenerated for multiple reuses and can be used as curtains or upholstery items to help keep closed spaces free of toxic gaseous pollutants. They can also be used for capturing bad odors like cigarette smoke, body odors, and other smells.

Smart textiles that can…

- **Capture 25 mg of pollutants (toxic gases and/or odors) per gram of fabric**
- **Be regenerated for reuse multiple times**
- **Be used in closed spaces to keep the environment free of pollutant gases or bad odors**



Prof. Ashwini K. Agrawal and Prof. Manjeet Jassal
Department of Textile and Fibre Engineering

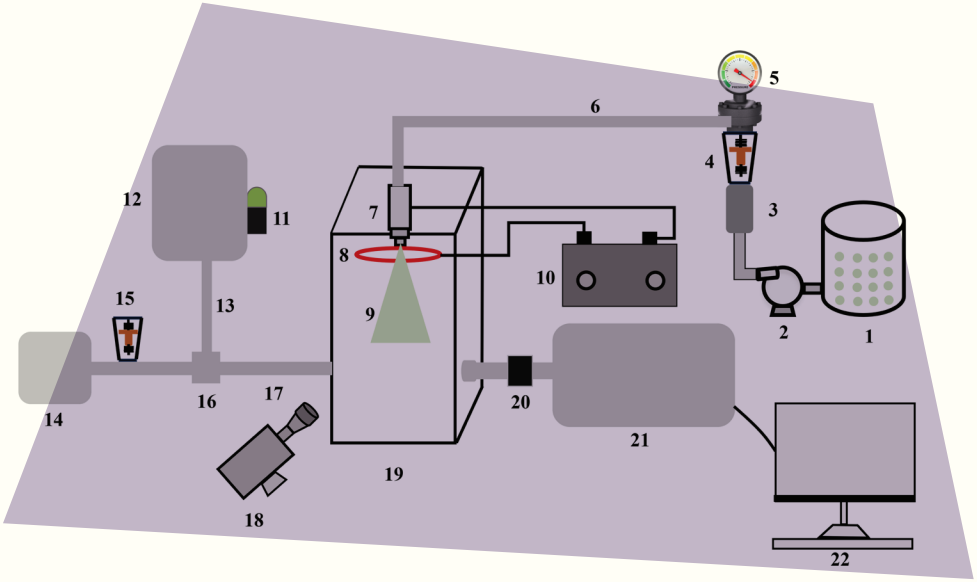


An Electrospray Technology for Air Purification

Understanding how raindrops reduce air pollution: A study of fluid and particle interactions to propose electrosprays

During the extreme pollution in the winter, the air becomes clean immediately after rainfall, through a phenomenon called wet deposition in air. But this cleaning mechanism is not as simple as it sounds. The droplet size, shape, velocity, and pollutant type determine the outcome. Not all particles get captured; some remain stuck to the droplet surface or get rebounded. This process involves inertial impaction, interception, and Brownian diffusion between the particulate matter (PM) and raindrops, as well as the absorption of gaseous pollutants into raindrops. In addition, source suppression also reduces PM concentrations during and after rainfall, which mitigates the suspension and resuspension of pollutants. Researchers have tried to mimic this mechanism by using water sprinklers. In recent times, lab studies have shown that using charged water drops enhances the capturing efficiency of particles.

- **Aerosols are attracted to the charged water drop but their motion depends on drag force, gravity, and electrical force. Attachment to electrospray droplets is due to Coulombic attraction between the oppositely charged electrospray droplets and aerosol particles.**
- **Enhancing particle removal using charged droplets offers a promising solution for improving air quality, cleaning industrial surfaces, and tackling pollution, potentially benefiting industries like manufacturing, healthcare, and environmental protection.**



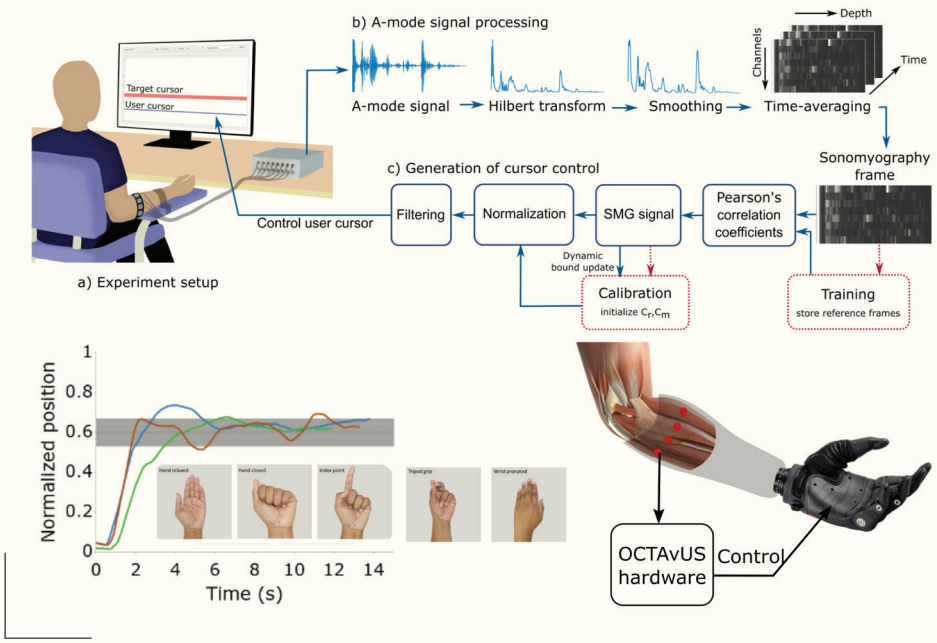
Prof. Bahni Ray, Prof. Debabrata Dasgupta, and Prof. Mayank Kumar
Department of Mechanical Engineering

Multimodal Sensing for the Next Generation of Human-Machine Interfaces

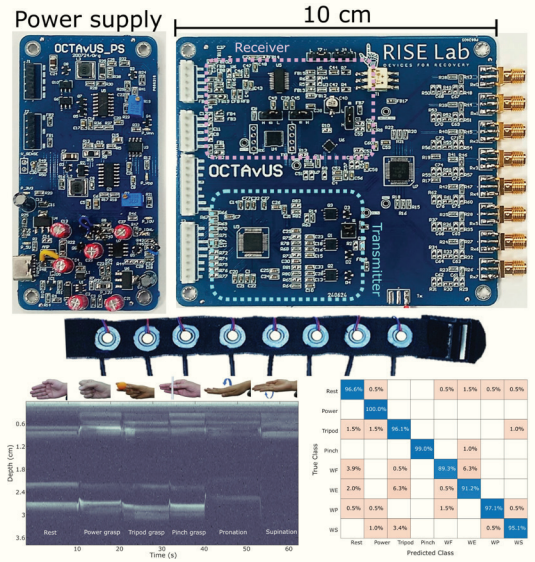
Harnessing the potential of wearable ultrasound imaging coupled with neuroimaging for neuromuscular activity sensing

Sonomyography, an emerging alternative to traditional myoelectric control, uses ultrasound waves to image and measure deep muscle activity. This technique offers high spatial and temporal resolution, enabling real-time differentiation of muscle activity. Despite its potential for intuitive control of bionic devices, challenges remain, such as the large form factor of clinical ultrasound systems. Our work is focused on developing wearable ultrasound systems for human-machine interfaces. We have developed miniaturized and optimized ultrasound transceiver circuits and have demonstrated that they provide effective control across multiple degrees of freedom. Additionally, we are developing low-power Frequency Modulated Continuous Wave (FMCW) ultrasound systems to address power consumption and safety concerns. Integrating sonomyography with soft haptic devices can close the sensorimotor loop in prosthetics, enhancing tactile feedback. These advancements could lead to practical bionic control devices, significantly improving the lives of individuals with neuromuscular disorders.

Prof. Biswarup Mukherjee
Centre for Biomedical Engineering



- **Our work demonstrates that wearable ultrasound systems can provide fine dexterous control of multiple degrees of freedom. We tested the wearable system on individuals with transradial amputation and partial spinal cord injury to demonstrate its practical utility as a human-machine interface.**



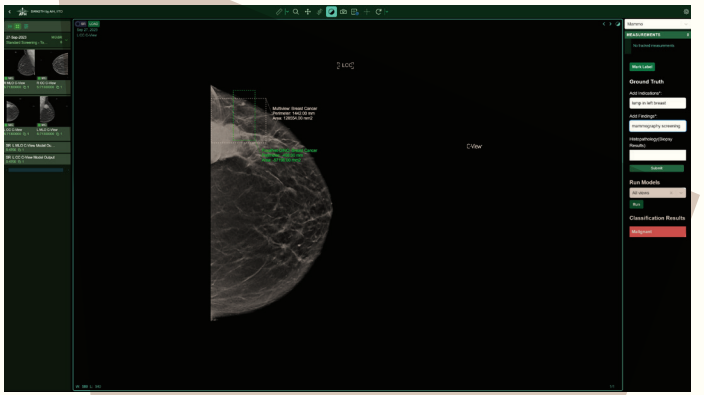
- **A "Made in India" AI technology for robust and explainable cancer detection.**
- **Designed for challenging Indian conditions: cost-effective and capable of functioning without Internet access.**
- **Follows the mantra of Make AI in India and Make AI Work for India.**
- **Developing digital public goods for population-level cancer screening in India.**

Indigenous AI Technology for Population-Level Cancer Screening in India

An AI-based, cost-effective point-of-care device for cancer screening

Current AI-based methods for cancer detection, developed by Western researchers, focus primarily on the Caucasian population. These techniques are expensive and tend to perform poorly in the Indian context, making the service inaccessible to a large portion of the population leaving our community vulnerable. The AI in Healthcare lab led by Prof. Chetan Arora is committed to the mantra of Make AI in India and Make AI Work for India. They have developed an AI-based technology for detecting several types of cancer such as gall bladder cancer and breast cancer, in partnership with experts from the Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh, and All India Institute of Medical Sciences (AIIMS), Delhi. The indigenously developed AI technology not only outperforms existing cancer detection methods but also demonstrates superior performance compared to radiologists in tests conducted at a tertiary care center.

Considering the challenging conditions in India, the developed AI technique is both cost-effective and capable of functioning without Internet access, making advanced diagnostic capabilities available to underserved communities in remote areas.
AI in Healthcare lab is dedicated to developing digital public goods in the healthcare sector for the country, with the goal of making cancer screening accessible at a population level. This initiative will not only save countless lives but also position the country as a leader in advanced AI technology for healthcare.



Prof. Chetan Arora
Department of Computer Science and Engineering
and Yardi School of Artificial Intelligence

A Hearing Screening Device for All Ages

A cutting-edge device for rapid, reliable, and user-friendly auditory screening, designed for all settings

Our Hearing Screening Device (HearIT) is a digital system intended for Auditory Otoacoustic Emission (OAE) to enable rapid and accurate screening cum evaluation of hearing loss. Its operation involves inserting a probe into the external ear canal to measure Distortion Product Otoacoustic Emissions (DPOAE) from the outer hair cells of the inner ear. The results are processed using advanced algorithms via computer software and reported either as “pass” or “refer”. The device is designed for use in acoustically sealed or unsealed settings by professionals with minimal training.

- **Impact: Over 100 successful screenings conducted in different acoustically sealed or unsealed settings, aiding early detection of hearing loss.**
- **Efficiency: Results provided within seconds, requiring minimal operator training.**
- **MD13 Test License: mPragati-IIT Delhi Received MD13 Test License from CDSCO**

Prof. Dinesh Kalyanasundaram
Centre for Biomedical Engineering

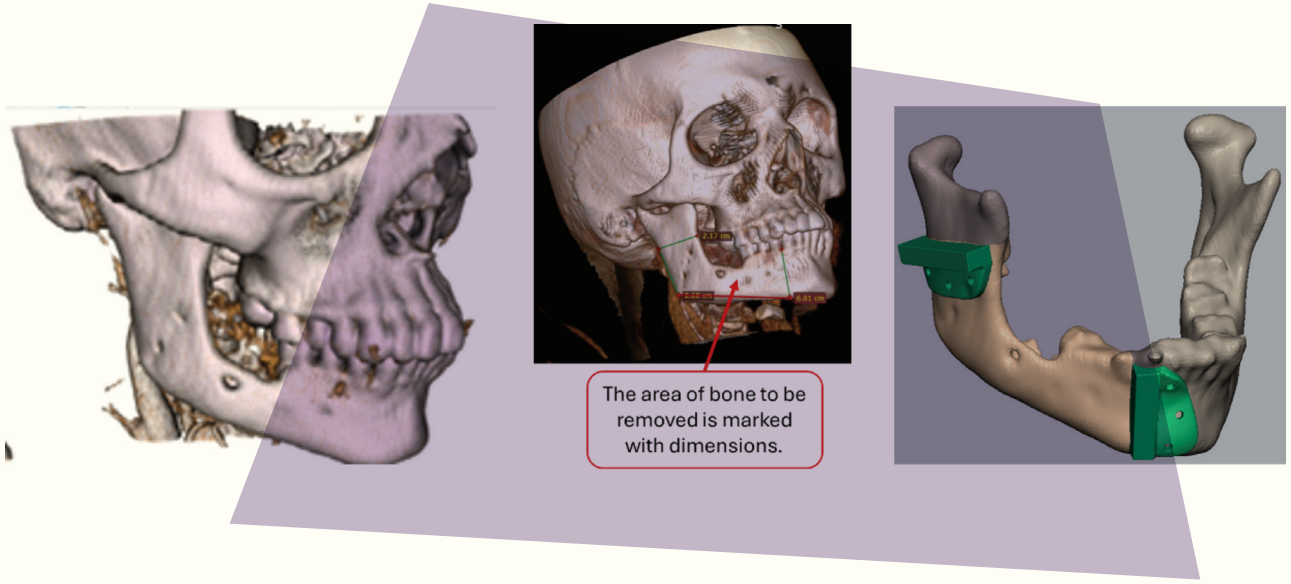
Design and Development of Patient-Specific Surgical Guides

Custom surgical cutting guides for mandibular reconstruction using the fibula in oral cavity squamous cell carcinoma

- **The mandible and fibula guides collectively saved around 60 minutes of total operative time in comparison to traditional surgical techniques.**
- **The guides helped the surgeon to make precise cuts and reconstruct mandible quickly.**

Reconstructing the mandible has been a challenge due to its multiple angles and contours. The need of the hour is reconstructing a functional and aesthetic mandible which provides accurate symmetry, occlusion, masticatory efficiency, and a better quality of life after surgery.

mPRAGATI, IIT Delhi, in collaboration with surgeons from All India Institute of Medical Sciences (AIIMS), Delhi has devised a methodology to design cutting jigs for reconstruction surgery. A patient with squamous cell carcinoma in the right lower alveolus (lower jaw) required right mandibular resection and reconstruction using their left fibula. The team used CT DICOM data to reconstruct the mandible and design jigs, which were 3D printed using biocompatible SLA resin.



Prof. Dinesh Kalyanasundaram and Prof. Amit Chirom
Centre for Biomedical Engineering

FRIGATE: Efficient Spatio-Temporal Modeling Using Graph Neural Nets

A cutting-edge framework - FRIGATE - for traffic forecasting leveraging frugal sensing, inductive modeling, and robust spatio-temporal analytics

FRIGATE is a cutting-edge solution to transform traffic prediction on road networks by minimizing reliance on costly and extensive sensor systems. Traditional traffic prediction models depend on sensors at every intersection, making them expensive and prone to failures. FRIGATE addresses this challenge by utilizing a fraction of the sensors while maintaining high prediction accuracy. Powered by advanced graph neural networks (GNNs) and inductive learning, it captures vehicle movement patterns and evolving road dynamics, ensuring reliable forecasts even with missing data or sensor failures.

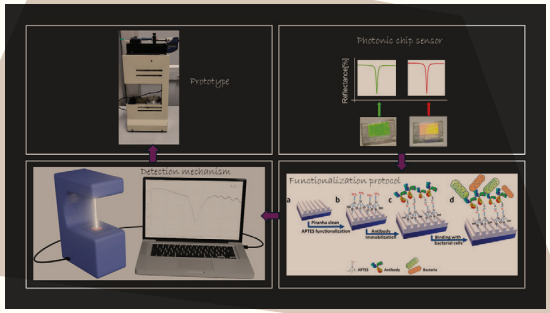
The system adapts seamlessly to changes like road closures or new routes without requiring retraining, making it robust and efficient. FRIGATE also handles irregular data intervals and partial sensing, enabling it to deliver accurate predictions while significantly reducing deployment and maintenance costs.

The result is an innovative and cost-effective traffic management tool that enhances transportation planning, reduces congestion, and improves commuter experiences. FRIGATE is particularly impactful in cities with large, complex road networks, offering a scalable solution to modern urban mobility challenges.

- **Achieved over 25% lower prediction errors compared to leading traffic forecasting models on real-world datasets.**
- **Handles missing sensor data and evolving road networks without retraining, ensuring robust, adaptable performance.**
- **Enables accurate traffic forecasting with up to 70% fewer sensors, significantly reducing deployment and maintenance costs.**
- **Won the Audience Appreciation Award at the 29th ACM SIGKDD International Conference on Knowledge Discovery Data Mining (KDD23).**

Prof. Sayan Ranu
Department of Computer Science and Engineering and Yardi School of Artificial Intelligence

Prof. Hariprasad Kodamana
Department of Chemical Engineering and Yardi School of Artificial Intelligence



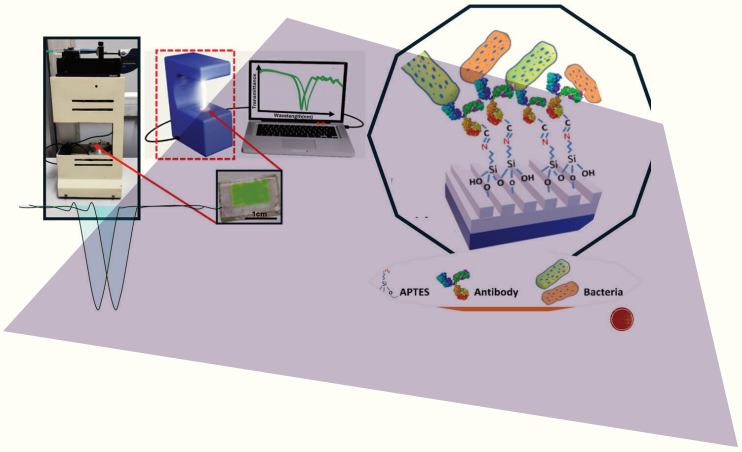
Photonic Chip-Based Spectrometric Biosensor for Pathogen Detection

A compact and portable photonic chip-based spectrometric biosensor for rapid, sensitive, and accurate pathogen detection for near real-time medical diagnostics

We developed a photonic chip-based spectrometric biosensor for rapid, ultra-sensitive, and label-free detection of biomolecules. This cutting-edge device boasts a design with minimal optical components, integrating microfluidics and a photonic sensing chip to detect spectral shifts induced by interactions between biospecimens and functionalized sensor surface. Using our in-house laser interference lithography technique, we have established a scalable method for fabricating photonic chip sensors. The versatile sensing element can be bio-functionalized to target a wide range of biomolecules, from small proteins to whole cells, including pathogenic bacteria. Demonstrating its potential, the photonic crystal sensing element successfully detected highly pathogenic bacteria Pseudomonas aeruginosa at very low limit of detection of 100 CFU/ml in laboratory tests. This technology is poised to revolutionize early disease diagnosis and treatment and has been transferred to the industry UNNINO Pvt.Ltd, Mumbai for commercialization.

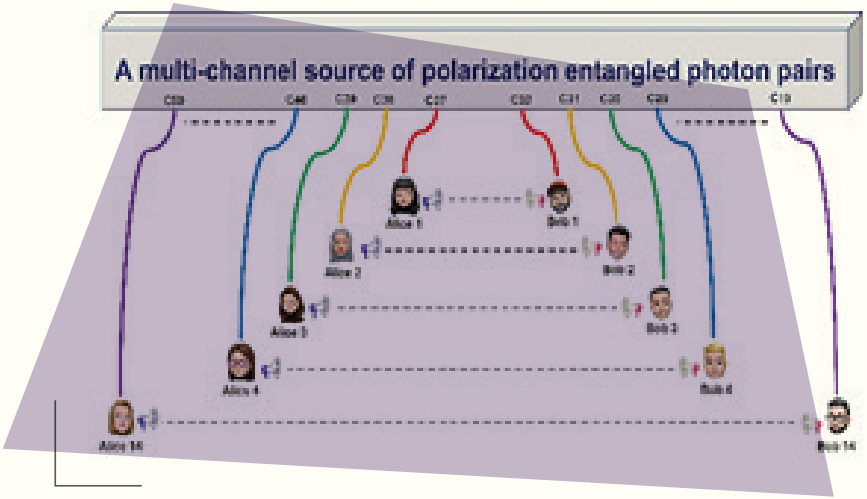
A startup company, SpectroFab Tech Pvt. Ltd., has been incubated recently, to turn such research products into practical, market-ready solutions. The company's initial focus includes developing biosensing chips, laser-induced graphene-based heat pads, and flexible electronic devices, bringing advanced technological innovations to everyday use.

- **Having said that, 'Photonic biosensors are the future of diagnostics—delivering rapid, ultra-sensitive, and label-free detection schemes that can transform healthcare through photonics technologies'. Our invention of the photonic chip-based spectrometric biosensor for pathogen detection is a promising first step towards unlocking the full potential of advanced diagnostics and healthcare.**

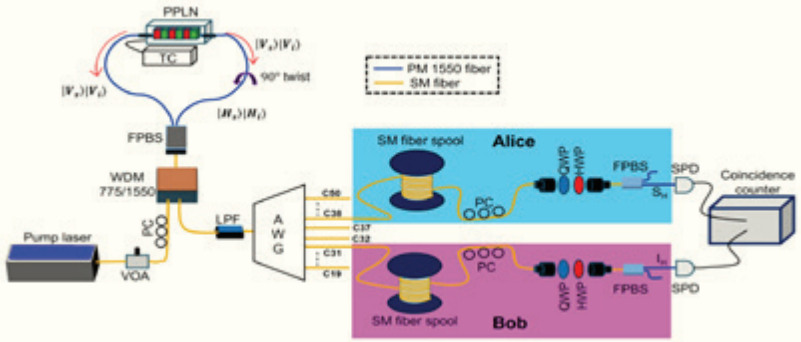


Prof. Joby Joseph
Optics & Photonics Centre

Prof. Prashant Mishra
Department of Biochemical Engineering and Biotechnology



- **The development of a completely fiber-integrated multi-user source of entangled photons at telecom wavelengths for long-distance QKD (up to 100 km) and quantum communication.**



Prof. Joyee Ghosh
Department of Physics

Multi-User Long-Distance Fiber-Based Secure Quantum Communication up to 100 km Using Entangled Telecom-Wavelength Photons

A multi-user source to enhance the scalability of fiber-based quantum communication and key distribution

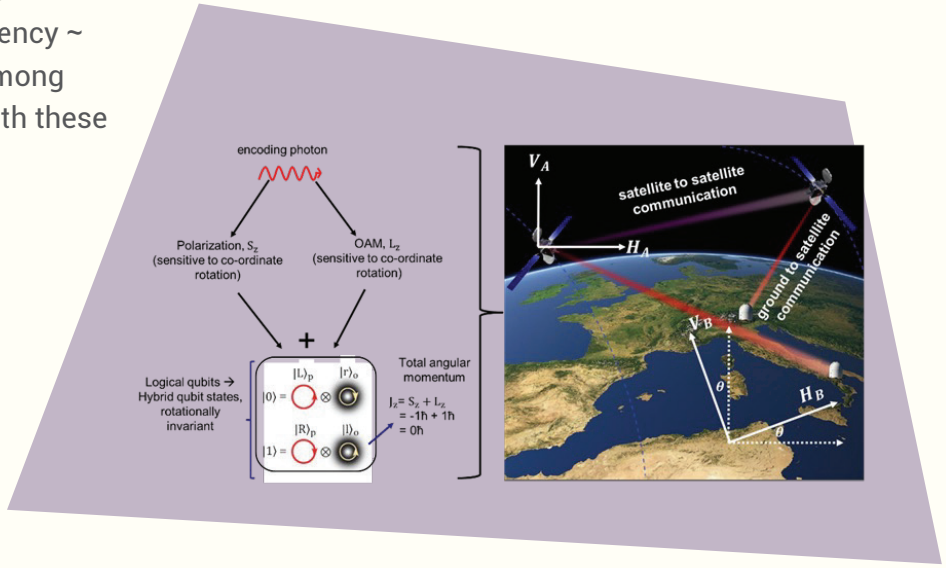
The scalability of fiber-based quantum communication networks requires compact, fiber-integrated, easy-to-deploy, and efficient multi-user sources for quantum key distribution (QKD) and quantum communication. At the heart of the network, the source can cater different user-pairs simultaneously to generate a secure key which they can use to encrypt and decrypt their information. Here we demonstrate such a multi-channel fully-fiber-integrated source of entangled photon pairs in the low-loss telecom C-band based on spontaneous parametric down-conversion (SPDC). The source can be easily tuned to generate the entangled |Φ^+> or |Φ^-> Bell state in 14 channel pairs of the International Telecommunication Union (ITU) (dense WDM, 100-GHz spacing) grid around 1550-nm with a maximum fidelity ≳ 94%. This is confirmed by the violation of CHSH-Bell's inequality ($S > 2.56 \pm 0.04$). The source's suitability for long-distance entanglement transmission is also demonstrated by the successful transfer of entangled photons up to 100 km, while maintaining fidelity >85% and quantum bit error rate (QBER) < 9%. We measured all performance metrics using conventional room-temperature semiconductor-based single-photon avalanche detectors (SPADs). Our highly flexible source can support up to ~ 40 user pairs for simultaneous quantum communication, and it can be easily deployed into the current metro-area fiber-optic telecom infrastructure.

Hybrid Entangled Photons for Alignment-Free QKD and Secure Quantum Communication

Making India Quantum-Proof

The Indian government's recent announcement of the National Quantum Mission (NQM), aimed at making India quantum-proof and joining the elite group of countries with quantum satellites, created a lot of excitement in the Indian scientific community. The vision of demonstrating satellite-based secure quantum communications between ground stations over a range of 2,000 kilometers within India conventionally requires entangled photon-based quantum key distribution (PEQKD), which is prone to a minor misalignment of the shared frame of reference. We propose that rotationally invariant hybrid photon pairs with robust entanglement properties offer a significant advantage for secure and reliable quantum communication, making them lucrative candidates for applications such as satellite-to-satellite and ground-to-satellite QKD networks. We show the reliability and stability of the entangled photon source over a period of 6 hours by demonstrating the BBM92 protocol with a raw key rate > 2.8 kbps and a quantum bit error rate (QBER) of ~ 5% in a single-pass configuration. The performance metrics of our quantum source, measured with the conventional avalanche photo detectors (SPADs, quantum efficiency ~ 60%, dark counts ~ 40 cps) are among the best values reported so far with these detectors.

- **Developed polarization and hybrid-entangled photon source with a brightness of 2.36×10^5 pairs/s/mW for alignment-free QKD e.g., satellite-based secure communication with rotational tolerance of θ >45° under the National Quantum Mission.**
- **Demonstrated the BBM92 QKD protocol with polarization-entangled photons with the highest raw key rate of ~ 2.8 kbps and QBER < 11% over a long time period of ~ 6h (lab-based).**



Prof. Joyee Ghosh
Department of Physics

Developing a Real-Time Bioelectrochemical Sensor for Rapid Water Quality Monitoring

An innovative sensor that leverages electricity-generating microorganisms for cost-effective, real-time pollutant detection

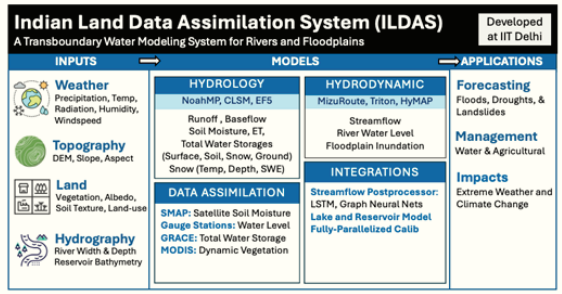
The Electromicrobiology Group at IIT Delhi developed a real-time bioelectrochemical sensor to monitor water quality. This sensor uses “weak electricigens” - microorganisms that generate a small electrical current and, as we now understand, are widespread in the natural environment. When pollutants are present, the microbes' electrical output decreases, enabling continuous water quality tracking.

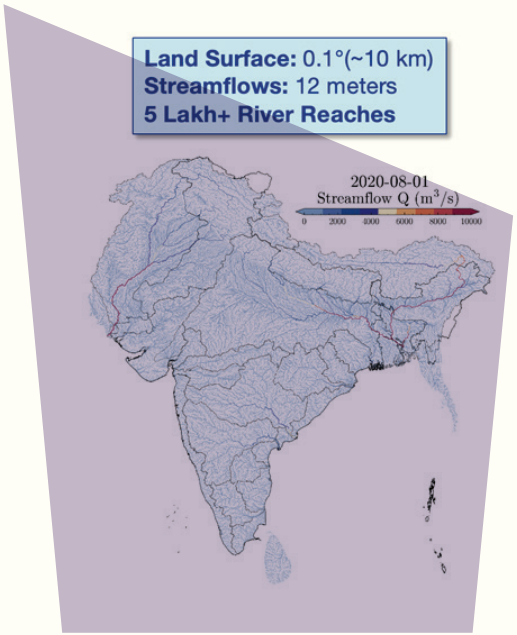
This technology supports cost-effective and efficient monitoring, particularly in areas prone to contamination. Unlike conventional methods that are expensive and not suitable for 24/7 use, this sensor offers an early-warning system to detect pollutants. It is demonstrably responsive to pesticides and allows long-term use, making it a valuable addition to existing monitoring systems.

Future uses include detecting emerging contaminants and integrating on-site monitoring systems with naturally occurring weak electricigens. Such innovations are pivotal to achieving the UN's 2030 Agenda for Sustainable Development of ensuring sufficient water and sanitation (Sustainable Development Goal 6).

- **Harnesses electricity-generating microbes present in the environment.**
- **Enables widespread, cost-effective water monitoring to meet global sustainability goals.**

Prof. Lucinda Elizabeth Doyle
Department of Biochemical Engineering and Biotechnology





Prof. Manabendra Sahariaa
Department of Civil Engineering

Development of the Indian Land Data Assimilation System (ILDAS) and Technology Transfer to ISRO

ILDAS is a transboundary water modeling system for rivers and floodplains in the Indian subcontinent, transferred officially to the ISRO Space Applications Center, Ahmedabad

Effective management of water resources requires reliable estimates of land surface states and fluxes, including water balance components. But most land surface models run in uncoupled mode and do not produce river discharge at catchment scales to be useful for water resources management applications. Such integrated systems are also rare in India where hydrometeorological extremes have wreaked havoc on the economy and people. Driven by several meteorological forces, we developed an Indian Land Data Assimilation System (ILDAS) with multiple land surface and hydrodynamic models to estimate land surface states, channel discharge, and floodplain inundation. ILDAS can also assimilate satellite remote sensing datasets related to soil moisture, total water storage, dynamic vegetation, etc.

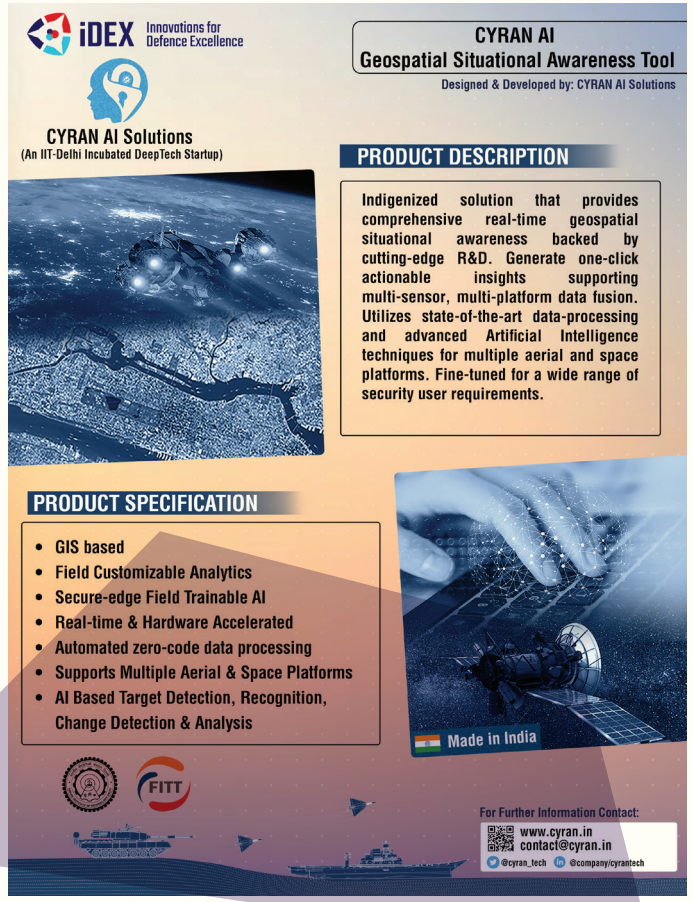
- **ILDAS enables simulating land surface variables (0.1°), floodplain inundation, and channel discharge (12 meters) in over 500,000 river reaches in the Indian subcontinent**
- **We officially transferred ILDAS to the Indian Space Research Organization's (ISRO) Space Applications Center (SAC) in September 2024 for operational use.**
- **ILDAS can generate a medium-range flood forecast for the entire country in less than 10 minutes by leveraging the IIT Delhi supercomputer.**

An AI-Based System for Geospatial Data Processing

An Edge AI System for efficiently processing multi-source geospatial remote sensing data for diverse analytics developed by the IIT-Delhi faculty-led startup CYRAN AI Solutions under the MoD's IDEX mission

- **Successfully cleared field trials of Indian Government users**
- **Successfully deployed with multiple Indian Government users**
- **Received Raksha Mantri's Award for Excellence in Defence & Aerospace Sectors**
- **Among the few iDEX projects showcased to the Prime Minister**
- **Solution included in the Ministry of Defence's 5th positive indigenization list.**

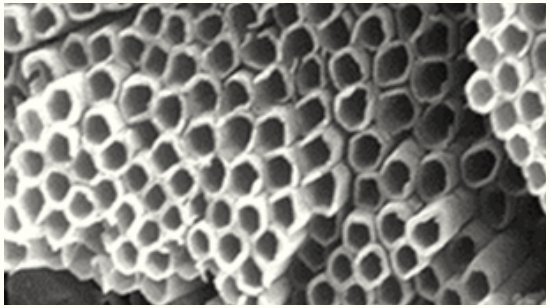
The volume of space-based geospatial data is increasing exponentially due to the development of new sensors, drones, UAVs, satellites, constellations, and aerial platforms. It is humanly impossible to analyze all this data utilizing purely manual techniques. To solve this problem, the IIT Delhi-faculty-led startup CYRAN AI Solutions developed an efficient AI-based Geospatial Data Analysis System under the Department of Defence Production's Scheme for Innovations for Defence Excellence (iDEX). The CYRAN AI team successfully deployed the solution with multiple users and it is helping process multi-sensor remote sensing data analysis in a timely and uniform manner. They also foresee deploying the solution in such domains as Defence & Security, Urban planning, Agriculture, etc.



Prof. Manan Suri
Department of Electrical Engineering

Development of Dental Implants for Advanced and Critical Applications

Dental implants with a nano surface for faster osseointegration, immediate loading, and drug loading capabilities



- **Patented the novel implant design, and transferred the technology to the industry unit.**
- **Patented improvised designs as a design iteration which demonstrated bone forming for immediate loading.**
- **Validated and patented novel surface modification technique to achieve nanotube formation on the surface of the dental implants.**

Prof. Naresh Bhatnagar
Department of Mechanical Engineering

A dental implant is a surgical component or screw that interfaces with the bone of the jaw to support a dental prosthesis such as a crown, bridge, denture, facial prosthesis, or to act as an orthodontic anchor. It is an artificial tooth root that is placed either in the maxilla or the mandible of the jaw for people who have lost a tooth or teeth due to periodontal disease, an injury, or some other reason. The dental implant system comprises three main components that are subsequently assembled.

1. Implant
2. Abutment
3. Implant screw

A dental implant's success is primarily measured by the initial primary stability that arises from the mechanical locking between the implant and bone (Macro Design) and secondary stability stemming from the biological locking (Osseointegration) between the implant and the bone (Micro features and surface). Our objective in developing an implant with an advanced nano surface was to address the long procedure and frequent post-implantation visits to the dentist until a crown is fixed on the jaw. This necessitated the development of ready-to-load implants that can also osseointegrate faster.

The implants developed at IIT Delhi addressed both criteria through their novel design with macro and micro features that lower stress concentrations at implant-bone interface and ensure efficient load distribution. The team simulated design analysis on implant bone assembly through FEA studies. To enhance the osseointegration, they developed a novel surface modification technique to generate nanotubes with appropriate hydrophilicity and drug-loading capabilities. This novel nano-surface demonstrated faster and better osseointegration against control-marketed implants by showing stable ISQ (stability) values and an immediate loading capability. The team manufactured, surface treated, cleaned and packed the implants and their prosthetic components in-house at IIT-Delhi.

Design and Development of Bioresorbable Cardiovascular Stents (BS)

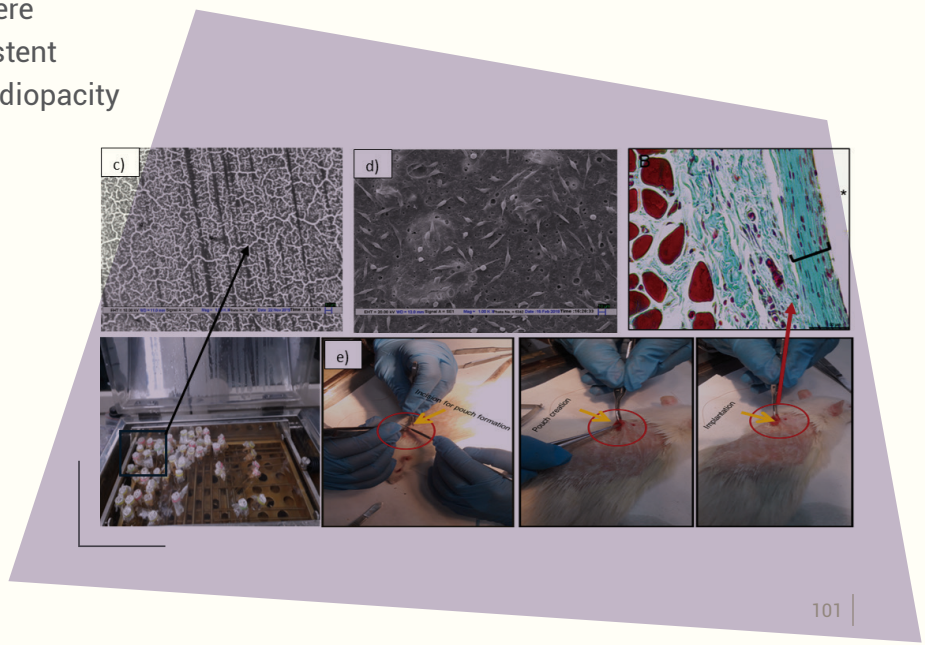
BS can provide support to the plaque-clogged artery and get reabsorbed in the body, eliminating the need for anti coagulant therapy

Cardiac diseases are responsible for most of the deaths occurring in India. With atherosclerosis emerging as a major social epidemic in the country, angioplasty is now an established procedure for treating the resultant Coronary Artery Disease (CAD). Stenting the plaque-clogged artery is the most efficient solution for CAD. Compared to commercially available bare metal/ drug-eluting metal stents, the technology of the future is a fully Bioresorbable (Drug-Eluting) Vascular Stent (BS). These stents are made of polymers that can be reabsorbed inside the artery and leave no permanent implant behind after positively remodeling the lumen. The benefits of BS over available permanent stents include reducing the risk of late stent thrombosis, minimizing inflammation, eliminating the need for lifetime medication, and speeding up healing and function restoration.

Additionally, BS are easier to fabricate, biocompatible, achieve tailored properties, non-corrosive, and have a low density. Therefore, we designed, fabricated, physico-mechanically tested, and drug loaded a new BS using polymers, and later conducted Ex Vitro, In Vitro, and In Vivo studies on large animals. This project involves optimizing the blending ratio, extrusion parameters, mechanical strength, cutting parameters, packaging, and sterilization. We were granted patents on the polymeric stent design, fabrication process, and radiopacity of BS.

Prof. Naresh Bhatnagar
Department of Mechanical Engineering

- Published 13 journal articles and received 3 patents
- Presented the technology at 4 International Conferences
- Conducted In Vivo Large Animal Trials on Swine.
- Commercialized and transferred the Drug Eluting Stent technology

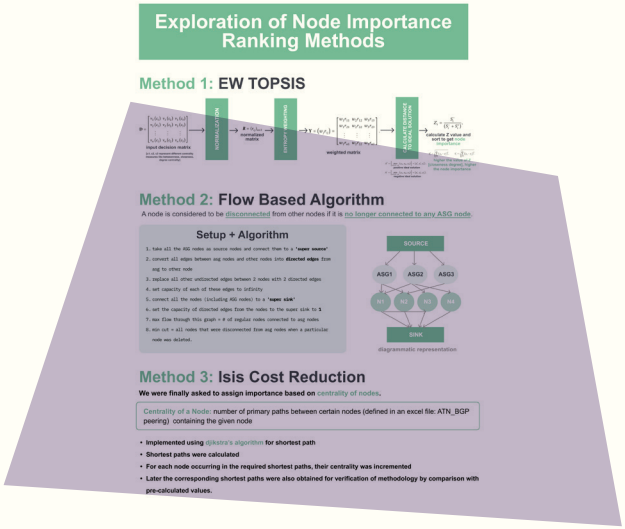


NOKIA CoE: Transport Topology Mapping Through Network Configuration

The project's aim is automating network topology for improving connectivity, efficiency, and visualization, for lightening the network maintenance load

Disruption-free wireless transmission is the most efficient option. However, various factors cause loss of information during transmission. This work proposes an algorithm for automating network topology to improve transmission quality. As these transmissions are typically multi-hop, a dynamic evaluation and optimization of node topology is considered ideal. In this work, we provide a smart algorithm designed for this purpose. It consists of three primary steps, viz. Node Importance Ranking, Network Optimization, and Interactive Network Visualization. We considered three different algorithmic ways for node importance - matrix-based algorithms, flow-based algorithms, and centrality-based algorithms. We used Dijkstra's algorithm to evaluate node significance, analyze connectivity, and confirm the best paths. In the network optimization phase, we developed an algorithm for minimizing latency through a modified Dijkstra's algorithm, which dynamically enhances connectivity as the network expands. In order to make it easier to use these functionalities, we developed an interactive network visualization using tools like Pyvis and NetworkX, which we integrated into a Flask web application. We designed this visualization to provide a dynamic and filterable map, enabling detailed insights into the network's structure at every stage of transmission.

- **Developed a smart algorithm to dynamically evaluate and optimize node topology and improve transmission quality.**
- **Developed an interactive network visualization to simplify using the algorithm's functionalities and provide detailed insights into the network's structure.**



Prof. Niladri Chatterjee
Department of Mathematics and Yardi School of Artificial Intelligence

ICMR-IIT Delhi National Center for Assistive Health Technologies (NCAHT)

Research and innovation in assistive technologies for persons with visual impairment aiding mobility, education, and social inclusion

The NCAHT project aims to develop effective and affordable assistive technology (AT) solutions to improve the lives of persons with disabilities in India. The project takes a holistic view of the AT sector and seeks to contribute research into and development of new devices or solutions, translation of current technologies into the field, and dissemination and capacity building work to ensure impact at scale. The research projects undertaken leverage product design, embedded systems, AI, and robotics technologies towards the goal of creating solutions that improve the possibilities for education, independent and safe living, and employment of persons with impairments and, in particular, visually impaired people. Examples include tactile textbooks for learning science subjects, accessible science experiments kit, devices for safe mobility, braille display units, accessible interfaces for programming, and devices for basic reading and writing in schools. The center develops these technologies jointly with the end-users as well as manufacturers, with IIT Delhi serving as the catalyst for the research and development. As part of this project, the Center has established a demonstration zone at R&I Park, IIT Delhi, to showcase currently available AT devices. and engages with end-users, special educators, and social workers for evaluation, ideation, and dissemination.

- **Under this project, over 200 AT solutions for the visually impaired have been collated for assessment, the largest in the country.**
- **Over 10 technologies have emerged addressing unmet needs, and over three major field trials have been launched with industry partners.**
- **The Center has held more than 100 training sessions in collaboration with organizations in nearly every state in India.**

Prof. P. V. M. Rao
Department of Design, Department of Mechanical Engineering, and School of IT

Prof. Rohan Paul
Department of Computer Science and Engineering, School of IT, and Yardi School of Artificial Intelligence

Prof. Piyush Chanana
Alumnus, School of IT

I-Hub Foundation for Cobotics (IHFC) – Collaborative Robotics for a Better World

Making a difference to the world by creating impactful technology through disruptive innovations in R&D and startups empowering one and all from a young age

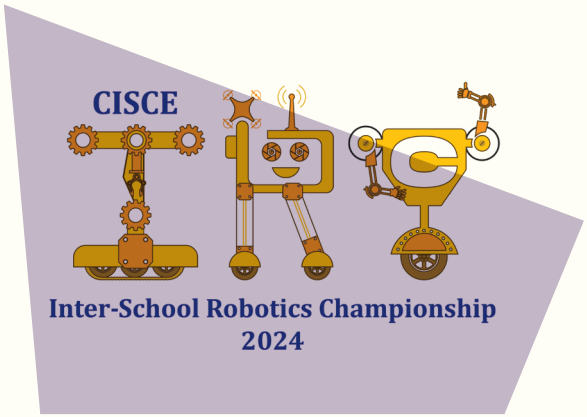
- **IHFC is at the forefront of creating breakthrough technologies in R&D and startups.**
- **Its READY Students program has been a significant contributor, with two participants successfully launching thriving startups.**
- **Additionally, IHFC is actively developing 10 Co-Innovation Centers across selected engineering institutes and universities in India to nurture future innovators and entrepreneurs, with a strong focus on advancing technology, particularly in the field of robotics.**

IHFC takes a comprehensive approach to innovation, beginning with immersive teaching and learning methods that gamify education at the national level. Currently, IHFC is spearheading 40 ongoing R&D projects to deliver global solutions to complex industry challenges.

The Foundation's key international partnerships involve collaborations with the National Science Foundation (NSF), USA; Odense Robotics, Denmark; and Keio University, Japan, and reinforce its commitment to advancing technology solutions. In addition, IHFC has successfully incubated, accelerated, and mentored 32 startups, including notable ones like Botlabs, Kaidoko, TSAW, Arka Aerospace, and Cocoslabs, many of which credit IHFC for their success.

IHFC's CSR initiative Nurture partners with over 19 entities to build capabilities and empower underprivileged communities.

With two established Centers of Excellence—Drone Technology Park (at IIT Delhi Sonipat Campus) and Medical Cobotics Centre (at IIIT Delhi Okhla campus in collaboration with their Technology Innovation Hub iHub Anubhuti), IHFC is fostering innovation at the intersection of academia, industry, and government. These efforts aim to position India as a global leader in technological advancements, empowering the nation to compete on the world stage.



Prof. S.K Saha
Department of Mechanical Engineering

“Enabling 6G and Beyond:...” Advanced THz Detector and Source Device Technologies

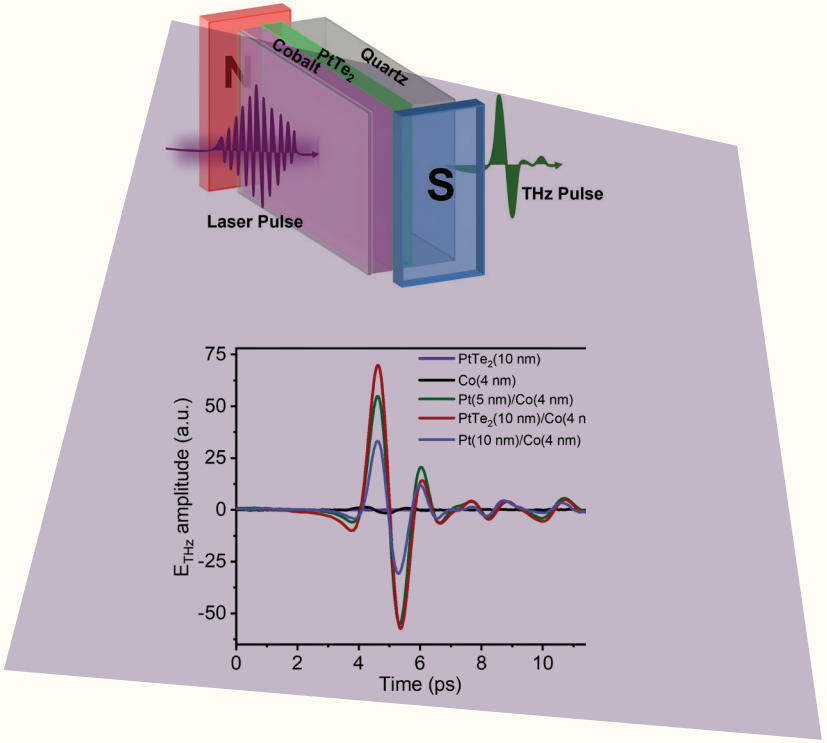
Designing and characterizing a high-efficiency and scalable terahertz (THz) detector and a high-efficiency spintronic THz emitter based on a $PtTe_2$/Co heterostructure

The PI group developed scalable terahertz (THz) detector technology using silicon nanowire FETs and 2D materials like semimetal platinum ditelluride ($PtTe_2$), grown through chemical vapour deposition (CVD). It also developed two advanced detectors: the first, based on silicon nanowire FETs and utilizing the Dynkov-Shur mechanism, offers high efficiency and a broad detection range from 0.1 to 1 THz, making it suitable for communications, security, and medical imaging. The second detector uses $PtTe_2$ and covers a wider range from 0.1 to 2 THz, providing superior responsivity and low noise equivalent power via the photo-galvanic and photon drag effects. The group designed a 4×4 array of these detectors, making it an excellent candidate for THz imaging applications. Both detectors are cost-effective, reliable, and scalable, paving the way for more accessible and efficient THz sensing technologies in the future.

In a separate project, the PI group developed a spintronic THz emitter by combining ferromagnetic cobalt with semimetal $PtTe_2$. This emitter achieves 15% higher efficiency compared to conventional platinum-based emitters. The device generates high-intensity THz pulses via spin-to-charge conversion, operates at room temperature, and is particularly suitable for 6G communication technologies.

Prof. Samaresh Das and Prof. Rahul Mishra
Center for Applied Research in Electronics (CARE)

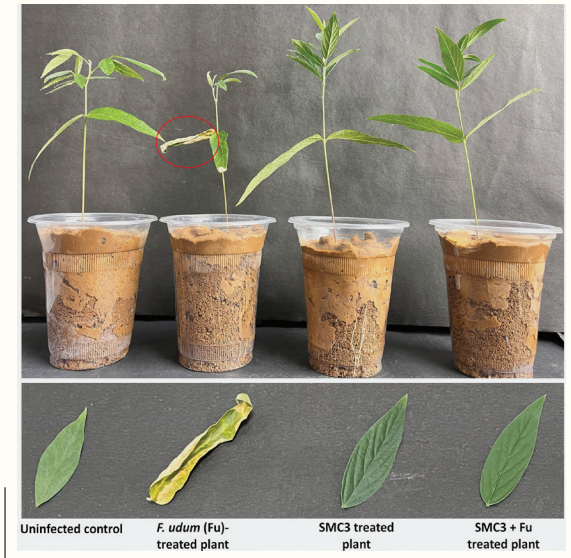
- **Developed high efficiency broadband (0.1-1THz) THz detector using Silicon nanowire FET with voltage responsivity 468 VW^{-1} at 0.425 THz and with a noise equivalent power (NEP) value of ~ 10^{-9} $W/Hz^{½}$.**
- **Also developed a 2D material ($PtTe_2$)- based broadband (0.1-1.5 THz) THz detector with maximum current responsivity of 16.4 A/W and lower NEP value of $1.5×10^{-11}$ $W/Hz^{½}$.**
- **The $PtTe_2$/Co based THz emitter showed 15% higher THz generation compared to conventional Pt-based spintronic THz emitters.**



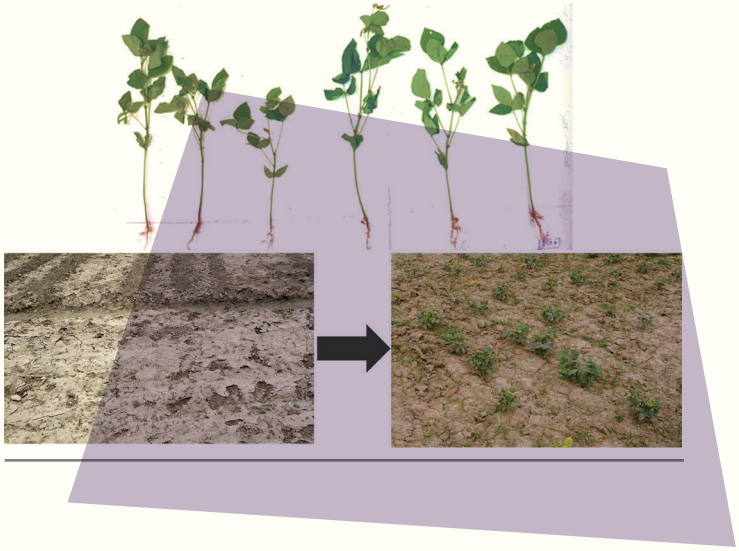
Plant Microbiomes as Drivers of the Next Green Revolution

Harnessing the plant microbiome as a sustainable approach for climate-resilient agriculture

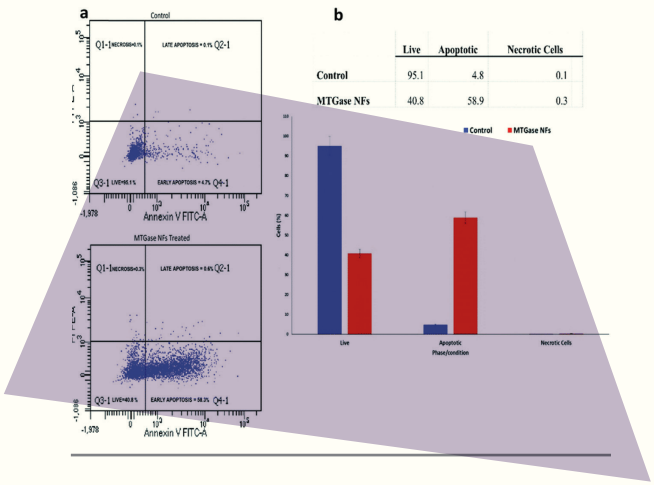
In view of the increasing population and continuously deteriorating arable land, Climate-Resilient Agriculture (CRA) is of utmost importance. The plant is no longer viewed as an independent entity but as a holobiont with its associated microbiomes, the latter being crucial for determining the host's fitness. The group is assessing and harnessing the nexus between the host plant, its associated microbiome, the soil, and the environment as a holistic approach for minimizing the use of chemicals. Engineering the plant-associated microbiomes is a promising and sustainable approach for enhancing plant productivity and maintaining soil health, especially under various abiotic and biotic stresses. In this context, the group adopted both the top-down and bottom-up approaches of strategically tailoring the microbiomes associated with plant roots. Using novel strategies of generating the optimal microbiomes as "next generation bioformulations", the group demonstrated success in experimental fields and subsequently in farmers' fields.



- **Successfully adopted the strategy of acclimatization of plant microbiome to mitigate abiotic stresses**
- **The first group to work towards mapping arable Indian land for "general suppressiveness" of soil towards plant pathogens**
- **Outcome covered in the proceedings of the National Academy of Sciences as "Front Matter"**



Prof. Shilpi Sharma
Department of Biochemical Engineering and Biotechnology



Isolated novel halophiles from India's coastlines and exploited their uniqueness to develop the following outcomes:

- **Formulating marine actinobacterial bioactive molecules for killing drug-resistant MRSA and disallowing biofilm formations in medical devices like catheters**
- **Designing Transglutaminase nano-flowers for arresting cancer progression and apoptosis in breast cancer cell lines**
- **Developing chemo-sensors for detection of toxic or carcinogenic acrylamide**

Prof. Sunil Kumar Khare
Department of Chemistry

Extremophiles – Life at Extremes: Uniquely Useful for Extreme Applications

Discovering and exploiting extremophiles' unique enzymes and molecules against multidrug resistance pathogens, cancer theranostics, bioremediation of emerging toxicants, and harsh bioprocesses

Extremophiles are exotic microorganisms inhabiting some of the most hostile environments on Earth. Deciphering how their cells survive and perform life processes and physiological functions under extreme conditions wherein normal cells may not survive is fascinating. Our research focused on discovering novel extremophiles and exploiting their unique cells and enzymes for applications in antimicrobial resistance, environmental bioremediation, and bio-based platforms.

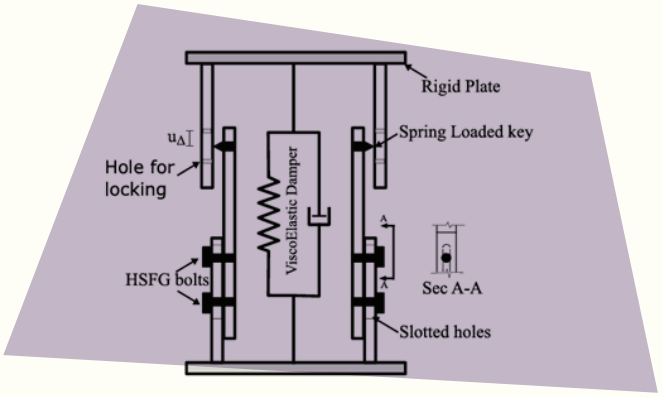
We chose halophiles, which inhabit extremely saline environments (1-25 M), as a model system for addressing our questions. We conducted the study across India's vast coastline and salt lakes, isolating more than 100 diverse halophiles with some novel genera now deposited in the National Microbial Type Culture Collection Facility. We also submitted their gene sequences to the National GenBank, USA. Further, we delineated that their proteomes are differential and their proteins have a highly hydrophobic surface with embedded acidic and basic amino acids lining their surface. This characteristic allows them to retain their native structure to function efficiently in low water activity and salty environments.

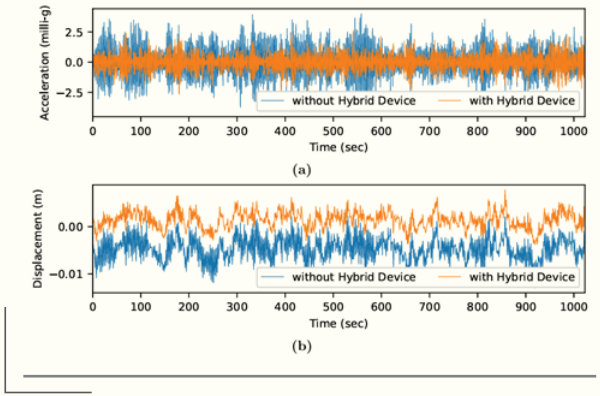
Can their unique properties be exploited to resolve some of the major unmet global challenges? We developed several innovative applications using extremophiles and leveraged their enzymes for several bioprocesses of which significant and noteworthy ones include:

1) Killing multidrug-resistant bacteria
2) Developing biomedical applications to fight cancers
3) Bioremediation of emerging toxic pollutants
4) Biobased production of commodity chemicals

A Hybrid Passive Energy Dissipation Device for Multi-Objective Performance-Based Control of Building Frames

Multi-objective performance-based control of building frames during wind and earthquake events for multi-hazard mitigation using a new hybrid passive energy dissipation device





We developed a versatile and innovative hybrid passive energy dissipation (PED) device for controlling a broad range of wind- and earthquake- induced structural vibrations in a multi-hazard scenario. The proposed hybrid PED device implements a novel combination and assembly of viscous and friction elements along with a slip-lock element for controlling the low as well as high amplitude structural vibrations by dissipating the input wind or seismic energy in both low and high intensity events. The viscous element in the hybrid PED device reduces the structural response from the onset of structural vibrations during mild to moderate wind or earthquake events in which the friction element remains inactive. On the other hand, the friction element in the hybrid PED device is activated only in the event of extremely strong winds or severe earthquakes that surpass the slip load of the friction element. We can design the hybrid PED device using an energy-based plastic design method in the performance-based design (PBD) framework for effectively controlling the vibration response of building frames under the action of dynamic wind and earthquake loads. This control brings the vibration response within the respective limiting values for performance-based wind engineering and performance-based earthquake engineering of buildings for various performance limit states and hazard levels recommended by published design standards.

- **Under the aegis of FITT, R&I Park recently incubated the technology startup Richter Resilience Pvt Ltd for evolving a commercially viable, factory-finished product from the experimental working prototype.**

Prof. Suresh Bhalla and Prof. Alok Madan
Department of Civil Engineering

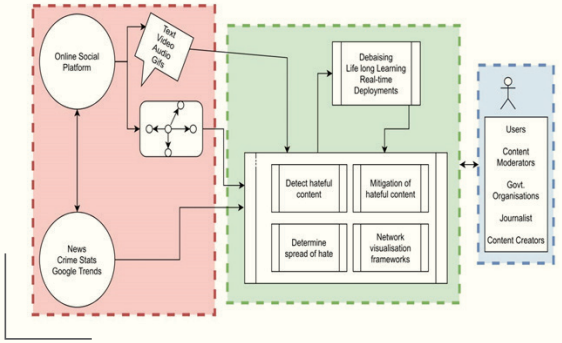
Project Robinhood: Combating Offensive Content on Social Media

Use of Generative AI in combating offensive content on social media by leveraging graph structure, user behavior, and multimodality

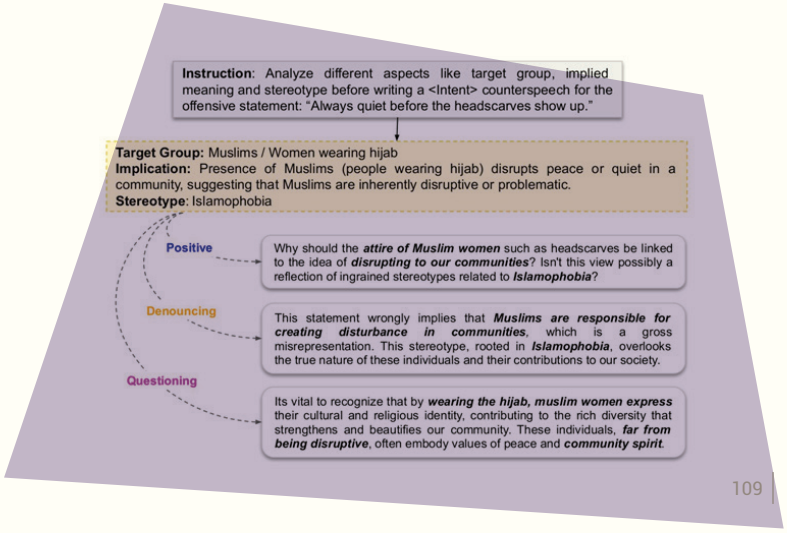
Online spaces are prone to malicious social behavior, from hate speech to misinformation to fake product reviews. In a broader effort to analyze and combat such harmful activities at scale, we explored computational techniques. As systems are incentivized for engagement, people employ collusive behavior to increase engagement numbers. We developed ML models to detect such patterns. We narrowed down collusive patterns in terms of how quickly and similarly users comment on or like a post, and the implicit harmful behavior therein.

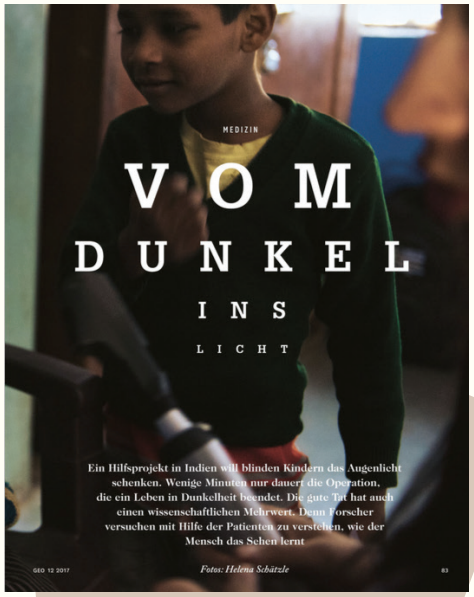
Our studies introduced AI models that explained hidden stereotypes in hate speech, helping moderators understand the underlying context. We further built on detecting hate speech to counter it. By focusing on cultural sensitivity and ethical considerations, our work aims to create safer online environments while ensuring fairness and inclusivity in content moderation processes. As a byproduct of our research, we have also released multiple datasets that can help in further developing social computing.

Prof. Tanmoy Chakraborty
Department of Electrical Engineering & Yardi School of AI



- **CoReRank: Ranking to Detect Users Involved in Blackmarket-based Collusive Retweeting Activities, WSDM, 2019**
- **HawkesEye: Detecting Fake Retweeters Using Hawkes Process and Topic Modeling, IEEE IFS, 2020**
- **Nipping in the bud: Detection, diffusion, and mitigation of hate speech on social media, AC**
- **Intent-conditioned and Non-toxic Counterspeech Generation using Multi-Task Instruction Tuning with RLAIF, NAACL 2024**
- **Tox-BART: Leveraging Toxicity Attributes for Explanation Generation of Implicit Hate Speech, ACL 2024**





Alleviation of Childhood Blindness: Illuminating Science, Illuminating Lives

Groundbreaking research with 'Project Prakash' restores sight to blind children in India and sheds light on the development of vision, learning, and the human brain

- **The human brain remains capable of visual learning well into late childhood. Curable blind patients should not be denied treatment on the basis of age alone.**
- **The human brain has an impressive ability to reorganize late in life.**
- **Early patterned visual inputs are necessary for developing normal-like vision.**
- **People can acquire many visual abilities late in life, well after the normal period of deployment of such abilities, beyond the famous critical period.**

The overarching goal of this research is simultaneously to contribute to the advancement of basic science as well as the betterment of the human condition. The work on visual learning and contribution to alleviating childhood blindness in India is noteworthy. India is home to nearly 40% of the world's population of blind people. Further, whether a child who had suffered several years of blindness from birth could recover their visual function through surgical treatment later in life was unknown.

Project Prakash is an initiative that provides sight-restoring surgeries to congenitally blind children and also studies their subsequent progress. Its work has not only restored sight to many blind persons in India but also helped in unraveling many important but lesser known hypotheses. The applications arising from this research are contributing to understanding various medical problems besides advancing Artificial Intelligence.

Prof. Tapan Kumar Gandhi
Department of Electrical Engineering

Empowering Villages Through Innovative Farming and Sustainable Living

Driving rural transformation with mushroom and lemongrass cultivation, clean energy, and self-sustainable villages

The Unnat Bharat Abhiyan (UBA), a flagship initiative of the Ministry of Education, aims to bridge the gap between higher education institutions and rural India. Launched in 2014, UBA connects 4,037 institutions with 19,033 villages, fostering participatory development while providing students and faculty with experiential learning opportunities.

As the National Coordinating Institute, IIT Delhi oversees UBA's nationwide efforts and also works as a Participating Institute (PI), adding villages across five clusters in Haryana, Uttar Pradesh, and Uttarakhand to the UBA network. UBA Villages in Gaindikhata, Khurrampur, and Anwalkheda, overseen by IIT Delhi, have experienced remarkable improvements in livelihoods through sustainable practices, entrepreneurship, and technological innovations. Over the past 5-6 years, the following interventions have significantly enhanced family incomes across these clusters.

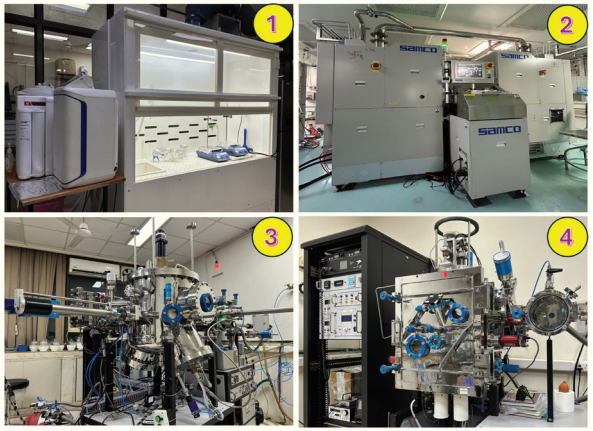
- **Lemongrass Farming:** A transformative initiative in Gaindikhata, where 15 farmers were introduced to lemongrass farming as a solution to wild animal crop destruction. Supported by two oil extraction units, farmers now earn an additional INR 8,000 - INR 10,000 month, with similar successes in Anwalkheda ensuring year-round revenue.
- **Mushroom Cultivation:** This initiative has revitalized Gaindikhata's economy, with farmers earning INR 100 - INR 200 day from mushroom sales. Large farms in Laldhang and Pili Padav employ 35-40 villagers daily, and production is projected to reach 1,000-1,500 kg/day by 2025. Dissemination of its nutritional benefits, establishment of spawn units, and the recognition of Mushroom as the One District One Product (ODOP) for Haridwar further emphasize its importance.
- **Biogas Plants:** In Anwalkheda, biogas plants convert dung from 90 cows into clean cooking gas and organic slurry. This initiative supports sustainable energy and eco-friendly agriculture.
- **Other Initiatives:** Programs in dairy farming, organic and natural farming, and women-led enterprises have empowered more than 100 women and provided daily employment to over 100 villagers, creating self-reliant, vibrant communities.
- **Khurrampur initiatives** include solar street lighting funded by IREDA, pottery kilns supported by NBCFDC, and improved access to health services through an easy-access clinic. These efforts showcase UBA's commitment to sustainable rural transformation across India.

Prof. Vivek Kumar, Prof. Priyanka Kaushal, Prof. Virendra Kumar Vijay, Prof. Pooja Ghosh, and Prof. Sangeeta Kohli
Centre for Rural Development and Technology

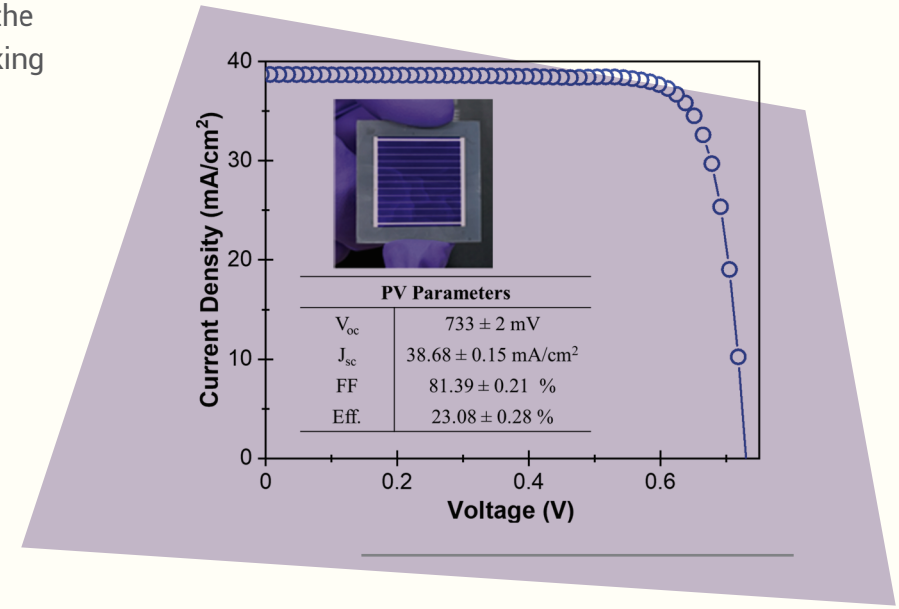
Development of ~23% Efficient Next-Generation Silicon Heterojunction Solar Cell Technology

Harnessing solar energy directly as electrical energy using next-generation technology to meet sustainable development goals

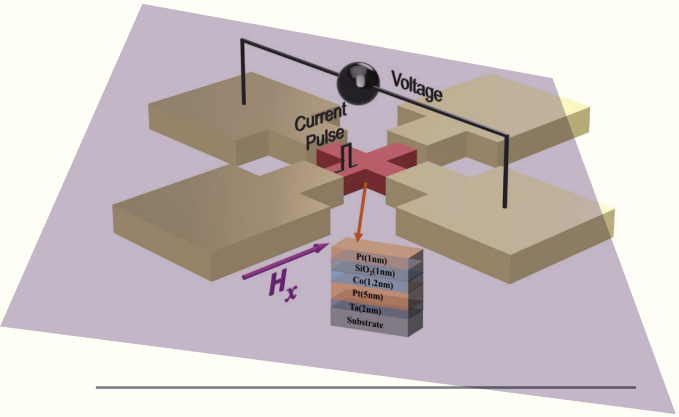
Working on an indigenously developed Plasma Enhanced Chemical Vapor Deposition (PECVD) system, we consistently observed improvements in the power conversion efficiency of our next-generation silicon heterojunction (SHJ) solar cell from approximately 12% to approximately 23%. One pleasing milestone is achieving a fill factor in our devices in excess of 81% and an open-circuit voltage exceeding ~733 mV. This accomplishment is underpinned by years of dedicated effort from several students and post-doctoral researchers, many of whom have since moved on to various international industries and institutions. We have attained such high efficiency from a silicon heterojunction cell for the first time in Indian conditions - a well-deserved reward! We primarily attribute this achievement to carefully optimizing the (1) textured silicon surface, (2) PECVD-grown intrinsic and doped amorphous silicon layers, (3) sputtered transparent conducting oxide layers, and (4) metal contacts (as shown in Fig.1). While we still trail behind the international research laboratory efficiency benchmark for SHJ solar cells in small areas of ~25%, we have identified methods to enhance the efficiency further. Our lab is also making efforts for fabricating industrial-size silicon heterojunction solar cells.



- **Achieved power conversion efficiency of ~23% for silicon heterojunction solar cells with 4 cm² area.**
- **Completed process development for fabricating industrial-scale silicon solar cells.**



Prof. Vamsi Krishna Komarala
Department of Energy Science and Engineering

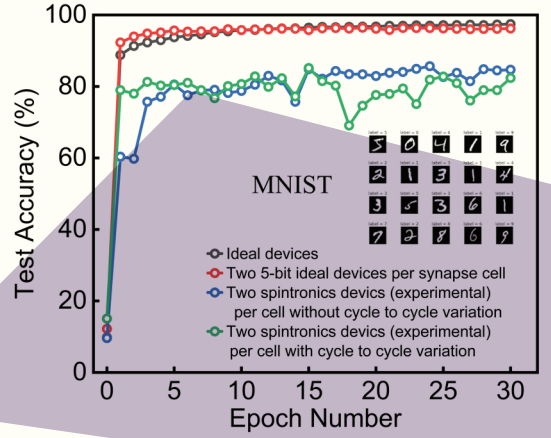


Development of Spintronics-Based Neuromorphic Hardware

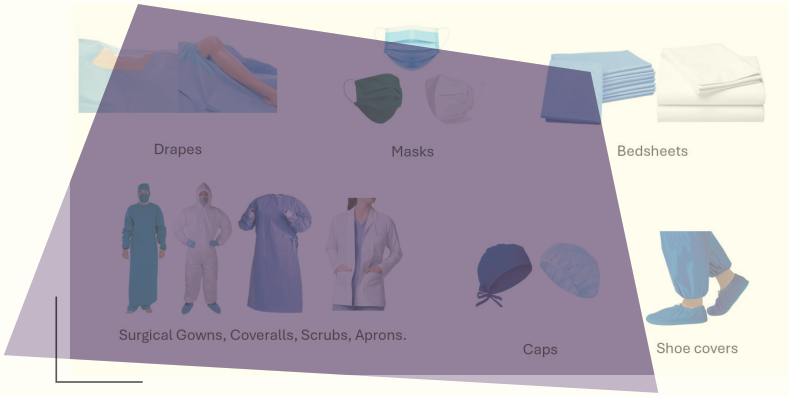
Developing spintronics devices with human brain-like synaptic functionality and implemeting its hardware for neuromorphic computing

- **Novel spintronics devices with perpendicular magnetic anisotropy for synaptic behavior demonstration**
- **Hardware implementation for the image classification of the MNIST and Fashion-MNIST data sets.**

Spintronics-based neuromorphic hardware is a promising frontier for high-performance and energy-efficient computing, inspired by the human brain's functionality. Spintronics is a new branch of electronics that utilizes the spin degree of freedom of electrons compared to conventional electronics in which we leverage only the charge degree of freedom. These devices are non-volatile, and their low power operation makes them ideal candidates for neuromorphic computing. In this study, we developed the spintronics heterostructures ($Pt/Co/SiO_2$) with perpendicular magnetic anisotropy using magnetron sputtering and demonstrated the synaptic functionality required for neuromorphic computing. Subsequently, we modeled a crossbar-array-based artificial neural network (ANN) for image classification and obtained the test accuracy for the Modified National Institute of Standards and Technology (MNIST) and Fashion-MNIST data sets at 83% and 72%, respectively. This development can potentially change neuromorphic computing, wherein we rely on local hardware with inbuilt memory to execute all operations, thus preventing data loss and simultaneously reducing power consumption.



Prof. Pranaba Kishor Muduli
Department of Physics



Fabium®: A High-Performance Antimicrobial Fabric to Prevent Infections

Developed an affordable, high-efficiency antimicrobial fabric that eliminates >99.9% of bacteria, viruses, and fungi within 30 minutes, to effectively prevent hospital-acquired infections

- **Successfully developed Fabium® antimicrobial fabric and hospital supplies, scaling from laboratory to industrial production.**
- **Tested the fabrics successfully according to AATCC100, ISO18184, and AATCC30 standards.**
- **Ten leading hospitals are using Fabium® hospital supplies like bedsheets, scrubs, gowns, and drapes to mitigate infection risks and have given good feedback.**
- **Awarded the Department of Biotechnology's Biotech Ignition Grant (BIG), Pfizer Innovation Award, Most Promising Startup Award (IITD Alumni Association), and recognized among the Department of Science and Technology's Top 75 most impactful startups in 2022.**

According to published data, hospital acquired infections (HAIs) affect 10% - 20% of patients in Indian hospitals, with Staphylococcus aureus being a major culprit. Overcrowding and poor hygiene pose significant risks, particularly to children, the elderly, and immunocompromised individuals.

Fabiosys Innovations developed Fabium® to address this crisis.The developed fabric eliminates 99.9% of germs in 30 minutes and is used in hospital essentials like bedsheets, gowns, masks, PPE kits, and surgical drapes. Designed for critical areas like ICUs and operating rooms, healthcare facilities and staff can use this fabric to prevent the spread of infections and reduce the risk of cross-contamination.

The fabric has been certified for its antiviral, antibacterial, and antifungal efficacy by standard testing laboratories. What sets Fabium® apart is its breathability while being free from harmful substances like formaldehyde and metal nanoparticles. This makes it ideal for protective gear like masks and PPEs, ensuring comfort and safety.

With support from the Department of Biotechnology, Office of the Principal Scientific Advisor, and FITT, IIT Delhi, this innovation aims to reduce HAIs, helping patients recover faster and setting a new benchmark for healthcare safety.

Prof. Samrat Mukhopadhyay
Department of Textile & Fiber Engineering

Oxygen Infrastructure and Supply Chain Management in GNCTD

Strategic recommendations provided to the Government of National Capital Territory of Delhi (GNCTD) for the improvement of oxygen infrastructure and supply chain management in Delhi

We provided evidence-based strategic recommendations to the Government of National Capital Territory of Delhi (GNCTD) for the improvement of oxygen infrastructure and supply chain management in Delhi.

Along with officials from the Delhi government's various departments like Health and IT, we analyzed the issues affecting management of oxygen infrastructure within Delhi and developed practical solutions to resolve them and strengthen the fight against COVID-19. The joint team submitted its report to the Honorable Delhi High Court on 28 May, 2021 and received the judge's appreciation.

We also analyzed the strategic issues of the oxygen infrastructure in Delhi and prepared a blueprint to address these.

Further, we revamped and improved the IT Portal and Dashboard created for oxygen management by the Delhi Government by integrating technological solutions.

Lastly, we augmented and created medical oxygen storage, production, and distribution services in Delhi.

- **Our objective was to ensure that we provided specific and practically implementable solutions to the Delhi government. We endeavored to prevent the loss of lives due to oxygen infrastructure-related issues.**
- **Speaking about the collaboration with IIT Delhi, Mr. Ankur Garg, Commissioner (Trade and Taxation), GNCTD, said, "GNCTD is already preparing for the third wave of COVID-19 and the collaboration with IIT Delhi will further add value to the strategic planning process".**


Hindustan Times

IIT D collaborates with Delhi govt to improve oxygen infra, supply chain mgmt

The Indian Institute of Technology-Delhi has collaborated with the Delhi government to provide strategic recommendations for improving oxygen infrastructure and its supply chain management in the national capital.

Prof. Sanjay Dhir
Department of Management Studies

examined, and suggestions which are made may be examined from the point of view of their utility, and feasibility for implementation. The said note shall be considered with the response of the GNCTD on 07.07.2021.

2. The GNCTD has placed on record, the Review and Recommendations for Management of Oxygen, undertaken by Professor Dhir, IIT Delhi. Professor Dhir is also present during the video hearing, and he has taken us through his presentation which appears to be very comprehensive, and deals with, practically, all aspects relating to management of Oxygen during COVID-19 crises in the GNCTD. As per the recommendations, the State and other institutions, such as hospitals in Delhi should undertake several steps to augment the production, storage, and transportation capacities of Medical Oxygen in the NCT of Delhi to avoid the kind of crises the NCT of Delhi has witnessed in the second wave of COVID-19 Pandemic.

3. Mr. Mehra states that the GNCTD is actively considering the recommendations of Professor Dhir, and shall endeavour to implement them in the right earnest, and at the earliest. Let the GNCTD file, before the Court, a time chart indicating the timelines, within which the several steps that need to be undertaken, are planned to be implemented. The said chart be placed before the Court within the next 4 weeks. The said chart shall be filed under the signatures of the Chief Secretary, GNCTD.

4. In appreciation of the immense work that has gone into preparation of the report by Professor Dhir, we are of the view that the GNCTD may, only as a token, offer him an amount of Rs 1,00,000/-. We make it clear that the

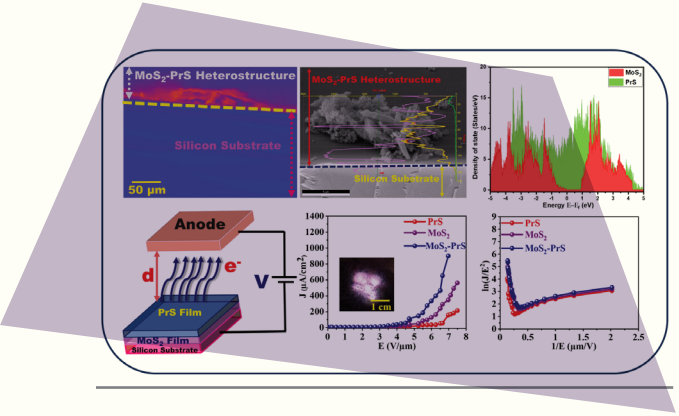
COVID-19 Vaccine: Strategic and Program Management Support for Roll-Out

COVID-19 vaccine roll-out was a critical activity in which multiple partners were working together for planning, executing, and monitoring the vaccine delivery

The project supported the government and generated evidence of the successful delivery of COVID-19 vaccination in various states. We offered program management support to the Ministry of Health and Family Welfare (MoHFW) for seamless coordination of various program activities. We also provided strategic inputs and guidance to communication and training workstreams. Further, the project involved data management through dashboards and deploying sophisticated tools for advanced data analytics. In addition, we supported the COVID-19 Vaccine Intelligence Network (CoWIN) IT platform for enabling beneficiary registration and integrating with the MoHFW's other IT platforms. We also delivered strategic insights by identifying bottlenecks in the processes and quality gaps for improving system design, post-introduction assessment, and the economic evaluation of the vaccine's introduction and scaling up.

- **We achieved the intended outcomes through evidence generation and research that enabled day-to-day support to MoHFW by providing expertise in Program management and strategy, Software development and maintenance, Strategic communication and community engagement, Data analytics, Automation, Modeling and use of sophisticated digital tools to.**
- **We consistently provided domain expertise for advisory support and enabled the project's leadership in close coordination with senior Indian government officials and other stakeholders.**

Prof. Sanjay Dhir, Prof. Sushil, Prof. Mahim Sagar
Department of Management Studies



A Miniaturized Electron Gun for Electron Microscopes and X-Ray Sources

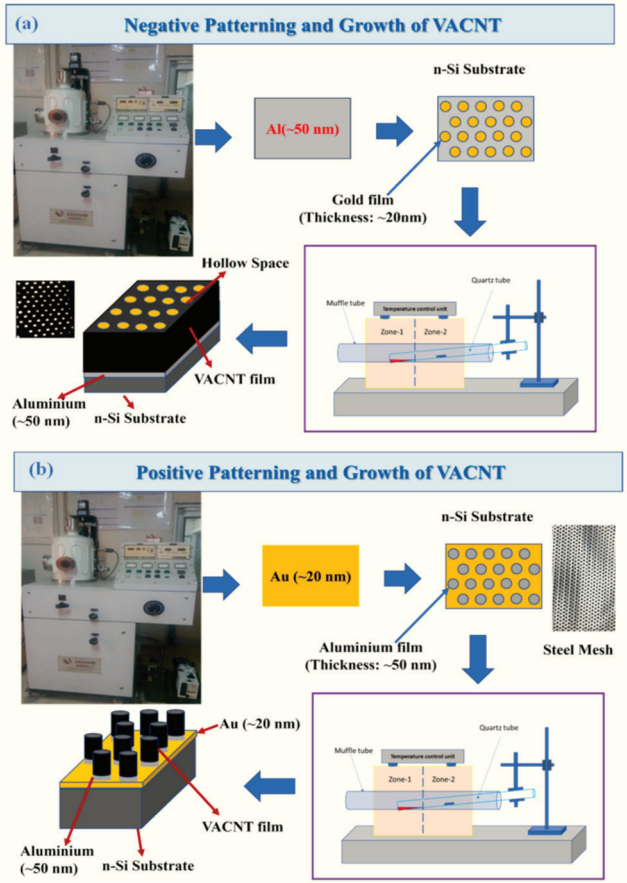
Design and fabrication of a nanohybrid-based small electron gun containing ultrasmall nanoscale emitters for electron microscopes and X-ray sources

- **Synthesized a nanohybrid-based electron gun to generate electrons for use in electron microscopes and x-ray sources**
- **Demonstrated prototypes to the Department of Science and Technology, Government of India.**

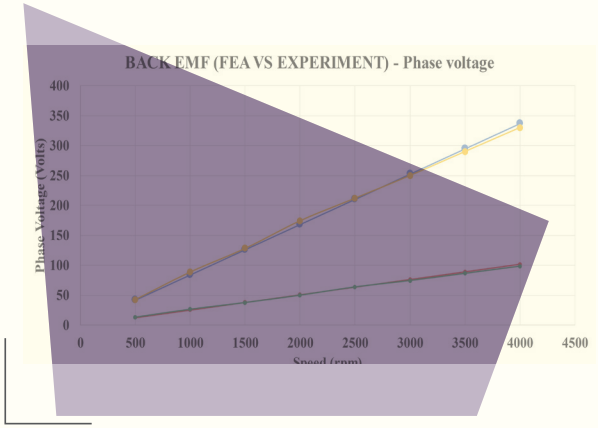
Electron microscopes and X-ray sources are extremely important for imaging materials, including biological species. At the heart of this equipment is an electron gun. For microscopes, the electrons produced from this gun interact with the specimen and produce its image down to a resolution of a few nanometers. For x-ray sources, electrons produced from this gun hit a metal target, generating the x-ray which is used for imaging biological specimens including human organs. The novelty of this type of electron gun is that it works on the principle of field emission and does not require any external heating. These guns are highly miniaturized and can therefore be assembled with table top electron microscopes and x-ray generators.

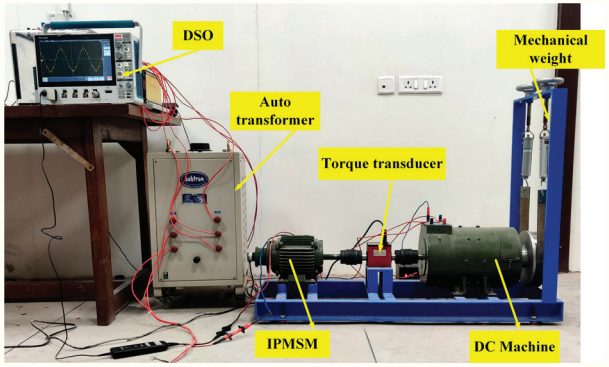
This work is ongoing under the device development project and technology development program (TDP) of the Department of Science and Technology, Government of India. We have developed and demonstrated prototypes.

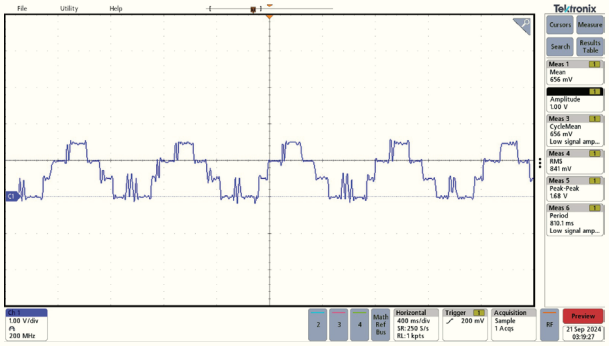
Growth of CNT pillars without lithography: Efficient cathode for field emission



Prof. Santanu Ghosh
Department of Physics







Development of Reduced Rare-Earth Interior Permanent Magnet Motors

Reducing the use of rare-earth magnets for developing the high efficiency compact motors used in electric vehicles

The motor technology presently used in the automotive industry relies on the supply of rare-earth magnets for improving the motor's efficiency and torque-density. However, the supply of such magnets is dependent on other countries. At the same time, there is risk of to releasing radioactive materials during the extraction of the elements used to develop such magnets. Reducing the dependence on rare-earth magnets is vital to improving the localization potential of automotive grade motor development and minimizing environmental hazards. Ferrite magnets, which do not use any rare earths and are readily available in India, comprise the majority of magnets in the present design. We performed the motor's analytical design and finite element simulation at the Motor Design Lab in the Center for Automotive Research and Tribology (CART). Further, we developed the proof-of-concept prototype at a power level of 5 kW. We are now upscaling the same design to 30 kW, targeting the mini-bus application, with the help of TSUYO Manufacturing India Limited, a startup company manufacturing electric vehicle powertrain components.

- **The power density of the 30 kW Motor is 5.62 kW/L**
- **The peak efficiency is observed at 94.28%**
- **The cogging torque obtained is 1.9 Nm (less than 2% of rated torque) which ensures a smooth start and jerk-free operation.**

Prof. Saptarshi Basak
Centre for Automotive Research and Tribology (CART)

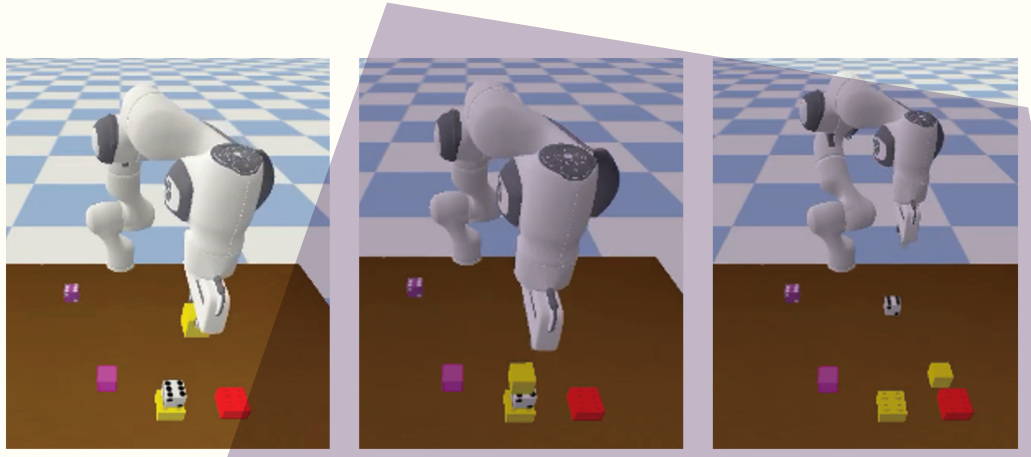
Neuro-Symbolic Intelligence for Robots to Understand and Follow Human Instructions

An AI-based algorithm allowing a robot to understand human instructions, perform reasoning or planning, and execute a high-level task such as object movement or structure assembly

Robotic agents are now found in factories, workplaces, and homes where the interaction between humans and robots is crucial. Our research has contributed AI models for a robot to understand, plan, and take actions as per the intent of the human partner. Our approach is neuro-symbolic: a form of learning that fuses symbolic search or reasoning methods with data-driven neural approaches. We innovated a method that allows a robot to observe human-object interactions and learn spatial concepts ("left, "right" or "on top") and action compositions to accomplish a task based on interpretation of such instructions as, "robot, move the red block that is to the left of the green block on top of the cyan block". Further, we equipped the robot to recover quickly from runtime errors. Our approach repairs only the part of the plan affected by the error, thereby preserving some planning effort. Further, we enabled the robot to incrementally build a rich 3D model of objects in its environment. The robot estimates locations with high uncertainty in object geometry, which aids in determining future information gathering actions to rapidly develop a complete scene model.

Our research enabled:

- **execution of multi-step (4-5 steps) interaction tasks by robot manipulators instructed by a human partner in natural language.**
- **strong combinatorial generalization to unseen tasks, and**
- **inferring a neural model for objects in the robot's workspace by information-guided visual and tactile exploration.**
- **Such capabilities can potentially impact service robots of the future supporting humans.**



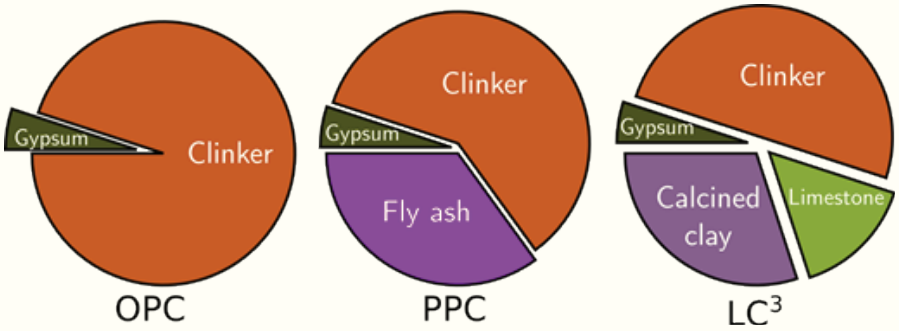
A simulated robot following the instruction, "Put the white dice above the yellow lego object and move the yellow cube on top of the white dice"

Prof. Rohan Paul and Prof. Parag Singla
Department of Computer Science and Engineering and School of AI

LC^3: A Cement for Faster, More Sustainable Development

10 years of research at IIT Delhi has led to worldwide acceptance for LC^3, a sustainable cement

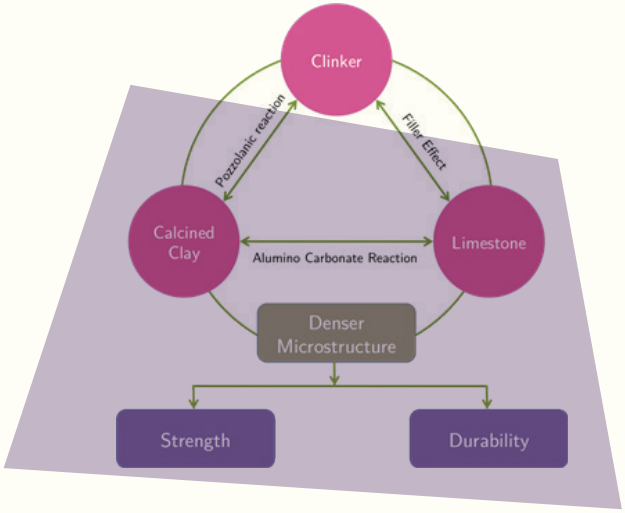
IIT Delhi has been at the forefront of development and dissemination of limestone calcined clay cement (LC^3), which reduces the CO_2 emissions in cement production by up to 40% while assuring high performance. The research began in 2012 and was accepted by the Bureau of Indian Standards (BIS) under IS18189. LC^3 is now allowed for use in preparing reinforced concrete. Its reduced clinker content of 50% can facilitate rapid, low-carbon, and cost-effective construction and, by extension, national development. While the CO_2 emissions are reduced by 40%, low grade raw materials can be used. LC^3 is strong and durable, and can be used in the same manner as other cements. It is commercially available in more than 10 countries. IIT Delhi is supporting the cement and construction industry around the world in using this technology, besides widely disseminating it through ongoing cutting-edge research. We are also mentoring a centre in Kenya for the sustainable development of African countries.



Prof. Shashank Bishnoi
Department of Civil Engineering

Due to the lower clinker content, LC^3 technology has several advantages over other cements:

- **Lower CO_2 emission per tonne of cement produced**
- **Improved resource efficiency**
- **Reduced production cost without compromising the cement's performance**
- **Low capital investment costs due to easy processing and support from existing production facilities**
- **Nearly double cement output per tonne of clinker**
- **Enhanced durability of building materials and concrete produced using LC^3**



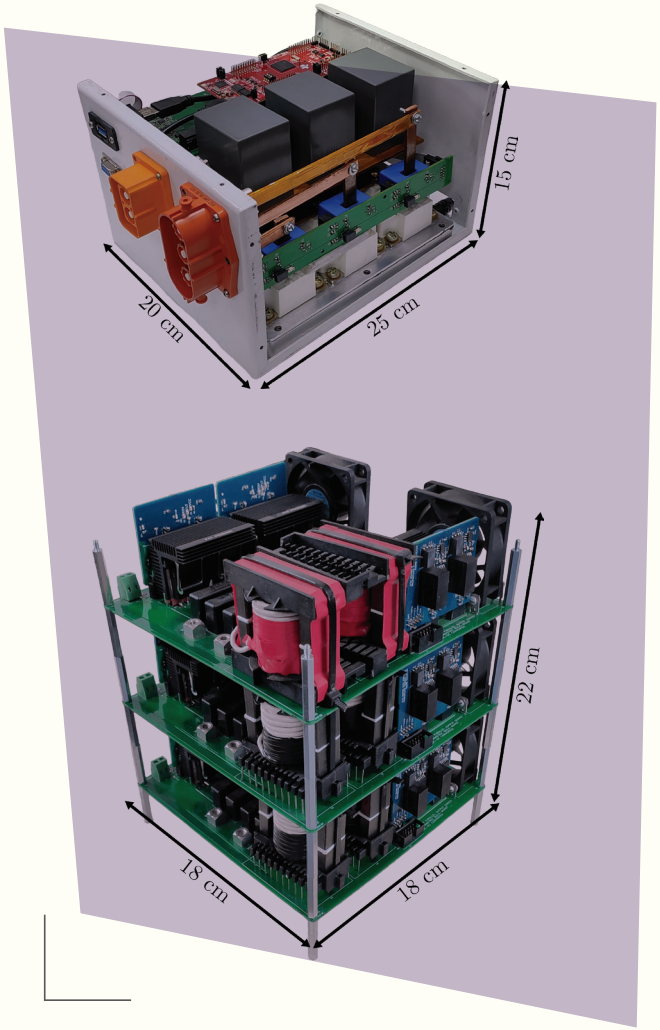
An Efficient Powertrain for Long-Range Electric Vehicles

Advanced modular converter designs to improve efficiency and reduce size across varying loads for next generation EVs

In electric vehicles (EVs), particularly hybrid and fuel cell vehicles, DC to three-phase AC conversion typically uses a two-stage system with a boost DC-DC converter and a DC-AC voltage source inverter (VSI). Powertrain efficiency directly impacts the vehicle's range, while heat sink and filter size determine the converter's compactness. Traditional boost converters exhibit reduced efficiency at low power, a critical issue as vehicles rarely operate at full speed. To address these issues, this project developed advanced buck-boost DC-DC converters with an input-parallel output-series configuration. This design lowers losses using lower voltage-rated semiconductors and current sharing, and reduces filter size through current ripple cancellation. A key innovation lies in the converter's strategic operation where one of the modules is intelligently disabled to improve efficiency when the output voltage requirement is low. Using a 24 kW SiC-based prototype with three interleaved phases, we demonstrated exceptional performance, achieving over 99% efficiency across a wide voltage range. Additionally, we developed a highly compact 50 kW VSI with a vertically stacked bus-bar design and distributed dc-link capacitors to minimize stray inductances and improve reliability.

Prof. Soumya Shubhra Nag
Department of Electrical Engineering

- **24 kW SiC-based Buck-Boost Converter: Achieved peak efficiencies >99% across 250-800 V, maintaining >98% efficiency from 10% to 100% power range.**
- **50 kW Liquid-Cooled SiC Inverter: Delivered a volumetric power density of 7.5 kW/L and gravimetric power density of 13.1 kW/kg.**



Devices for Making Tulsi Mala Beads

Development and adaptation of devices for making beads of Tulsi mala in villages around Mathura, U.P. and Bharatpur, Rajasthan

The Rural Technology Action Group (RuTAG) at IIT Delhi has modernized Tulsi mala bead-making for artisans in villages near Mathura and Bharatpur. Traditionally, artisans used hand-operated devices that limited production and caused physical strain such as back and neck pain. To address these challenges, two motorized bead-making devices were developed: one with a timing-belt pulley and another with an electronic drive. The design of these devices considered the comfort and working postures of artisans, allowing operation either while seated on the floor or on a chair with the device placed on a table. The development process incorporated the traditional knowledge of artisans, who actively contributed their expertise. The new devices have doubled productivity, empowering women artisans and increasing daily earnings by two to four times. The Group transferred the technology to Harraj Industries through FITT, IIT Delhi. The project's success is evident from the fact that local manufacturers in Jait village imitated the original design and sold over 1,500 devices. It highlights blending traditional knowledge with modern technology to enhance rural livelihoods and improve working conditions for artisans.

Prof. Subir Kumar Saha
Rural Technology Action Group (RuTAG)

- **Increased daily earnings of artisans from INR 500 - INR 700 to INR 1,500 - INR 3,000.**
- **Reduced artisans' physical strain and increased their working duration from 2-3 hours to 4-8 hours.**
- **Empowered over 1,000 women to earn livelihood and support their family financially.**
- **Different device versions adapted by imitating the new design.**
- **Over 1,500 devices were purchased by artisans entirely on their own, without any charitable assistance.**

Efficient Potters' Kilns and Air-Biomass Feeders

Indigenous development and dissemination of improved potters' kilns and mechanized devices for feeding powdery biomass and air to the furnaces

- **The developed kiln saves up to 50% of fuel. It thus also reduces emissions.**
- **The air-biomass feeder eases the feeding of powdery biomass and supplies sufficient air required for combustion.**
- **We demonstrated the kiln in more than 10 clusters across India during 2018-24.**

The air gaps in the rat-trap construction technique introduced by IIT Delhi saves up to 50% fuel when compared to kilns with a conventional structure. The Rural Technology Action Group (RuTAG) implemented this construction technique in developing kilns for earthen pottery-making clusters in Kachchh, Bharatpur, and Alwar districts between 2018 and 2024. We adopted a participatory development approach, involving experienced potters in knowledge sharing and educating communities to build and operate the kilns. Our NGO partners Khamir and Lupin Human Welfare and Research Foundation played a crucial role in operationalizing over 25 kilns in their regions. In Bharatpur and Alwar, potters traditionally use powdery mustard husk as fuel, manually feeding it into their kiln's firebox.

This labor-intensive process often results in incomplete combustion due to insufficient airflow. To address these challenges, RuTAG developed two types of air-biomass feeders with screw and hand feeders. We successfully demonstrated these feeders, capable of supplying up to 100 kg/hour of husk and 7 m^3/min of air, in Poonchhri and Semli villages of Bharatpur district and Beejwar village of Alwar district, significantly improving combustion and reducing drudgery.

Prof. M. R. Ravi and Prof. Sangeeta Kohli
Rural Technology Action Group (RuTAG)

An Indigenous Low-Cost Sheep Shearing Device

Indigenous development and dissemination of mechanized low-cost devices for shearing wool fleece

Shearing, the process of removing wool fleece from sheep, requires using either hand scissors or mechanized devices. In India, approximately 80% of sheep are shorn using hand scissors. This method is time-consuming, requiring 5 to 8 minutes to shear 300 grams of wool. Further, the prolonged use of hand scissors, typically up to 5 hours, causes muscle fatigue for shearers. Moreover, hand shearing often results in uneven cuts and shorter staple lengths, reducing wool quality and forcing producers to discard it or mix it with imported wool for processing. Mechanized devices, in contrast, shear wool closer to the skin, yielding longer staple lengths and higher-quality yarn. However, imported mechanized devices are expensive, costing around INR 2.5 lakh. To address this challenge, IIT Delhi, through RuTAG and with funding support from the Central Wool Development Board (CWDB) developed an indigenous, low-cost mechanized sheep-shearing device. Priced at INR 1.3 lakh or almost half the cost of imported alternatives, the device aims to enhance the livelihood of shepherds. We successfully tested the devices in Himachal Pradesh and Haryana, and deployed three of them in Gujarat, Ladakh, and Rajasthan.

- **The device cost is halved in comparison to an imported device which costs approx. INR 2.5 lakh to INR 3.0 lakh, with our device priced at INR 1.3 lakh.**
- **The device reduced the physical strain and muscle pain induced by using scissors for long hours.**
- **The staple length of the wool shorn by the mechanized device is sufficient to produce high-quality yarn.**

Prof. Subir Kumar Saha, add Prof. D. Ravi Kumar
Rural Technology Action Group (RuTAG)

An Energy-Efficient Underground Building for Vegetable Storage

Thermal analysis and ventilation performance of underground structures for army applications at the forward location of Leh, Ladakh

We arrived at the following conclusions from conducting a thermal analysis of existing underground buildings:

1. Ambient exposed surfaces (roofs, doors, and walls) contribute most of the heat loss compared to the surfaces in direct contact with the soil.
2. The below-ground depth of the building has the least effect on the energy performance.
3. Three-dimensional heat flow is concentrated near the corners while two-dimensional heat dominates the center, of the surfaces in direct contact with soil.

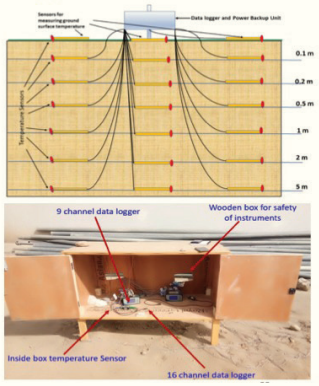
Accordingly, we came up with an optimized design using natural insulating materials on the roof and cascaded doors. Further, we achieved humidification and dehumidification requirements by mixing ambient and indoor air.

- **The modified underground building can maintain indoor temperatures in the range of 0-8 ^{0}C even in extremely cold conditions.**
- **Our design reduced the spoilage loss by 80% and extended the storage period by 5-6 months.**

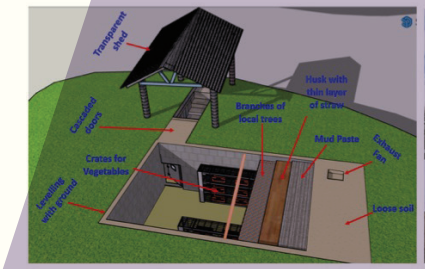
Prof. S. K. Tyagi and Prof. Rahul Goyal
Department of Energy Science and Engineering

Passive Vegetable Storage

- The Geo-climatic condition of the Leh-Ladakh is very harsh, no vegetable grows in winter.
- Local produce meets 1/3rd of total demand.
- Supply is only by air up to Army base Leh only then by road, spoilage in sub zero.
- Therefore, storage at the Army site.
- But is no electricity, so passive storage only.
- Made use of ground heat for passive storage.
- Record the temperature w.r.t. depth (0-5m).
- An SOP shared for data collection.



- Temperature range of 0-8^{0}C was found to be suitable for almost all vegetables.
- For onion the RH is very critical to be 65-70% for proper storage.
- The data provided by DIHAR was analysed, for different design parameters, and best among them was given to DIHAR for construction.
- The proposed design and constructed stores are given as below.



Proposed Final Design

The Constructed Storage

Novel Base-Isolation Devices for Earthquake Protection of Structures

Advancing earthquake resilience through innovative base-isolation devices and performance-enhancing algorithms for structural protection

We developed innovative solutions to make buildings and infrastructure safer during earthquakes. This work centers on base-isolation devices placed between a building and its foundation to reduce the impact of ground shaking. One of the key inventions is the oblate spheroid base isolation (OSBI) system. This device uses a rolling ball mechanism to stabilize structures during earthquakes and restores them to their original position once the shaking stops. Another major innovation is a tunable vibration control device, which uses adjustable springs to better absorb shocks and vibrations by matching their characteristics to the structural system. This device offers more effective shock absorption than traditional systems, especially for lightweight structures. In addition to these patented technologies, we developed methods to enhance the performance of existing devices. The copyrighted energy-based adaptive algorithm allows systems to adjust in real time using feedback sensors, while the multi-mode vibration control technique provides rational solutions to improve overall safety across various types of structures. These technologies have improved the earthquake resilience of structures, protecting lives, reducing damage, and offering practical tools for engineers worldwide.

Prof. Vasant Matsagar
Department of Civil Engineering

- **The innovations developed include two patented technologies: the OSBI system, ensuring stability for structures; and a tunable vibration control device which offers superior shock and vibration absorption.**
- **The adaptive algorithm and multi-mode control methods enhance earthquake resilience, reducing structural damage, and safeguarding lives, benefiting engineers globally.**

BioSURF: A Dual Promoter Biosurfactant Production System

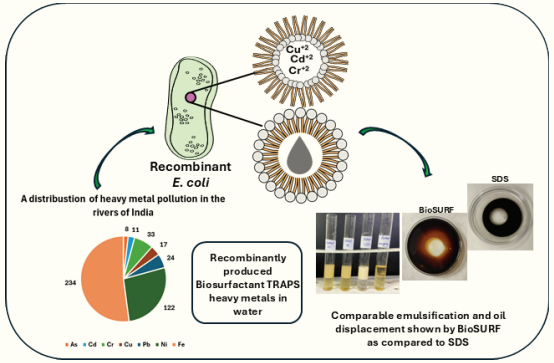
Biosurfactant-based heavy metal and oil remediation from rivers and other water bodies

Heavy metal pollution in water bodies poses a significant threat to ecosystems and human health. Traditional chemical methods for removing these contaminants often introduce additional environmental concerns. Rivers like the Yamuna which supply water to millions in India are particularly affected by this issue, highlighting the urgent need for sustainable and effective solutions for water pollution.

BioSURF is an innovative project that uses specially engineered bacteria to clean up water pollution. The team created harmless E. coli bacteria that produce natural, soap-like substances called biosurfactants. These biosurfactants act like tiny magnets for harmful heavy metals in water, making it easier to remove these pollutants. BioSURF has a unique, smart design with the bacteria having a special “switch” that allows the team to control the type and timing of biosurfactant produced. This flexibility allows adapting the bacteria to tackle different types of water pollution more effectively.

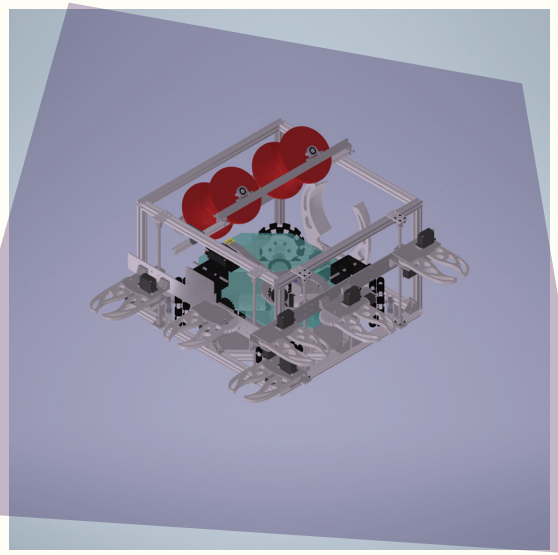
BioSURF offers a sustainable and environmentally friendly approach to water purification. Unlike traditional methods, this biosurfactant-based solution is biodegradable and non-toxic, aligning with environmental conservation efforts. The project's potential to improve water quality has far-reaching implications for public health, particularly in regions relying on polluted water sources. By addressing the limitations of natural microbial sources, such as pathogenicity concerns and low yields, BioSURF presents a scalable solution that can significantly impact water treatment practices and contribute to cleaner, safer water resources for millions of people.

- **Achieved Silver medal at iGEM 2023 held at Paris among 400 colleges from around the world.**
- **Filed for a patent for “A Method for producing Recombinant Biosurfactant” (application number: 202411086112) for the bacterial variant developed by Srivastava P., Sundar D., Bagchi A., Agarwal A. and Gupta N..**



Prof. Preeti Srivastava and Prof. Durai Sundar,
Department of Biochemical Engineering and Biotechnology

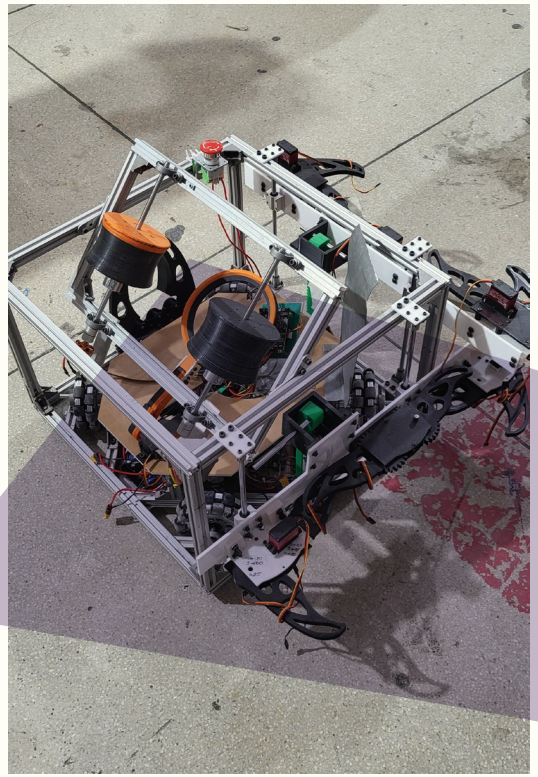
Aayushi Agarwal, Nischal Gupta, J. Ajai, and Asheemita Bagchi
Key Students



Harvesting Innovation: Robocon 2024 Challenge

Designing robots for Robocon's "Harvest Day" competition inspired by Vietnam's rice farming culture

The ABU Robocon 2024 theme, "Harvest Day," inspired by Vietnam's rice farming culture, challenges teams to simulate planting, harvesting, and storage tasks using two robots. The arena comprises three zones: planting (for seedlings), harvesting (for grains [balls]), and storage (for silos [baskets]), requiring robots to navigate seamlessly while completing specific task requirements and scoring.



- **Capable of picking and placing seedlings and throwing balls (paddy rice and empty grains) into the Storage Zone (about 5m away).**
- **Can detect balls and baskets and autonomously navigate to them using odometry and drop the picked balls into baskets.**

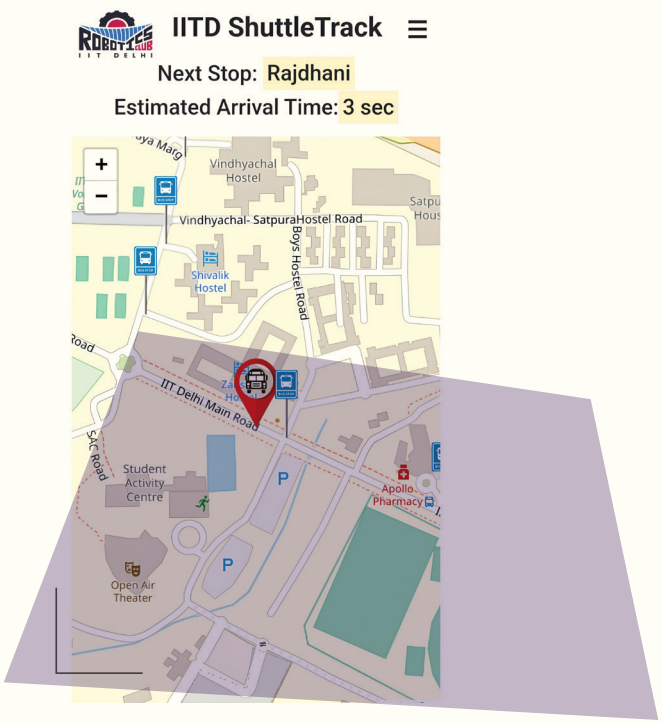
The manual robot is equipped with six grippers, mechanisms to pick, transfer, and throw balls (paddy rice and empty grains), and rollers aligned with the balls' dimensions to ensure precision when throwing. It utilizes a stereo camera to feed data into a machine learning (ML) model running on Jetson Orin, which identifies target grains (balls). The robot's three-fingered gripper then collects the ball, and motor actuators enable the robot to lift the seedlings efficiently. Finally, the robot is navigated to the baskets by 1D LiDAR in three perpendicular directions, combined with the camera feed for precise movement.

Prof. Rama Krishna K,
Department of Mechanical Engineering

Jyotiprakash Mallik, Ravi Kumawat, Shefali Sharma, and Ashish Kumar
Key Students

Reimagining Campus Transit: The IIT Delhi ShuttleTrack

A smart bus tracking system designed to make every ride at IIT Delhi effortless and efficient

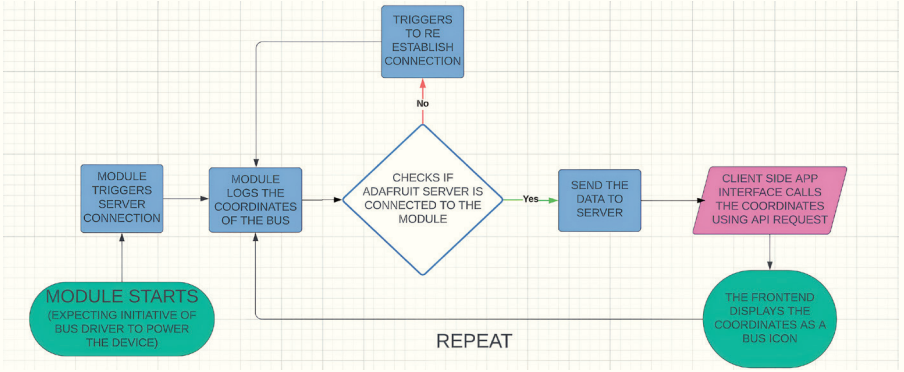


The bus tracker project is a real-time tracking solution designed to make campus transportation more efficient at IIT Delhi. Students and staff often face uncertainty about bus locations and schedules, leading to delays and inconvenience. Our webpage solves this problem by providing users with accurate, live updates on bus locations within the campus.

The tracker module uses GPS to monitor bus location and saves the data on the server which feeds into our client webpage, offering an intuitive interface that displays the live location of buses. This innovation significantly reduces waiting times and improves daily commutes for the campus community. By streamlining transportation, it provides punctuality and reduces unnecessary congestion at bus stops.

Currently developed for buses, the project can be scaled and integrated to auto-rickshaws and e-rickshaws, making the campus commute even more seamless. With a focus on accessibility and ease of use, the app ensures that even non-tech-savvy users can benefit.

- **Efficient Commutes: Minimized waiting times with real-time bus tracking, ensuring seamless travel across campus.**
- **Scalable Integration: Built to expand, incorporating autos and e-rickshaws for a unified campus transport system.**
- **Widespread Impact: Improved daily transit experience for over 5,000 students and staff at IIT Delhi.**



Prof. Rama Krishna K
Department of Mechanical Engineering

Garv Patidar, Sthitapragyan Mallick, Kataru Siri Dharan, and Abhishek Arnav
Key Students

An IoT Application: Biometric Attendance System

Following the discontinuation of the existing attendance system, we developed an IoT-based biometric solution for secure, paperless attendance

The biometric attendance system developed as part of this research project leverages advanced IoT technology to address the shortcomings of the previous attendance system. The device features a 2.8-inch vibrant touchscreen TFT display, ensuring a user-friendly interface for seamless operation. Equipped with a USB-C port for fast charging, the device provides convenience and efficiency. It can securely enroll up to 1,000 fingerprints, enabling large-scale implementation across various institutions.

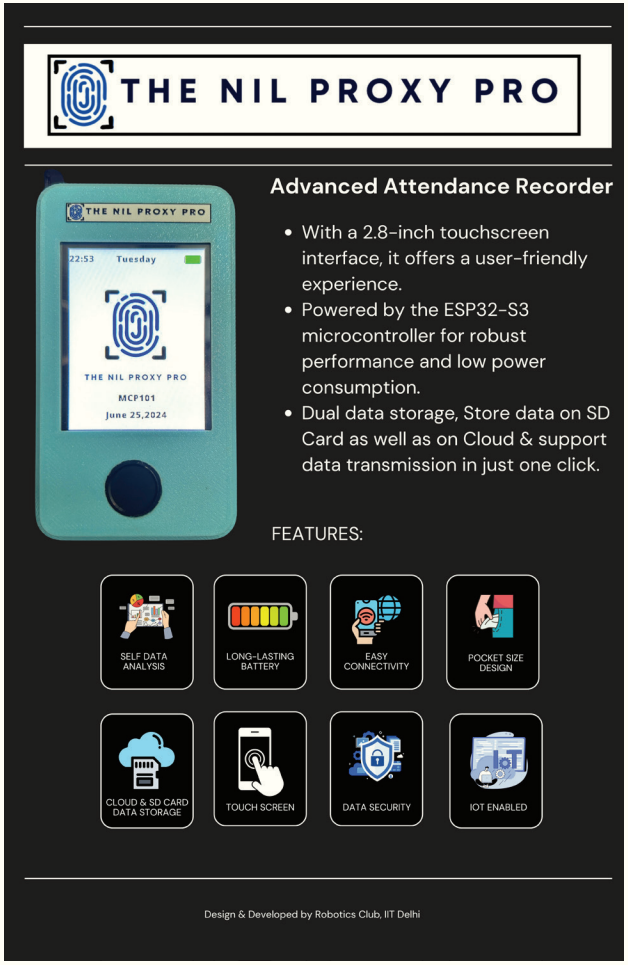
The device data is securely stored both locally and in the cloud, with Google's security ensuring cloud data protection. We designed the system to connect effortlessly to the IIT Delhi Wi-Fi network, enabling real-time data synchronization. A built-in Real-Time Clock (RTC) ensures precise timekeeping for accurate attendance records.

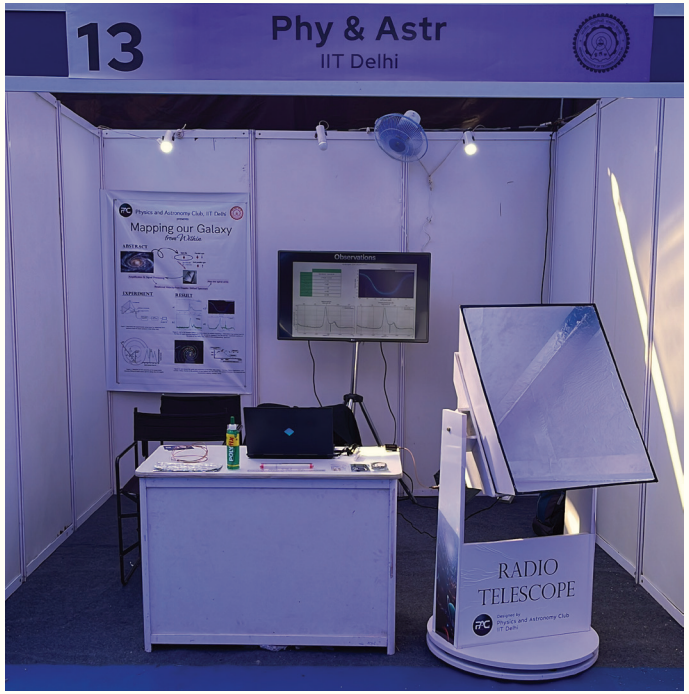
We have implemented this system across multiple departments and it is also used daily for mess attendance management in various hostels. Furthermore, we tested it in the MCP101 course, for which over 650 students have enrolled, proving its reliability and scalability.

Prof. Sunil Jha
Department of Mechanical Engineering

Madhav Gupta, Aman Gupta, and Arunim Garg
Key Students

- **Successfully enrolled up to 920 fingerprints, ensuring scalability across large student populations.**
- **Enabled cloud-based data storage with Google's security guaranteeing data integrity and protection.**
- **Implemented the solution in multiple departments and hostels, demonstrating its reliability in managing daily attendance for over 650 students.**





Mapping the Milky Way Rotation Curve and Spiral Structure

Building a low-cost 21 cm radio telescope, detected galactic emissions, derived rotation curves, and mapped neutral hydrogen clouds

- **Designed and constructed a pyramidal horn antenna to observe 21 cm hydrogen line emissions from interstellar HI regions.**
- **Successfully mapped the Milky Way's structure and rotation curve, revealing mass distribution and dark matter effects.**
- **Utilized HI-line software for precise spectroscopic analysis and signal processing.**

As members of the Physics and Astronomy Club (PAC), we took up a collaborative project to design and construct a 21 cm hydrogen line antenna for observing interstellar HI regions. This project aimed to map the structure and derive the galaxy rotation curve of the Milky Way by capturing radio emissions from neutral hydrogen atoms in the galaxy. Using a pyramidal horn antenna, coupled with a Low Noise Amplifier (LNA), a band-pass filter, and a software-defined Radio (RTL-SDR), we successfully amplified and analyzed signals from interstellar sources.

Our innovation was not only in the design but also in leveraging HI-line software for spectroscopic analysis, enabling precise measurements of hydrogen line emissions. This project provided insights into the galaxy's dynamics and its spiral structure, such as the distribution of mass and the effects of dark matter, which are critical for understanding fundamental astrophysical phenomena.

Beyond its academic significance, this work has broader implications in radio astronomy, offering a cost-effective, scalable method for observational studies. By democratizing access to high-quality data, this approach could inspire future innovations in the field. It also allowed us to develop hands-on skills in antenna electrodynamics, instrumentation, and data analysis, equipping us to tackle more complex astrophysical challenges.

Prof. Suprit Singh
Department of Physics

Divyanshu Bansal, Satwik Mittal, and Harshil
Key Students

Control Systems for Quadcopter Stability and Emergency Response

Developing robust solutions to stabilize quadcopters during motor failures, ensuring safer and more reliable drone operations

In the rapidly growing drone industry, safety and reliability are paramount. To address the critical challenge of motor failure in quadcopters, our team developed an innovative solution designed to maintain stability and control when even a single motor fails. Over two months, we focused on creating a robust detection algorithm to identify motor failures in real-time and implementing advanced control mechanisms for stabilization and safe recovery.

Our project uses adaptive control algorithms integrated into the PX4 flight stack, making it compatible with existing drone software. The system allows drones to continue operations with three functional motors, enabling emergency landings or autonomously returning to the launch position.

We have successfully addressed 60-70% of the problem and are actively working toward a complete solution. Once fully developed, this innovation will not only enhance drone safety and reliability but also set a benchmark for industrial drone applications.

Its ability to integrate seamlessly with various drone platforms makes it a game-changing development, ensuring broader applicability in significantly improving operational efficiency and reliability across industries.

- **Achieved 70% of the solution; nearing full completion.**
- **Seamlessly integrated with existing drone platforms for widespread adaptability.**
- **Set new standards for safety and operational efficiency in industrial drone applications**

Prof. Vamsi Krishna Chalamalla
Faculty Coordinator, Aeromodelling Club
Department of Applied Mechanics

Students:
Aman Sheoran, Jyotiprakash Mallik, Sanghvi Samyak Siddharth, Lakshya Bhatnagar, Mohit Kumar, Mohd Zaki, Ravi Kumawat, Soham Patil, Vaibhav Singh Maurya

- **Designed, fabricated, and tested Formula Electric Race Car with a 400 V battery, 52 kW Motors with an E-Differential powertrain capable of accelerating from 0-100 kmph in < 3 sec for the Formula Student races**

IIT Delhi's Formula Students

Developing the XLR-23 electric race car that ran on the Formula One (F1) racing track in Hockenheim, Germany

Formula Student challenges team members to go the extra step in their education by incorporating into it intensive experience in building and manufacturing as well as considering the economic aspects of the automotive industry.

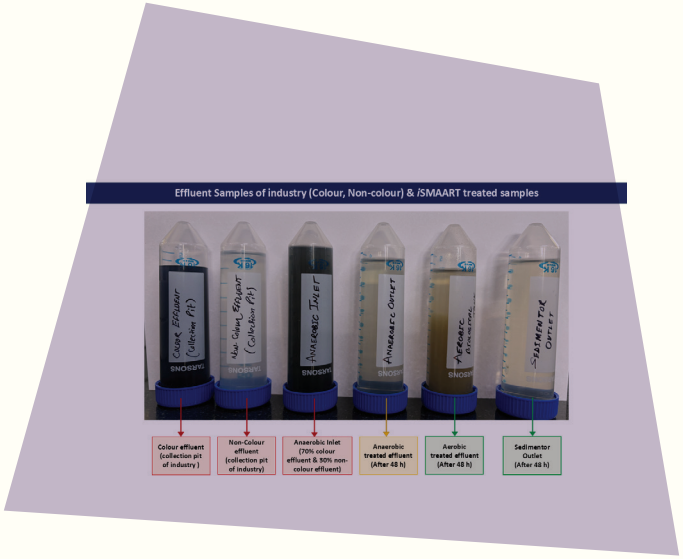
With the XLR-23, we cleared the technical scrutiny and became one of only 3 Indian Teams to drive our race car in Hockenheim at Formula Student Germany.

XLR-23, the 5th electric car developed by Axlr8r Formula Racing continues the legacy of its predecessor, the XLR-20, with a strong focus on dynamic performance. The team set goals according to hierarchy at the future, seasonal, vehicle, and subsystem levels. Future goals include an autonomous EV, a monocoque chassis, and a 4-wheel drive for enhanced power. Our seasonal goals, derived from these objectives, are greater **testing and tuning of control systems** to set up a foundation for autonomous functionalities and to gain system design experience for smaller wheel assemblies. Thus, our vehicle maximises powertrain utilization by implementing e-torque vectoring. We also **shifted to 10-inch rims from 13-inch** on the two-wheel drive itself.

Prof. JK Dutt
Department of Mechanical Engineering

Core team this season:
Manasi Korade, Anees Ahmed Khan, Mayank Arya, Akanksh Saxena, Polasa Durgadevi, Siddhant Dhirde, Aashay Pojge

Alumni:
Ishan Jain, Vatsal Mathur, Prateek Chandel, David, Sushmita Patil, Nikunj Gupta, Yashdeep, Muskan Gupta, Sandesh Choudhary, Bittu Kumar, Navneet Kumar Kashyap, Kailash Chandra Gupta, Bhavesh Bhati, Shovan Bairi, Tanmay Gupta



Improved Sequential Microbial-Based Anaerobic-Aerobic Reactor Technology (iSMAART): A Cutting-Edge Solution for Textile Effluent Treatment Achieving Zero Discharge (ZLD) Policy

A sustainable microbial based technology addressing textile effluent challenges for enhanced efficiency, resource recovery, and user-friendly microbial products

- **Novel microbial consortium developed for real textile effluent treatment**
- **Sustainable treatment technology for textile industries to fulfill ZLD criteria**
- **NaCl recovered from treated effluent exemplifies inner loop recycling, promoting sustainability and resource efficiency**
- **Microbial capsules developed show extended shelf life, ensuring ease of market access.**

The textile industry drives global fashion but faces environmental challenges due to extensive dye and chemical use which poses a negative impact on the ecosystem. In response, the Government of India has implemented stringent regulations, leading to the closure of non-compliant textile industries by the National Green Tribunal. Addressing these issues, we developed a novel microbial consortium-based decolourization process that can degrade dye molecules into non-toxic forms offering an eco-friendly approach for textile effluent treatment. Leveraging this capability of the microbial consortium, the research team developed Improved Sequential Microbial Consortium-Based Anaerobic-Aerobic Reactor Technology (iSMAART) as a cutting-edge solution to for textile effluent treatment. iSMAART operates under industrial conditions (TRL7) and achieves >94% decolorization and ~92% COD reduction during continuous 70-day operations. This technology is resilient to fluctuations in inlet parameters and site conditions. The treated effluent can be used to recover NaCl salt which can be reused in the dyeing unit of the textile industry. Enhancing market potential, the microbial consortia used in the process were formulated into products like tablets and capsules, simplifying their use for stakeholders. This innovative technology ensures regulatory compliance and aligns with sustainable development goals (SDGs). Therefore, iSMAART represents a scalable, eco-friendly solution for addressing environmental challenges in the textile industry.

Prof. Anushree Malik
Centre for Rural Development and Technology

Solar Water Pumping using Solar Grid-interfaced Systems

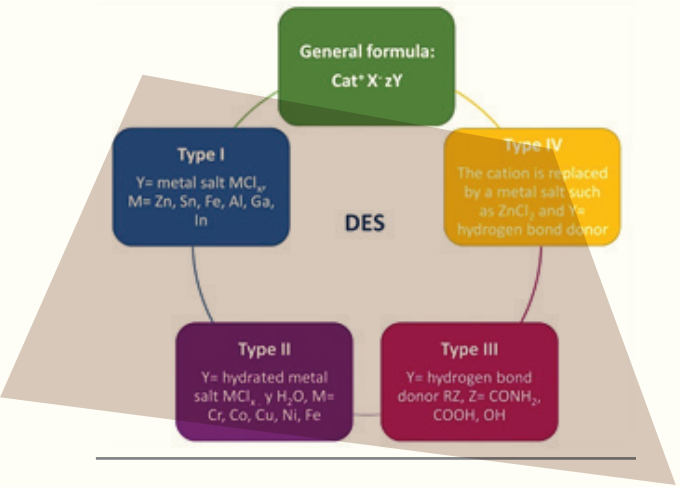
Leveraging an energy-efficient BLDC motor, a squirrel cage induction motor, a switched reluctance motor, a permanent magnet synchronous motor, and a synchronous reluctance motor for solar water pumping, solar photovoltaic power generation, and renewable energy-based charging stations.

We developed a novel water pumping system - leveraging a grid-interfaced high-efficiency brushless motor and drawing power from a solar photovoltaic array - for irrigation and supplying water. Using the most efficient brushless motor without current, position, or speed sensors enabled reducing the size of the solar panels. When not pumping water, the power generated by the solar array is fed into the grid. We designed this sytem using a brushless DC (BLDC) motor, a squirrel cage induction motor, a switched reluctance motor, a permanent magnet synchronous motor, and a synchronous reluctance motor for optimal operations and longer life. This development resulted in a low cost and efficient water pumping systems suitable for isolated rural areas across the Indian subcontinent. We are implementing this technology jointly with Messrs. Shakti Pumps Private Limited, Indore, India.

Developing solar grid-interfaced systems in single-stage and double-stage, and single-phase and three-phase configurations offered improved power quality for other connected loads at the point of common coupling (PCC) and enhanced the utilization of its voltage source converters over the 24 hours of the day for a reduced payback.

Prof. Bhim Singh
Department of Electrical Engineering

- **Developed optimally designed, energy-efficient cage induction motors for irrigation pumps operating under realistic conditions of voltage fluctuations and load variations (because of water level change in the rural sector)**
- **Motors delivered high efficiency and high power factor, resulting in substantial energy savings.**

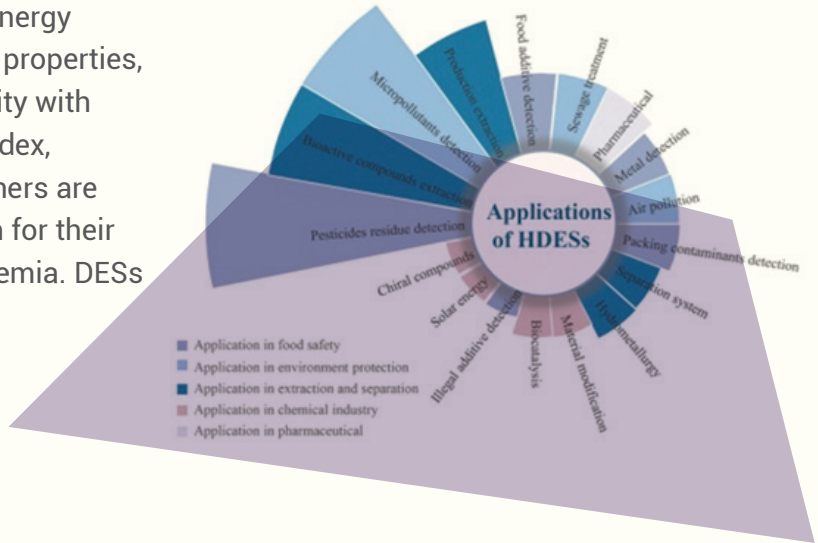


Deep Eutectic Solvents as Green Alternatives to Conventional Solvents

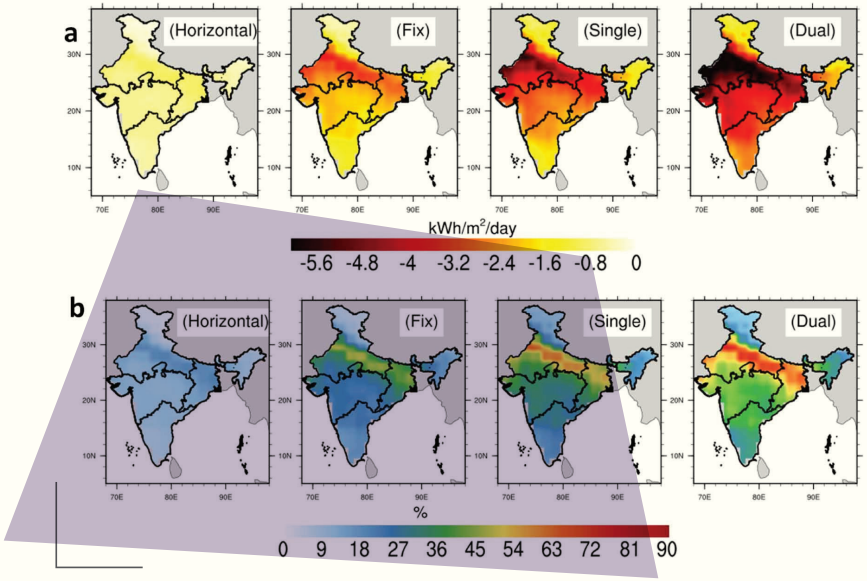
Investigation of solute solvation and molecular aggregation within deep eutectic solvent (DES) based systems to understand their properties

Investigation of physicochemical and spectroscopic properties of DESs will help in establishing them in visioning molecular architecture by manipulating intermolecular interactions, to design and optimize these novel solvent media for prospective applications and usability. We aim to establish DESs as environmentally-benign solvent systems that will replace conventional harmful organic solvents.

Researchers have been steadfastly striving to replace conventional (usually toxic) solvents with smart new-age environmentally-friendly solvents due to the harmful nature of volatile organic solvents (VOCs). The primary emphasis of our work is to gain molecular-level understanding of one such possible candidate - deep eutectic solvent (DES) - for its mass transport, charge transfer, solute solvation, dynamics, and molecular aggregation efficiency. DESs are constituted simply by mixing two or more components (usually inexpensive and benign solids) under ambient conditions with no energy penalty. Several important physical properties, such as dynamic viscosity, miscibility with other solvents, density, refractive index, and surface tension, and among others are estimated initially to establish them for their applications in industries and academia. DESs are developed for solute solvation/dynamics and diffusion using variety of spectroscopic and non-spectroscopic techniques and tools. The ability of DESs to support molecular aggregation, including dye aggregation, inter- and intra-molecular association in bifluorophoric molecules, formation of vesicles, gels, and microemulsions, micellization of surfactants, and surface-active ionic liquids (SAILs), has been investigated to facilitate their applications in synthesis, chemical separation, and catalytic science.



Prof. Siddharth Pandey
Department of Chemistry



The work was published in Environmental Research Letters – Ghosh et al. (2022), 17, 054007 and highlighted by several media houses.

Key message: Mitigating air pollution would accelerate India's progress towards its solar energy target at a lower installation capacity thereby increasing the financial returns

Air Pollution Diminishes India's Solar Energy Potential

This work addresses how air pollution has impacted India's ambitious solar energy target in the last two decades and the expected benefits

Expansion of solar energy infrastructure is crucial for India's ambitious plan to transition to renewable energy and achieve net zero targets. However, solar radiation gets reduced by fine particles, and the efficiency of the panels gets reduced due to the deposition of these particles on solar panels (Figure 1). Using various data measured by satellites, the study showed that India lost 29% of its utilizable solar energy between 2001 and 2018 (Figure 2). This translates to an economic loss of USD 245-835 million annually. If India reduces ambient air pollution, meeting the National Clean Air Program target everywhere and every household in India (which continues to use solid biomass for cooking, heating, and lighting) switches to clean energy (e.g., LPG), an additional 6-16 TWh of solar energy can be generated annually from the existing solar power infrastructure. This would translate to an economic benefit of USD 325-845 million annually. The work established the importance of considering environmental factors in solar energy resource assessment.

Prof. Sagnik Dey, Prof. Dilip Ganguly, and Prof. Somnath Baidya Roy
Centre for Atmospheric Sciences

Revolutionizing Structural Health Monitoring with Refined Lamb Wave Time Reversal Method

Structural Health Monitoring (SHM) ensures the safety and reliability of critical structures like aircraft, pipelines, wind turbine blades, and ship hulls by detecting damage early through built-in sensors

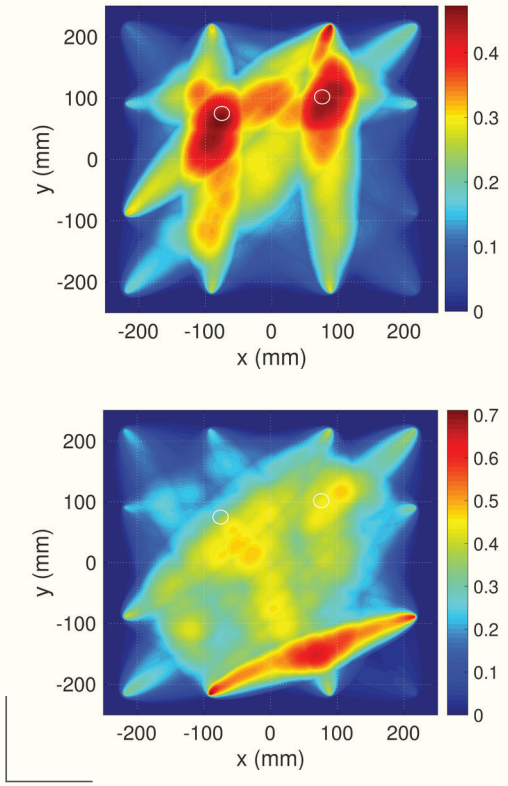
Our researcher group has made groundbreaking advancements in structural health monitoring (SHM) for critical thin-walled structures like aircraft fuselages, pipelines, wind turbine blades, and ship hulls. Traditional SHM methods often rely on baseline comparisons, which can be unreliable under changing environmental conditions. Our team has developed a cutting-edge Refined Time Reversal Method (RTRM) using Lamb waves that eliminates the need for baseline signals, while ensuring unparalleled damage sensitivity.

Unlike conventional approaches, RTRM excels in varying temperatures. We discovered that the conventional time-reversal method (TRM) fails under temperature changes, making it unsuitable for real-world applications. RTRM solves this long-standing challenge by using a “Best Reconstruction Frequency,” ensuring accurate damage detection and localization, even under thermal variations.

Supported by experimental and numerical studies, our work includes accurate analytical and fast simulation models for efficient design of SHM systems. These models capture the complex interaction between piezoelectric sensors and structures, enabling precise simulation of wave actuation and sensing.

RTRM is now recognized internationally, with testing underway at leading centers like TESTIA (AIRBUS) and DLR, Germany, funded by the Indo-German Science and Technology Centre. This innovation promises safer, more reliable infrastructure worldwide.

Over five years, this research has led to more than 30 top-tier journal papers and 18 invited talks worldwide. The Refined Time Reversal Method (RTRM) is hailed as a breakthrough, with global reviews recognizing it as the only baseline-free SHM technique effective under varying temperatures.



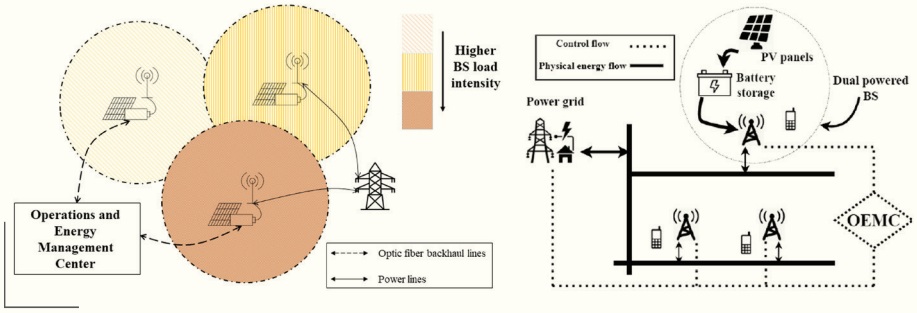
Prof. Santosh Kapuria
Department of Applied Mechanics

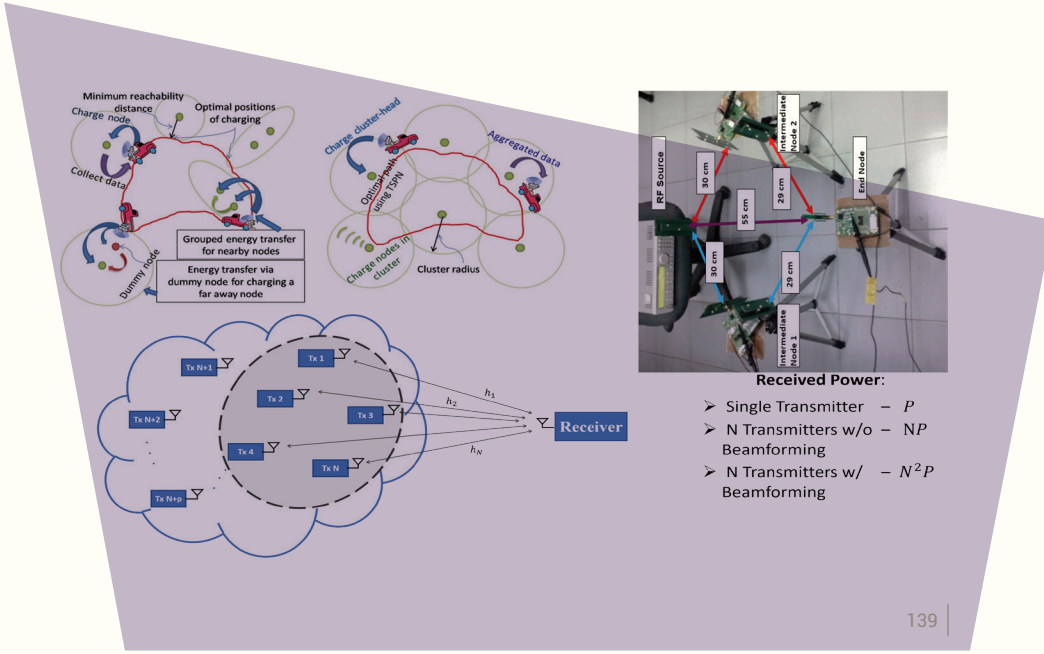
Leveraging IoTs for Sustainable Wireless Networks

Innovating a context aware AI/ML-aided Internet of Things (IoT) for sustainable, smart wireless environments

Our proposed context-aware, learning-based data pruning and smart sensing technology solutions have attracted significant attention. We developed a context-adaptive, learning-based data pruning technology for smart meters and data loggers which has since been implemented in campus installations. We have indigenously designed and developed an energy-efficient, ambient energy-aware, sustainable multi-sensing node offering minute and accurate sensing capability at an affordable cost. We have since transferred our edge computing-assisted smart pruning and sensing solutions, and cooperative energy and traffic management solutions to multiple IIT Delhi start-ups on both non-exclusive and exclusive bases. Multiple technology companies are actively pursuing and field-trialling these technology solutions. These companies include several start-ups, Tehri Hydroelectric Development Corp., and Airtel, all seeking customized deployment and technology adoption. Our research has led to the creation of two start-ups specializing in energy-efficient IoT solutions, incorporated in 2021 and 2022, respectively, and being nurtured at the IIT Delhi Technology Incubator.

Research recognized among top 10 indigenous 5G technology developments by the Department of Telecommunications (DoT, Government of India) in 2023.





Prof. Swades De
Department of Electrical Engineering and Bharti School of Telecommunication

New Algorithms that Enable Scheduling with Priorities

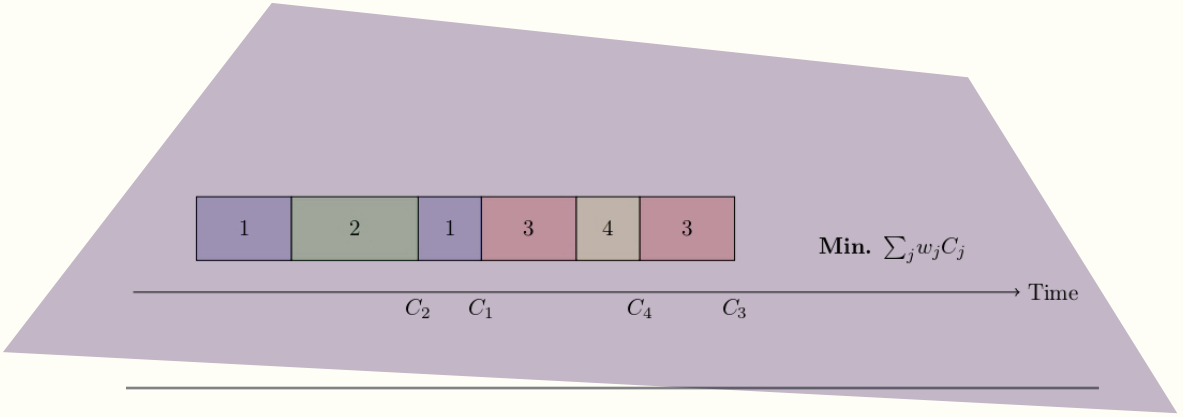
First constant-factor approximation for weighted flow time scheduling with preemption

- **First constant-factor approximation for the weighted flow time problem with preemption.**
- **Resolves a major open question in scheduling theory.**
- **Balances job priorities and system-wide performance with theoretical guarantees.**

Imagine a single machine where jobs arrive at different times, each with a weight (importance) and a processing time. The challenge is to decide the order of these jobs to minimize the total weighted flow time, i.e. the sum of the time for which each job waits adjusted by its importance. This minimization is critical in many systems, such as manufacturing or cloud computing, where priorities vary.

For years, finding a constant-factor approximation for this problem in an online setting (where jobs arrive unpredictably) was a major open question in scheduling theory. Our team made a breakthrough by presenting the first constant-factor approximation algorithm for the online weighted flow time problem. Our method demonstrated new connections between scheduling problems and problems arising on networks wherein ``disconnecting'' a set of users is required. We extended this idea to give significantly improved results on many related problems.

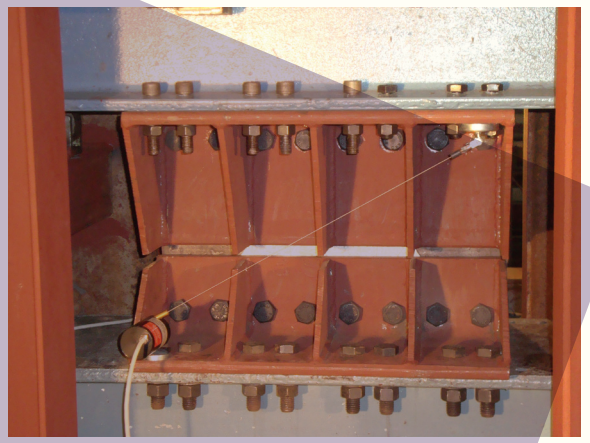
Our work not only offers a after solution a longstanding theoretical problem but also has practical implications, offering efficient ways to handle job scheduling in real-world systems.



Prof. Naveen Garg and Prof. Amit Kumar
Department of Computer Science and Engineering

Using Novel Structural Fuses and Energy Dissipating Devices to Resist Earthquakes

Improving earthquake resistance of civil infrastructures through passive energy dissipation and supplemental damping using metallic yielding techniques



- **Tested the device's components as well as prototype and observed excellent earthquake-resistance potential.**
- **Studied the effectiveness of these devices for retrofitting a prototype building frame**
- **Received three Indian patents for these devices.**

We developed structural fuses and energy dissipation devices leveraging the yielding characteristics of steel and aluminum elements by eliminating compression buckling problems. Structural fuses called buckling-restrained aluminum shear yielding devices (BR-AlSYDs) comprise a soft aluminum core plate sandwiched between restraining elements. All-steel buckling-restrained braces (ABRBs) are special structural systems that provide lateral strength and ductility besides dissipating seismic energy. One of the objectives of seismic-resilient structures is to preserve their utility during and after an earthquake event. We also developed self-centering braces (SCBs) using Fe-based super-elastic (Fe-SMA) material to increase their self-centering capability in the event of earthquakes. Depending on site constraints, these devices can be installed either diagonally, between the joints of members, or partially filling the panel or just below the beams or girders of buildings or bridges. These devices are not only highly effective and less expensive, but are also ready for on-site production and installation. Further, they are suitable for upgrading or retrofitting existing deficient structures.

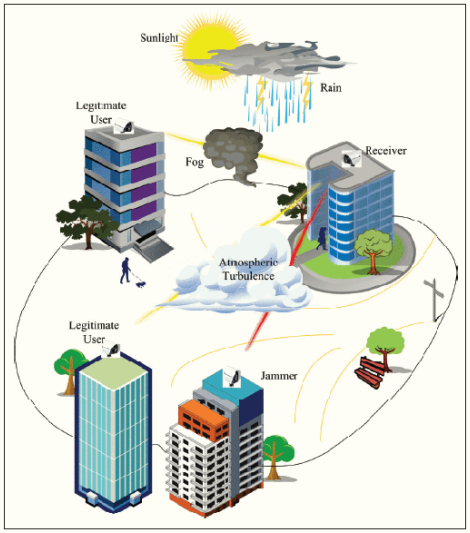
Prof. Dipti Ranjan Sahoo
Department of Civil Engineering

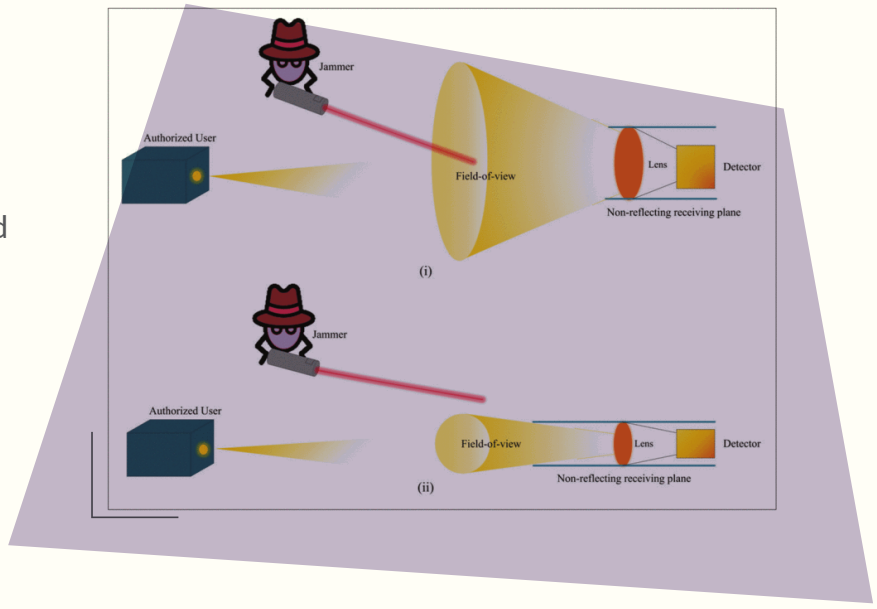
Mitigating Jamming in Free-space Optical Systems

Investigating the genesis, potential, and mitigation of Jamming in diverse wireless communication networks

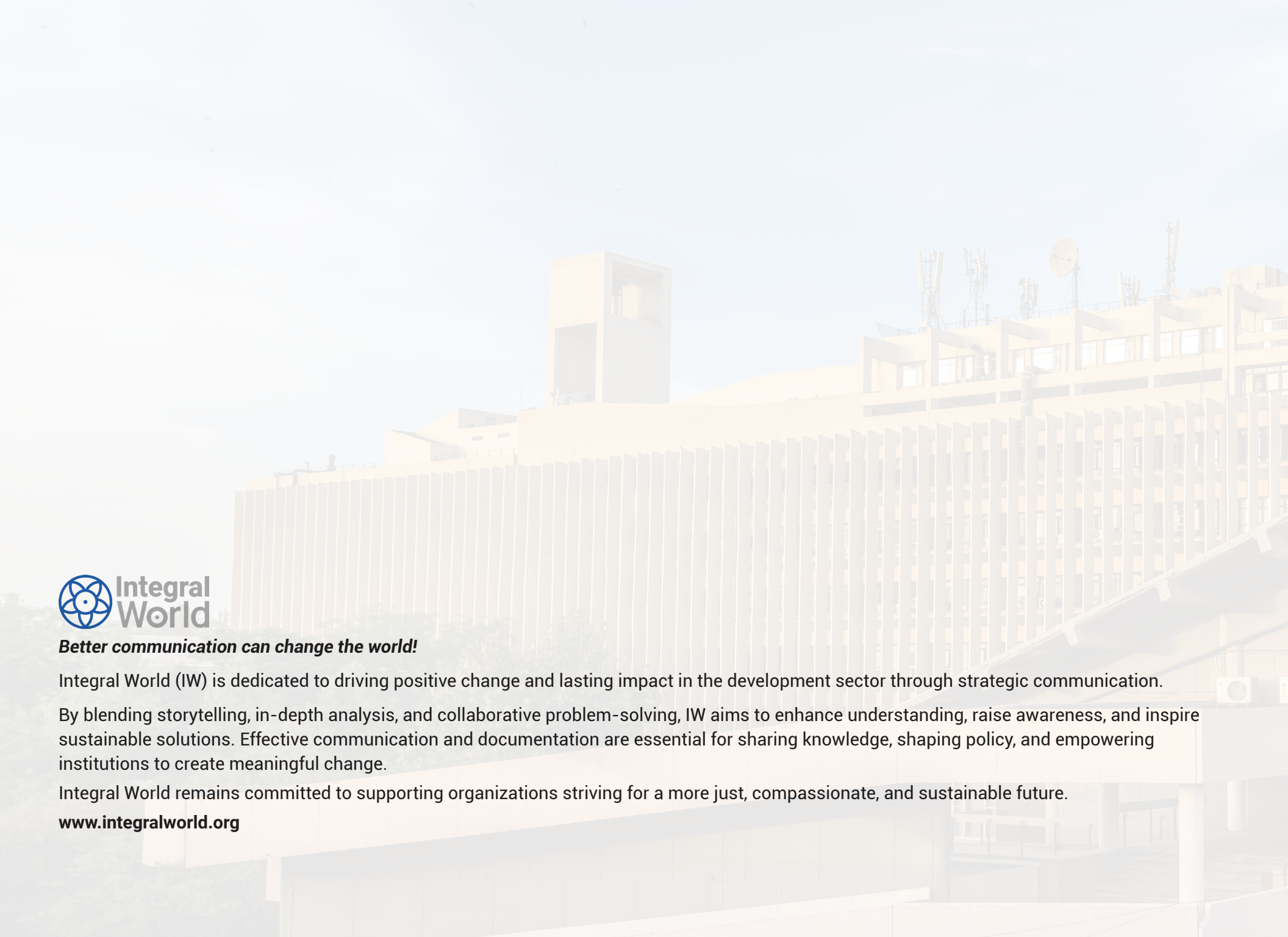
Jamming, in its essence, is the deliberate disruption of communication signals between a transmitter and a receiver. It involves injecting interference into the channel and effectively obstructing the smooth flow of data.

The development of the Meadowlands jamming system and the Counter Communications System Block 10.2 by the United States of America (USA) is a response to advancements made by China and Russia via investing heavily in co-orbital weapons and GPS interference technologies. Such intense militarization of space led us to ponder on the potential, implication, and mitigation of jamming in diverse wireless communication networks. Free-space optical (FSO) systems, which use laser beams for transmitting information, are increasing in significance due to their high bandwidth and immunity to radio frequency interference. FSO technology is currently deployed in many domains and applications, including Starlink satellites. Given the exponential growth in research on both physical layer disruptions and FSO communication, we ask about the impact of jamming and eavesdropping in FSO systems. In this regard, we designed novel system models in diverse FSO communication domains, including multiple transmitters, relay networks, and eclectic noise representations, accounting for ever-changing atmospheric conditions, and employing Game Theory. For each of these research problems, our study has proposed unprecedented mathematical models accompanied by a strict performance evaluation to verify their veracity. Several academic projects related to terrestrial and non-terrestrial communication systems, such as multidomain anti-jamming algorithm design and anti-jamming resource allocation, are also concerned with jamming, which has now presented itself as an imminent threat to wireless communication.





Prof. Manav Bhatnagar
Department of Electrical Engineering



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Indian Institute Of Technology Delhi
Hauz Khas, New Delhi - 110016
www.iitd.ac.in