Projects Page

At UPES, research is at the heart of innovation, driving solutions to some of the world's most pressing challenges. Our diverse research projects span multiple disciplines, including computer science, health sciences, engineering, sustainability and more.

From leveraging deep learning for fetal arrhythmia detection to developing eco-friendly agricultural strategies and advanced materials for ballistic protection, UPES researchers are pushing boundaries with groundbreaking discoveries. Supported by prestigious funding agencies such as SERB, DST, and KVIC, our projects address critical issues in healthcare, energy, environmental conservation, and national security.

With a strong focus on applied research, industry collaboration, and societal impact, UPES is advancing knowledge, creating technological breakthroughs, and shaping a better future for communities worldwide.

Ongoing Projects

1.

Name: Muthukumar Ka

School: School of Computer Science

Title: Data-Driven Approaches for Enhanced Detection of Fetal Arrhythmia

Funding Agency: Science and Engineering Research Board (SERB)

Objective: The project aims to advance the detection of fetal arrhythmias and assess the quality of fetal electrocardiogram (FECG) signals through cutting-edge deep learning and innovative evaluation techniques.

Key Highlights:

- **Deep Learning for Arrhythmia Detection**: Classifies FECG signals into normal or arrhythmic categories using deep learning, reducing reliance on precise heartbeat detection.
- **Signal Quality Assessment with EMD**: Uses Earth Mover's Distance to compare FECG signals against a reference, removing the need for labeled training data.
- **Enhanced Signal Analysis**: Employs unsupervised learning techniques to categorise signal quality, improving fetal heart rate estimation and arrhythmia detection.
- **Automated Evaluation**: Streamlines analysis with an automated process to identify low-quality signal segments.

Application and Impact: The project has a significant societal impact by improving prenatal care through advanced tools that enhance fetal health monitoring and intervention strategies. By enabling the early detection of fetal arrhythmias, it supports timely interventions that can reduce infant mortality and morbidity. Additionally, it provides clearer diagnostic insights, alleviating anxiety for expectant parents and fostering reassurance about the health of their unborn child. Furthermore, the project establishes a foundation for innovation in fetal health technologies, paving the way for future advancements in prenatal healthcare.

This project addresses critical challenges in fetal arrhythmia detection and FECG signal quality assessment, contributing to improved pregnancy outcomes and advancing prenatal healthcare technologies.

2.

Name: Prasanta Mandal

School: School of Advanced Engineering

Title: Ultra-Sensitive SERB Probing for food and health safety using hybrid plasmonic metasurfaces and dual-beam pump-probe Raman

Funding Agency: Science and Engineering Research Board (SERB)

Objective: The project aims to design, compute, and fabricate cost-effective hybrid plasmonic metasurfaces using advanced soft and interference lithography techniques. These metasurfaces will provide high sensitivity essential for precision applications. Additionally, it seeks to develop a novel dual-beam pump-probe near-field Raman methodology, enabling ultra-sensitive Surface-Enhanced Raman Scattering (SERS) detection with a focus on applications in food and health safety. Another key objective is to understand the physical mechanisms behind high SERS enhancement by exploring the influence of surface plasmon resonance (SPR) excitation using a dedicated pump beam.

Key Highlights:

- **Dual-Beam Pump-Probe Raman:** Enhances Raman sensitivity by using separate beams for SPR excitation and signal measurement.
- **Ultrasensitive SERS Detection:** Enables precise molecular fingerprinting with high sensitivity.
- **Hybrid Plasmonic Metasurfaces:** Cost-effective substrates fabricated using soft and interference lithography.
- **Versatile Applications:** Applicable in food safety, forensic science, and medical diagnostics.

Application and Impact: The dual-beam pump-probe Raman system and hybrid plasmonic metasurfaces will revolutionise molecular sensing, enabling highly sensitive and cost-effective SERS detection. This development holds promise for a wide range of fields, including spectroscopy, chemical sensing, defense, forensic science, and medical diagnostics.

By overcoming challenges like high laser power requirements in Raman sensing, the project paves the way for more accessible and efficient SERS platforms. The research outcomes, documented through publications and patents, will drive innovation, offering significant advancements in molecular analysis, food safety, and health monitoring technologies.

3.

Name: Dr. Himanshi Jangir

School: School of Health Sciences and Technology

Title: A Novel Eco-Friendly Nano-Agriculture Strategy for Small-Marginal Farmers of Higher Himalayas: A Nano-Pyrite Based Seed/Root/Shoot Treatment Approach for Improving Potato Yield and Dairy Green Fodder Production

Funding Agency: Sree Padmavathi Venkateswara Foundation

Objective: The project aims to develop a sustainable, fertilizer-free nano pyrite seed, root, and shoot priming strategy to enhance potato and green fodder crop production in the Himalayan region. It seeks to transform subsistence farming into a profitable agribusiness while preserving the unique Himalayan ecosystem. By reducing dependency on synthetic fertilizers and the energy-intensive Haber-Bosch process for ammonia synthesis, the initiative promotes environmentally friendly agricultural practices. Additionally, the project focuses on establishing high-quality seed banks for potato and fodder crops, ensuring improved soil health and crop sustainability for long-term benefits.

Key Highlights:

- **Nano Pyrite Priming:** Sustainable, cost-effective method replacing fertilizers to boost plant growth.
- **Improved Productivity:** Increases potato and green fodder yields, addressing fodder deficits.
- **Ecosystem Preservation:** Enhances genetic diversity, reduces fertilizer use, and improves soil stability.
- **Farmer Integration:** Field trials refine the strategy for market-ready, farmer-focused products.

Application and Impact: The proposed strategy significantly reduces the cost of cultivation, with nano pyrite priming costing only INR 26 per hectare compared to INR 890 for traditional

fertilizers. This one-time treatment minimises labor and increases crop resilience in harsh climates and challenging terrains. Potato and fodder crops treated with nano pyrite develop a denser root network, improving soil retention and crop sturdiness. The project addresses critical challenges in the Himalayan region, including below-average potato productivity and a 49.9% deficit in fodder. By enhancing crop yields and promoting sustainable practices, the project supports food security, improves milk production through better fodder availability, and reduces environmental impact, ultimately empowering small-scale farmers in mountainous terrains.

4.

Name: Nirlipta Priyadarshini Nayak

School: School of Advanced Engineering

Title: Biomass nanocomposite with reduced volatile matter as the substitution of conventional coal for co-firing operation in thermal power plants

Funding Agency: Department of Science & Technology (DST)

Objectives:
The project aims to develop biomass-derived chars as an alternative to coal in thermal power plants, addressing the urgent need to reduce greenhouse gas emissions. It focuses on the production of advanced low-volatile biomass pellets, enhancing safety and operational efficiency in coal-based power plants. Additionally, the initiative seeks to reduce reliance on coal by utilising the superior combustibility, reactivity, and lower emissions of biochar, making it a more sustainable and environmentally friendly fuel option.

Key Highlights:

- **Advanced Biomass Pellets:** Creation of low-volatile biomass pellets to minimise coal's auto-oxidative tendencies and related safety hazards.
- **Emission Reduction:** Substituting 5-7% of coal with biomass can cut CO_2 emissions by 38 million tons annually.
- **Cost and Efficiency Benefits:** Achieves a 40% reduction in power costs and a 60% reduction in exhaust effluents compared to conventional coal usage.

Application and Impact:
The project promotes Waste Utilisation by converting agricultural and forestry byproducts, such as stubble, into biomass pellets, thereby mitigating environmental damage from stubble burning and improving resource efficiency. It enhances Energy Efficiency and Security through highly efficient combustion of biomass pellets, reducing energy costs and dependence on imported fossil fuels. From an Environmental Perspective, the diversion of organic waste from landfills reduces methane and CO_2 emissions while minimising landfill

size. Moreover, the initiative drives Socioeconomic Impact by creating employment opportunities, supporting local community development, and fostering sustainability in energy production.

5.

Name: Ashish Mishra and Subhankar Das

School: School of Advanced Engineering

Title: Development of Impact Resistive and Thermally Resilient Hybrid Laminated Composite Panel for Personal and Vehicle Armours

Funding Agency: Science and Engineering Research Board (SERB)

Objectives:

The project aims to overcome the limitations of ultra-high-molecular-weight polyethylene (UHMWPE) fibers in ballistic protection systems, such as low creep resistance, low melting temperature, and poor bonding with polymer matrices. The project enhances the thermal and mechanical properties of UHMWPE fibers and polyurethane resin by using surface-modified graphene oxide and a patented electrophoretic deposition (EPD) technique. These treated fibers will be integrated into hybrid laminated composite panels, tested for energy absorption under high-velocity impacts, and analysed for damage mechanisms. A 3D finite element model will guide the design of curved composite panels for personal and vehicle armor, combining experimental and numerical methods to develop lightweight ballistic armor with enhanced survivability.

Key Highlights:

- **Innovative Techniques:** Utilises graphene oxide with the EPD method to improve UHMWPE fiber wettability and enhance the thermo-mechanical properties of polyurethane resin.
- **Advanced Composite Panels:** Develops lightweight, energy-absorbing laminated panels capable of withstanding high-velocity impacts (300–500 m/s).
- **Broad Applications:** Suitable for military, law enforcement, and civilian security, serving as standalone protection or as backing layers for advanced armor systems.

Application and Impact:

The project results in the development of lightweight composite panels with enhanced ballistic protection capabilities, addressing threats across various domains. These panels are applicable in personal and vehicle armor, benefiting military, law enforcement, and civilian security sectors. Beyond immediate applications, the research contributes to advancements in materials science, fostering innovations in composite materials for broader industrial uses. By enhancing safety and security measures, the project has significant societal impact, safeguarding lives and protecting critical infrastructure.

6.

Name: Girish Chandra Kothyari and Atul Kumar Patidar

School: School of Advanced Engineering

Title: Morphotectonic assessment of structurally induced geohazard potential areas within the MBT Zone: NW of Dehradun, Uttarakhand

Funding Agency: Science and Engineering Research Board (SERB)

Objective:
The project aims to map tectonically induced landforms and analyse the geohazard potential along the MBT zone in the central Himalayan region of Uttarakhand. It leverages advanced techniques such as InSAR/GLA/ML/SPIM modeling and field-based methods to identify zones of active deformation. Additionally, the project seeks to generate hazard maps and delineate active landform morphology, contributing to the establishment of a chronology of paleoseismic events. These efforts are directed towards supporting sustainable urban planning and development in the region.

Key Highlights:

1. Conduct fault linkage analysis of the Sirmauri Tal Fault (STF) and Malgi Fault (MF) and their connectivity with the MBT for hazard potential and landform evolution.
2. Map geological and geomorphic evidence of active deformation and create 3D stereographic projections to assess stress build-up and landslide vulnerability zones.
3. Analyse ground deformation patterns using InSAR/PSINSAR and SPIM modeling techniques.
4. Perform susceptibility assessments and categorisation of landslides in the study area.

Application and Impact:

The project will enhance understanding of the Quaternary evolutionary history and hazard potential of the MBT zones, focusing on neotectonic and seismic events that shaped the

region's terrain. It will deliver precise geohazard and active fault maps for densely populated areas between Dehradun and eastern Himachal Pradesh. These findings will support urban development, town planning, and civil engineering efforts, ensuring safer and more sustainable infrastructure in the region.

7.

Name: Laxmi Kirola

School: School of Health Sciences and Technology

Title: Human induced pluripotent stem cell-based functional characterisations of novel identified disease causal gene(s)/variant(s) in families with juvenile Parkinson's disease

Funding Agency: Science and Engineering Research Board (SERB)

Objectives:

The project focuses on identifying and characterising novel disease-causing gene(s) or variant(s) in families with Juvenile Parkinson's Disease (JPD) in the Indian population. With the rising incidences of Parkinson's Disease (PD), this study aims to leverage whole genome sequencing to map coding and noncoding genomic alterations and discover new causal genes or variants. Additionally, human-induced pluripotent stem cell-based studies will be utilised to explore disease biology and pathways, potentially identifying novel therapeutic targets. The ultimate goal is to advance early diagnostics, discover biomarkers, and contribute to personalised therapeutic strategies for JPD.

Key Highlights:

- Facilitates early diagnostics and predictive medicine for Parkinson's Disease (PD).
- Supports the discovery of biomarkers and personalised therapeutic targets.
- Advances precision medicine and improves early diagnosis and prognosis.
- Opens pathways for innovative therapeutic solutions.
- Contributes to global health impact by addressing PD on a broader scale.
- Provides insights for genetic counseling and informed family planning.
- Enhances scientific understanding and addresses ethical and societal considerations in neurodegenerative disease research.

Application and Impact:

The project has significant implications for global scientific research and healthcare. It fosters international collaboration, promotes the use of advanced technologies, and enables an interdisciplinary approach to unravel the complexities of Parkinson's Disease. The findings aim to bridge the gap between research and clinical applications, translating discoveries into improved patient care. By contributing to global data sharing and standardisation, the project ensures its outcomes benefit not only the Indian population but also the global community, marking a step forward in addressing neurodegenerative diseases.

8.

Name: Madhuben Sharma and Sapna Jain

School: School of Advanced Engineering

Title: Water Quality assessment of Nainital Springs and remediation using green nanoparticles

Funding Agency: G. B. Pant National Institute of Himalayan Environment

Objectives:

This project aims to comprehensively monitor and assess the quality of spring water near Nainital Lake, Uttarakhand, utilising multivariate statistical techniques (MSTs) and water quality index (WQI). By understanding the impact of local hydrogeology, rainfall patterns, and human intervention, the research seeks to identify sources of pollution and propose remediation strategies. A key goal is to develop a nanoparticle-based water filtration system to improve water quality and address contamination, ensuring safer water for local communities reliant on these springs.

Key Highlights:

1. Create an updated report on the quality of spring water in the study area.
2. Develop a site-specific action plan by identifying potential pollution sources.
3. Produce a water quality map of springs near Nainital Lake for use by researchers and policymakers.
4. Link water quality issues to prevalent diseases to provide preventive health advice.
5. Develop a nanoparticle-based water filtration system to enhance water quality for nearby communities.

Application and Impact:

The project aims to establish a clear connection between water quality and prevalent diseases in the Nainital Lake region, offering actionable health advice to residents. By developing a green nanoparticle-based water filtration system, the research addresses critical water quality concerns, improving the lives of local communities dependent on spring water. The water quality map and site-specific action plans will serve as valuable resources for future research and sustainable water management initiatives in the region.

8.

Name: Shailey Singhal and Amit Kumar Sharma

School: School of Advanced Engineering

Title: Design and development of a portable KVIC type biogas plant for colder region

Funding Agency: Khadi and Village Industries Commission (KVIC)

Objectives:

The project aims to technologically upgrade the KVIC-type biogas digester to enhance its efficiency and applicability, particularly in colder regions. By incorporating innovative solar techniques, the project seeks to improve digester performance, enabling effective anaerobic digestion of organic waste to produce biogas and nutrient-rich organic manure, contributing to sustainable waste management and rural development.

Key Highlights:

1. Integration of heat trapping within the digester using greenhouse techniques during daylight.
2. Utilisation of a solar heater with a heat exchanger to elevate digester temperatures.

Application and Impact:

The upgraded biogas technology will facilitate the conversion of organic waste, such as kitchen waste, cattle dung, and agricultural residue, into biogas and nutrient-rich manure. This innovation supports waste-to-wealth initiatives, particularly in colder regions, reducing rural dependence on LPG and promoting cleaner energy alternatives. It contributes to the socio-economic upliftment of residents in Uttarkashi and other hilly areas, aligns with the Swachh Bharat Abhiyaan and Gobardhan Yojana, and fosters sustainable rural development.