R & D NEWSLETTER

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Vol.10 September 2019

16 kW solar PV power-grid interactive system

MULTI EFFECT WATER DISTILLATION UNIT

A cost effective, multi-effect distillation (MED) unit coupled with a solar photo voltaic cell based electricity generation unit has been developed for de-contamination of water. The energy requirement and cost are optimized by using a solar PV power-grid interactive system followed by a portable boiler to generate steam. The steam is used in MED to produce drinking water from ground/surface water contaminated by arsenic, fluoride ions, and from high TDS containing water from other water bodies, e.g. river, sea or rain harvested water. The technology is cheaper than a RO system that uses a high pressure pump. Such a roof top MED system is capable of producing 1.5-2.0 m3 drinking water per day. It has been developed under the IMPRINT program by the research group of Prof. Abhijit Maiti in the Polymer & Process Engineering Department.

Recently Signed Memoranda of Understanding

Space Research: IIT Roorkee has inked an MoU with Indian Space Research Organization (ISRO) for setting up a Space Technology Cell (STC) at IIT Roorkee. STC will be dedicated to cutting edge research in the areas of Space technology and areas aligned with the programmatic goals of ISRO. The collaborative activities of the Space Technology Cell will leverage the infrastructure, research potential and expertise of both the institutions.

Energy Research : An MoU has been signed by IIT Roorkee and The Energy Research Institute (TERI), Delhi for collaboration in the areas of mutual interest with special focus on the thematic areas of Energy, Renewable Energy, Water Management, climate change, food, environment, sustainable habitat and sustainable transport. The agreement will also facilitate capacity building activities and joint events focusing on public policy and public action in the areas of Energy Transition, Energy Access, Energy Efficiency, Renewable Energy, Green Buildings, Sustainable Cities, Sustainable Transport, Air Quality, Sustainable Land Use, Waste Management, Climate Science & Policy, Resource Efficiency and Security.

Road Research: Madhya Pradesh Rural Road Academy (MPRRA), Bhopal has entered into an agreement with IIT Roorkee to strengthen mutual cooperation and collaboration in the areas of road network planning, design, construction and operation. The collaborative research will have special emphasis in the areas such as harmonization of regional and national cooperation on Rural Road connectivity, Construction, Maintenance, and Use of local material, Fly-ash in road construction, Soil stabilization, Innovative Technologies and related areas.

Development of Ultrasonic Assisted Tandem Electrochemical And Electro-Discharge Micromachining Process

Sponsor: Science and Engineering Research Board, DST

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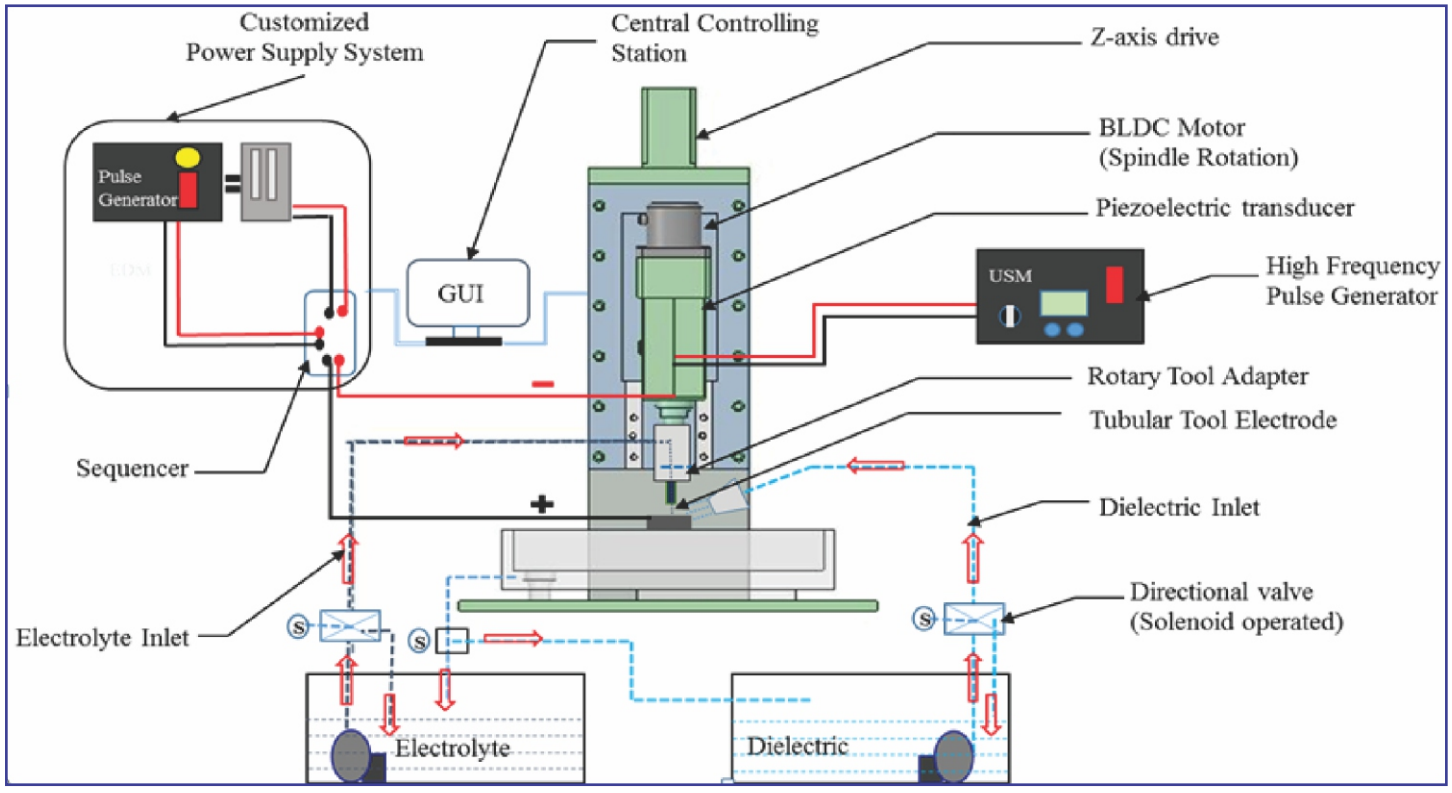
Abstract: The proposed project will lead towards the development of ultrasonic assisted tandem electrochemical and electrodischarge micromachining (UA-TECEDM) process for micromachining of difficult-to-machine materials and high corrosion resistant materials (titanium and its alloys, In conel based super alloys, metallic glass, MMC's). These materials have potential applications in the micro domain for micro flow filter (inertial particle separation), fuel injectors, cooling holes, bearing oil passages, micro-die, nozzles, etc. The range of application of these materials is currently limited due to the severity of the challenges faced during conventional machining on micro-scale with stringent requirements.



Schematic representation of proposed UA-TECEDM Process facility

In UA-TECEDM process, the micro electrochemical machining (micro-ECM) and the micro-electrodischarge machining (micro-EDM) processes will be performed in a tandem approach, i.e. micro-ECM with micro-EDM. The tendency to form a passive layer over anode surface during micro-ECM has been reported in literature. The proposed UA-TECEDM process will selectively break this passive layer beneath the tool electrode by spark discharges during micro-EDM. The residual passive layer will then be used as mask during micro-ECM operation, so as to negate any random pitting and uncontrolled anodic dissolution. Assistance of ultrasonic vibrations during UA-TECEDM process will provide improve circulation of liquid medium and aid in flushing of the machining zone. The notable characteristic of UA-TECEDM process will be its ability to machine micro-features on difficult-to-machine material having high corrosion resistance, with enhanced surface integrity and improved dimensional accuracy at a faster rate, which otherwise is not possible by either individual processes or sequential-EDM/ECM. The aforesaid process performance will be aimed to achieve with neutral salts negating the need for special type of non-aqueous and moderately toxic electrolytes.

The scientific theory and process mechanism of the proposed process will be explained by the use of imaging techniques, computational analysis and experimental data. The outcome of the proposed research will be an enhanced and flexible micromachining facility, which can be utilized to perform UA-TEDCM as well as other micromachining processes such as electrochemical discharge machining (ECDM), ultrasonic machining (USM), their process variants and combinations in the micro domain at a single machine set-up. Also, there will be no need to change machine set-up for finishing (electrochemical polishing) operation.

Investigation of The Unsteady Aerodynamic Response of LP Turbine Blade Under Part Load Condition

Sponsor: Science and Engineering Research Board , DST

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Abstract: In the last stage of steam or gas turbines, blade aeroelasticity becomes a major concern as the aspect ratio is high and un-shrouded tip section. These blades are exposed to severe dynamic excitation and prone to flutter (aeromechanical instability) risk subjected to variable flow condition and centrifugal force. At part load condition due to low volume flow and adverse pressure gradient, the flow can no longer pass through the root and is redirected towards the tip. As a result, a separation zone is developed behind the rotor blade. The goal of this study is to investigate the unsteady aerodynamic loading in the LP turbine under various incoming flow conditions. The outcome of the research will help in mitigating flutter problem in LP turbine blades.

Condition Monitoring and Diagnostics of Induction Motors Using Hybrid Schemes

Sponsor: Science and Engineering Research Board , DST

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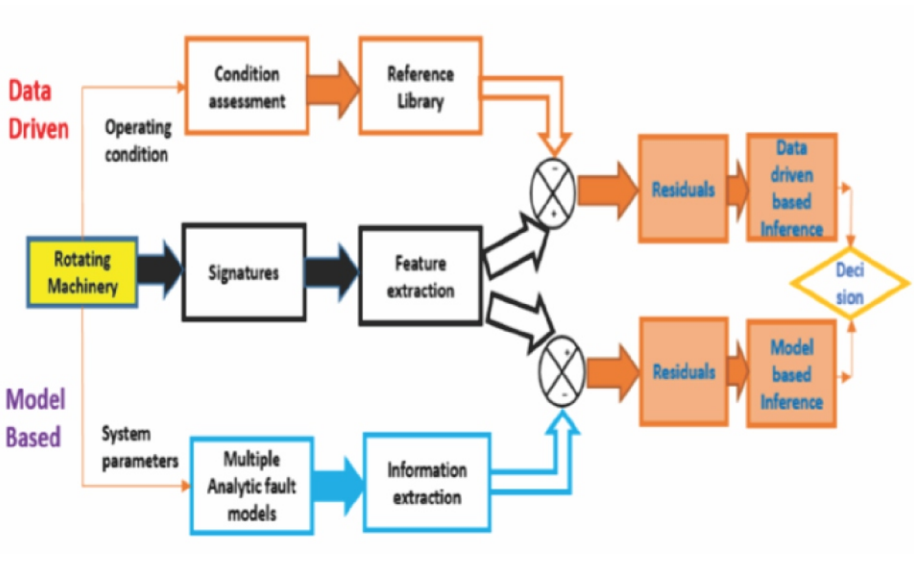
Abstract : Electrical machines, especially induction machines, are widely applied in industries and form essential parts of industrial systems. They are found in various applications in marine propulsions, aerospace actuators, process industries and traction system in electric vehicles/hybrid electric vehicles. Despite their rugged construction, they are subjected to fault due to aging, severe operating conditions, and harsh environments. Diagnosis and severity evaluation of fault have become an important topic to help increase the availability and reliability of electrical machines and the associated systems. In this project, effort will be to combine two complementary schemes (Model-based and data-driven) to form a hybrid approach for early fault detection and isolation. Model-based technique is one of the approaches to address the challenge of early fault detection under the influence of the ambiguous factors. Its strength lies in the ability to incorporate the electrical fault parameters in the model and hence the analysis of fault effects. Another complementary area of research is based on data-driven approach for diagnosis of electrical machines, which do not directly take into account the machine parameters, but it depends on the data available at the terminals of the machine for diagnosis and identification. In the proposed novel approach, the complementing schemes have to be combined into one single hybrid scheme, in which, one can take the advantage of each to form better and more reliable system.



Stator windings short circuit fault showing winding damaged and Hybrid schemes for fault diagnosis

Experimental Study of Film Evolution For a Surfactant-Laden Viscous Liquid Film Falling Down a Vertical Cylinder With a Major Focus on Mechanism of Lung Airway Closure and Flow Instabilities Occurring in Coating Flows

Sponsor: Science and Engineering Research Board , DST

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Abstract : This project aims to examine and uncover the mechanisms and role played by interfacial surfactant, and wall flexibility in affecting the process of lung airway closure. The lung airway is a liquid-lined flexible tube with an interfacial surfactant present at air-liquid interface. Capillary instability of air-liquid interface and compliant collapse of airway wall are two proposed mechanisms responsible for closure of lung airways. Most of the theoretical studies have either focused on effect of surfactants on capillary instability of an annular liquid film in rigid tubes or role of wall compliance and capillary instability in absence of interfacial surfactant. More crucially, there are no experimental studies on evolution of surfactant covered air liquid interface in a flexible tube. This forms a more realistic model of flow in pulmonary airways as opposed to analyzing flow in rigid tubes. We plan to systematically investigate the dynamics of film evolution for surfactant-laden liquid film flowing inside of a suspended flexible tube. The results obtained from the proposed research work will be helpful in better designing of several clinical treatments related to pulmonary disorders. Two treatment procedures where the proposed work is relevant are surfactant-replacement theory and liquid plug ventilation.

Development of Diabetic Retinopathy Imaging Biomarkers Using Compact Multispectral Ocular In-Vivo Imaging System For Validating Therapeutic Drugs and Lenses

Sponsor: Science and Engineering Research Board
(IMPRINT-II program)

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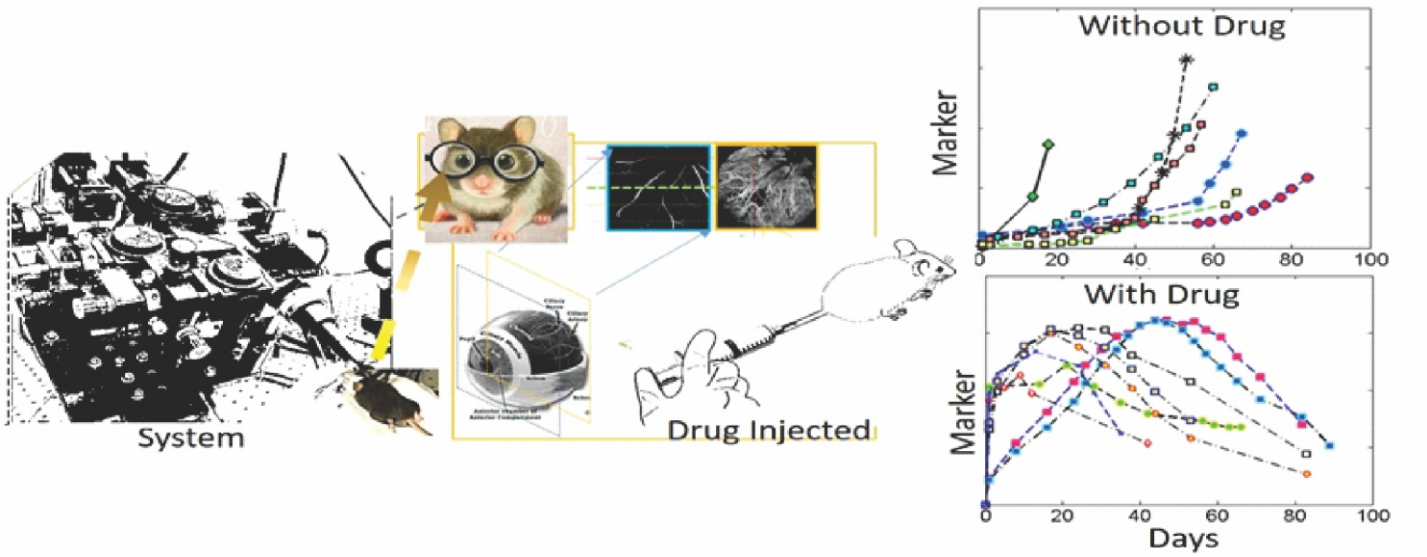
Abstract: The Objective is to develop quantitative and qualitative parameters associated with Diabetic Retinopathy. Animal Disease Models will be studied inducing associated symptoms artificially. A state of art Multispectral (Scanning LASER Ophthalmoscope combined with Optical Coherence Tomography) imaging system will be developed to achieve the above objectives. In final stage of hardware development, 3D Angiography system will be added on the same platform. Integration of advanced adaptive optics would be part of secondary target. Equal amount of efforts

will be invested for development and testing of Therapeutic Drugs & lenses, in-vivo, non-invasively. Mice under study will be kept alive until they die naturally.



Schematic representation of the mode of study on animal models

Electrodialytic Recovery of White Liquor From Green Liquor To Conserve Energy and Avoid Solid Waste Generation In Paper Mills

Sponsor: Science and Engineering Research Board
(IMPRINT-II program)

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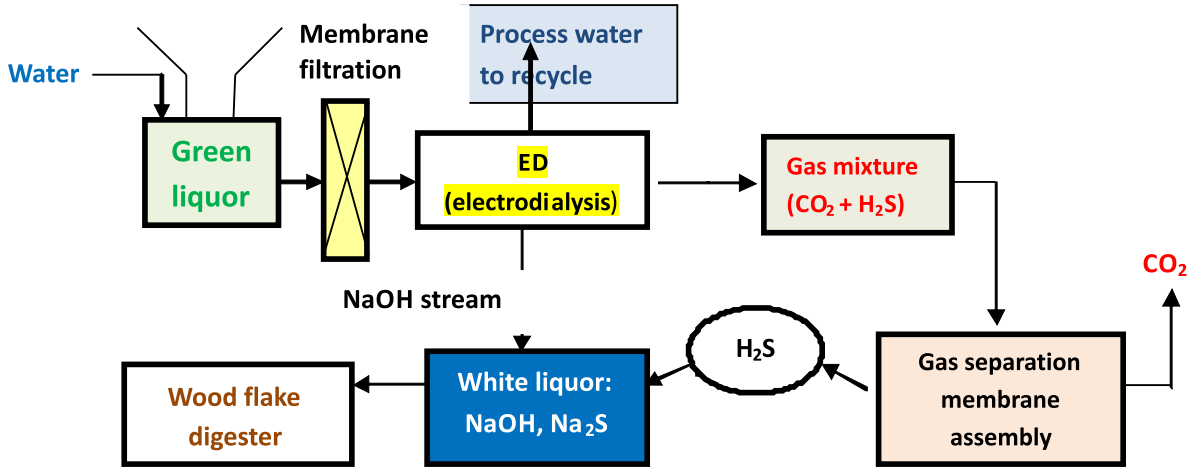
Abstract : Paper industries regenerate while pulping liquor (NaOH+Na2S) from green liquor following conventional soda lime process to reuse it in the process.



Scheme to generate NaOH using electrodialysis of green liquor

In this process, dry CaO powder is added in Green liquor (containing Na2CO3, Na2S, Na▫SO▫ etc.) solution and CaCO3 is precipitated generating NaOH which is used after filtration. The CaCO3 so precipitated is filtered, dried and calcined at very high temperature ~900 C-1000 C using lime kiln to form CaO. Thus, this process demands huge amount of energy for drying and calcination step of CaCO3 and produces large amount of suspended particulate matters causing severe air pollution. This energy demand and environmental issues can be simultaneously resolved by applying electrodialysis of green liquor. The project proposes a scheme to generate NaOH using electrodialysis of green liquor where no CaO will be required.

Evaluation of Test Protocol and Lethality Critieria For Fragments Generated From Warhead

Sponsor: Armament Research Board, DRDO

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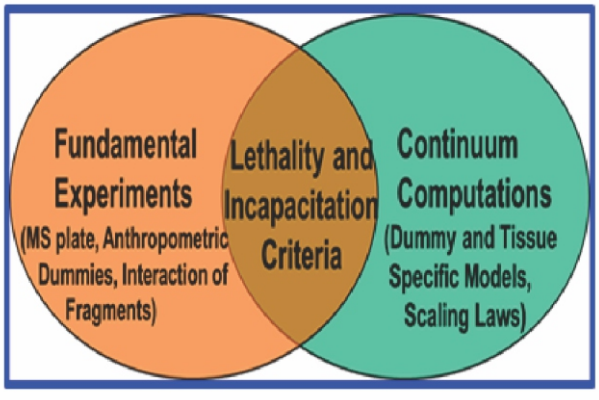
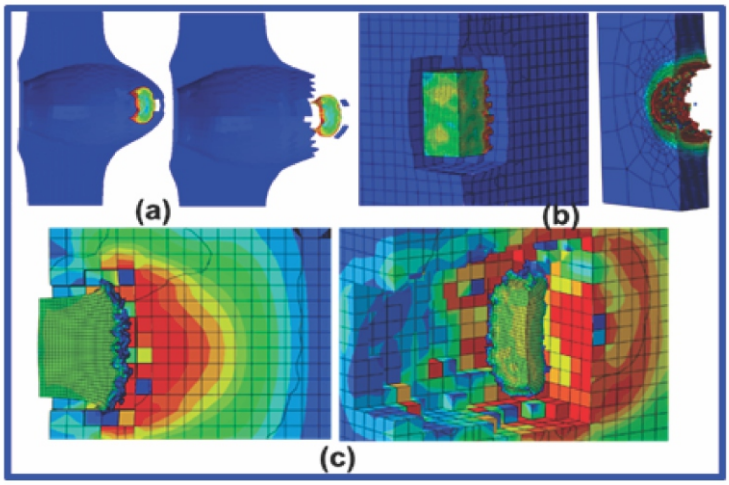
Abstract : Anti-personnel efficiency is an essential parameter for the determination of fragment's effectiveness against targets to be defeated. Critical parameters that determine lethality potential of a fragment are mass, velocity, and shape of fragments. Even though these parameters are intuitive, effect of aforementioned parameters on degree of lethality and human incapacitation are not known. This work aims to address the fundamental question of fragment mass, velocity, and shape and corresponding lethality potential for human incapacitation using novel computational and experimental approaches. We will develop injury corridors relating degree of lethality in human surrogates to fragment mass, velocity, and shape. The work has direct implications in optimal design of futuristic warheads.



Overall approach



Preliminary investigations of interaction of mild steel fragment with soft and hard tissues. (a) skin (b) muscle (c) bone.

[The tissues are modeled as isotropic, hyperelastic material. Damage model with element deletion capabilities is incorporated for mild steel fragment and tissues.]

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Projects under
Scheme for Promotion of Academic and Research Collaboration (SPARC)

Design and Development of Cable-Driven Parallel Robot for Automated Construction

Sponsor: Ministry of Human Resource Development

Collaborating University Abroad: Queen's University, Canada

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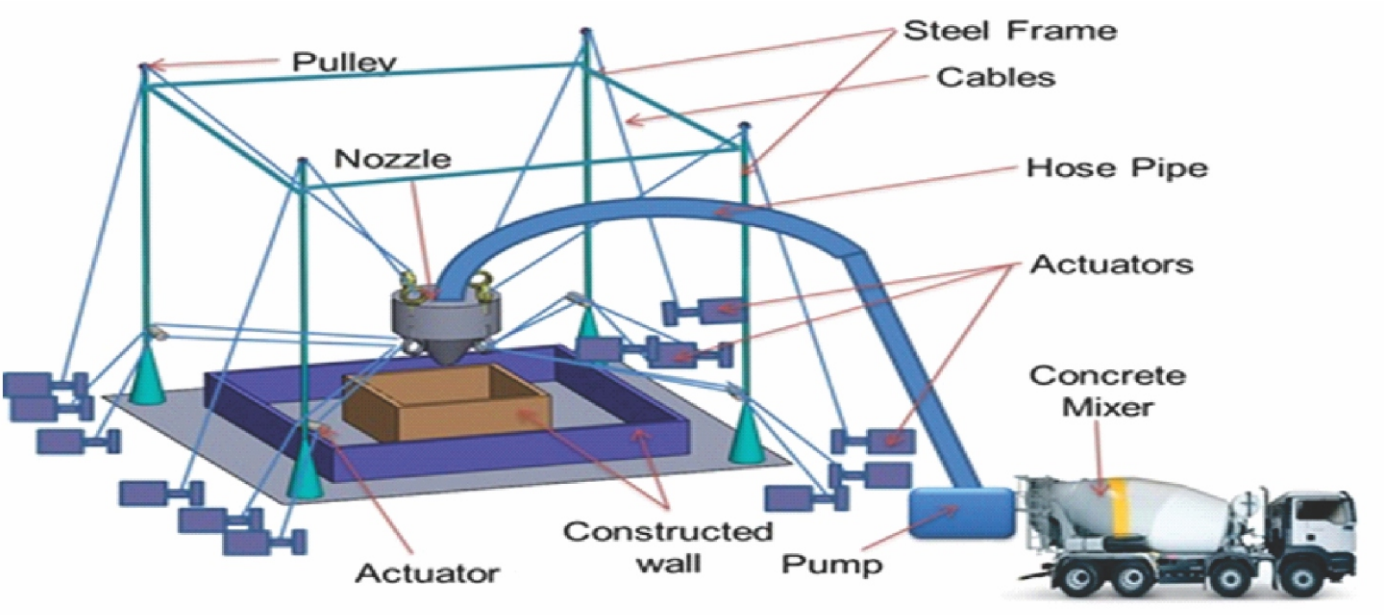
Abstract: India to be the third largest construction market globally by 2030, with its contribution to GDP increasing to 15% by 2030. The conventional construction methods are slow, over-budget, hazardous to labourers and environment, lack productivity and have limited architectural freedom in design. Apart from that, the government of India is promoting affordable housing in the form of schemes like 'Housing for All' etc. Thus, the automation in construction has a wide potential of providing affordable construction, productivity, reduced material wastage, labor safety and architectural design opportunities. Cable-driven parallel robots can be inferred to be the more reliable solution for large-scale/on-site construction. Since the cable can be extended to larger lengths and can be easily rolled around a spool, the cable-driven parallel robots are easy to transport, assemble and disassemble with an advantage of being lightweight and relatively inexpensive.



Systematic Malware Detection and Analysis of Software-Intensive System (Madesis)

Sponsor: Ministry of Human Resource Development
International Collaborator: Wageningen University, Netherlands

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Abstract: Due to the increasing complexity of software systems, critical infrastructures and key software components are becoming more and more vulnerable to cyber-attacks. Moreover, the widespread adoption of Internet technology as part of the business services and Internet of Things (IoT) devices are also adversely affecting the security aspects of many software-intensive systems. In this project, we will focus on the malware (malicious software) detection and analysis problem of software-intensive systems and provide a holistic solution approach. The state-of-the-art in malware detection mainly relies on designing systems that are resilient to cyber-attacks, and on proper machine learning approaches for detecting malware. In practice the design of cybersecure systems, and the analysis using machine learning have been carried out in isolation. In this project, we aim to provide an integrated approach that adopts both an engineering design perspective and machine learning perspective. From the design perspective, we will investigate and enhance the architecture design approaches for ensuring the prevention of malware in software-intensive systems. From the machine learning perspective, we will investigate the adoption of advanced machine learning algorithms for supporting the detection of malicious software.

INNOVIZATION: Discovery of Innovative Knowledge through Optimization and Machine Learning

Sponsor: Ministry of Human Resource Development
Collaborating University Abroad: Michigan State University, USA

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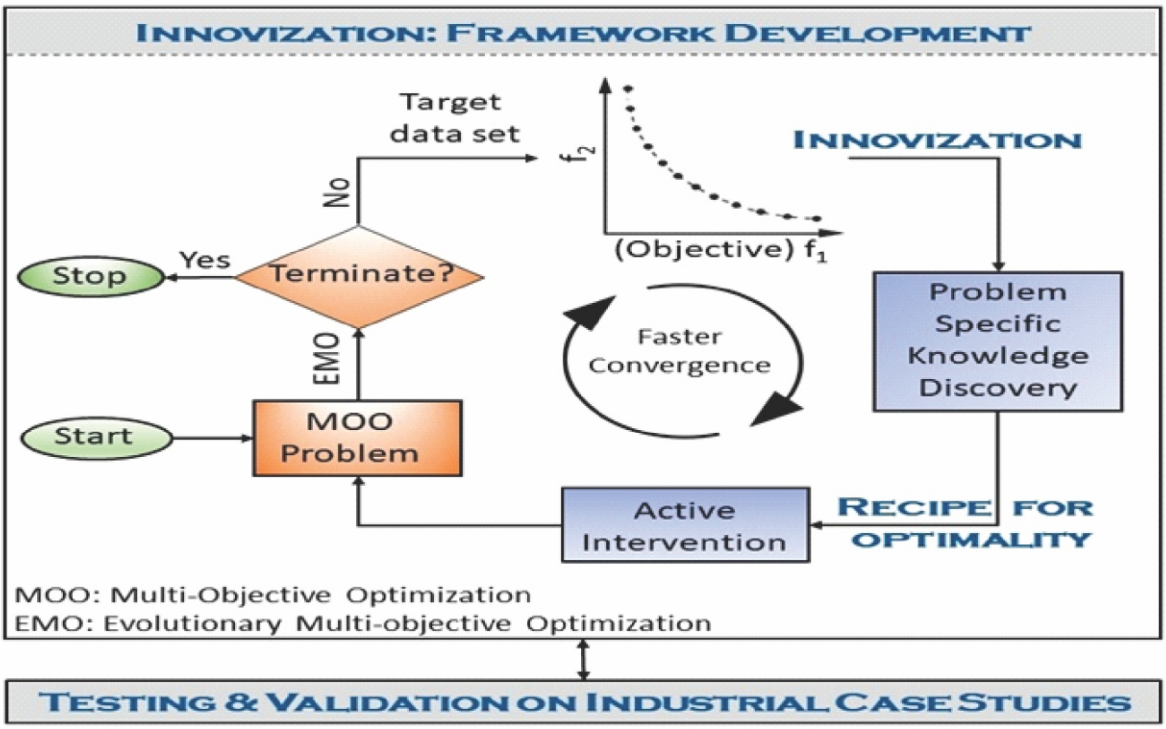
Abstract : Design Innovation through a discovery of pertinent knowledge of the design problem is a key for gaining sustainable competitive edge. Innovative designs should address most perceivable and often conflicting performance indicators, while ensuring their manufacturability with minimum lead time to market. This collaborative project between the Indian and US academics with synergetic expertise, further supported by GE India, aims at Innovization – Innovation through Optimization and Machine Learning.



In this project, methods would be developed for deriving innovative design principles (recipe for optimality); tested and validated for industrially relevant, emergent product- and process-design optimization problems, including many-objective, discrete-variable, combinatorial, graph-related (topology optimization) problems.

Non-Filamentary Three-Terminal Memristor Architecture For Bio-Mimetic and Logic Design

Sponsor: Ministry of Human Resource Development

Collaborating University Abroad: University of Sheffield, UK

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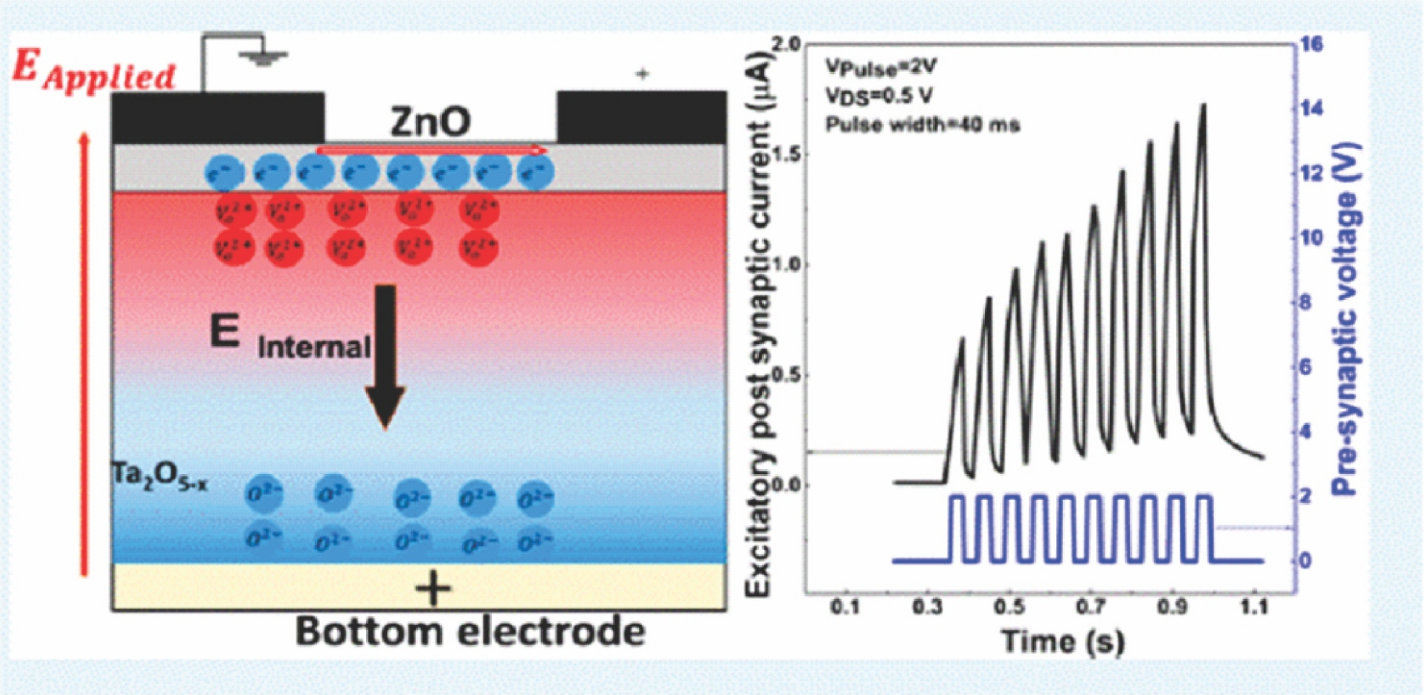
Abstract : Neuromorphic Computing based on highly integrated memristor cross bar arrays is expected to be the next evolution to replace conventional Von-Neumann computers that are restrictive because of separated memory and processing units. In this work we planto develop methodologies combining experiment and modelling in neuromorphic devices and models that are more biomimetic in comparison to existing digital/ multistate analogue CMOS. We plan to use solid electrolyte field effect transistor experimental data from Sheffield University, UK and device TCAD and modelling and characterisation expertise at IIT Roorkee to develop a model for Spike Timing dependent Plasticity (STDP) and the long and short-term behaviour of the devices and application

in neural network. The work will be undertaken through joint PhD scholars both at IIT Roorkee and Sheffield University.



Nanoionics-Based Three-Terminal Synaptic Device with Spike Timing Dependent Plasticity.

Tracking Depression And Elucidating Its Mechanism Using Cognitive Neuroscience, EEG, Machine Learning

Sponsor: Ministry of Human Resource Development
International Collaborator: University of Groningen, Netherlands

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Abstract: Depression is turning out to be a major psychiatric disorder from which many people in India and Netherlands alike are suffering. Depression is associated with tremendous costs to society in terms of decreased productivity and years lost due to disability. Specifically, for India, the social stigma associated with depression is a concern, which leaves many cases of depression untreated. A third major problem in depression is that even after successful treatment, the probability of relapse is considerable. For all these reasons, it is important to know more about the mechanisms by which depression arises. In this project, we seek to develop an objective measure to diagnose and track depression. We also want to further elucidate the mechanisms underlying depression by combining state-of-the-art neuroscience with machine learning to detect depressogenic thinking

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online, as well as with computational modeling of cognition to develop more detailed theories about how depressogenic thinking is amplified and dampened by different interventions.

Spintronics Based In Memory Computing For Neuromorphic Applications

Sponsor: Ministry of Human Resource Development
Collaborating University Abroad: Purdue University, USA

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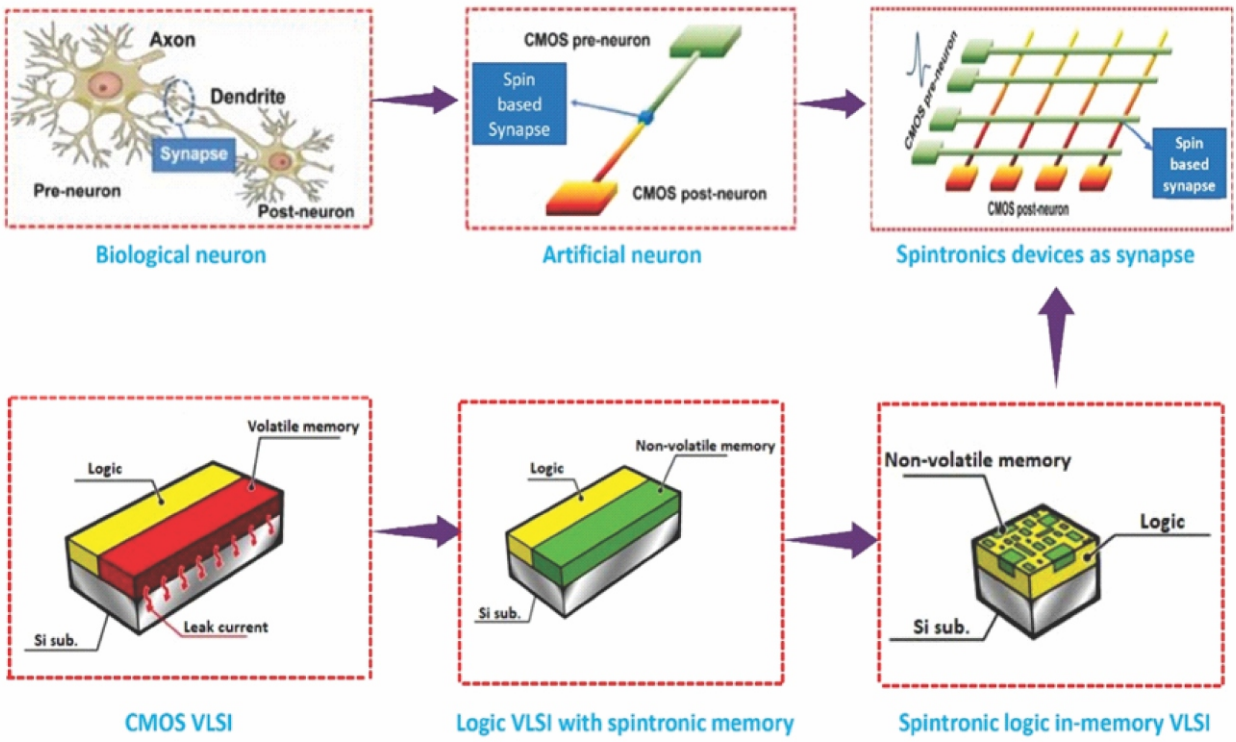
Abstract: The computers often use different technologies (SRAM,DRAM etc.) for storing data at different levels of abstraction that relates to major performance issues in terms of power and speed. Spintronics is an emerging research field that stores data in form of spin of electron instead of charge of electron, thereby significantly improving the speed and reducing power. In-memory computing has emerged as promising solution for further improving the performance. Spintronic devices based non-volatile memories are suitable candidates for in-memory computing due to their compatibility with CMOS fabrication technology. Spintronics based in-memory computing is attracting researchers in the area of neuromorphic computation that emulates the biological human neuron. This project will implement in-memory computing using spin devices for neuromorphic applications while integrating logic and memory in form of synapse for efficient and improved performance.



Structure and Reactions of Nuclei Away From The Valley of Stability

Sponsor: Ministry of Human Resource Development
Collaborating University Abroad: Hokkaido University, Japan

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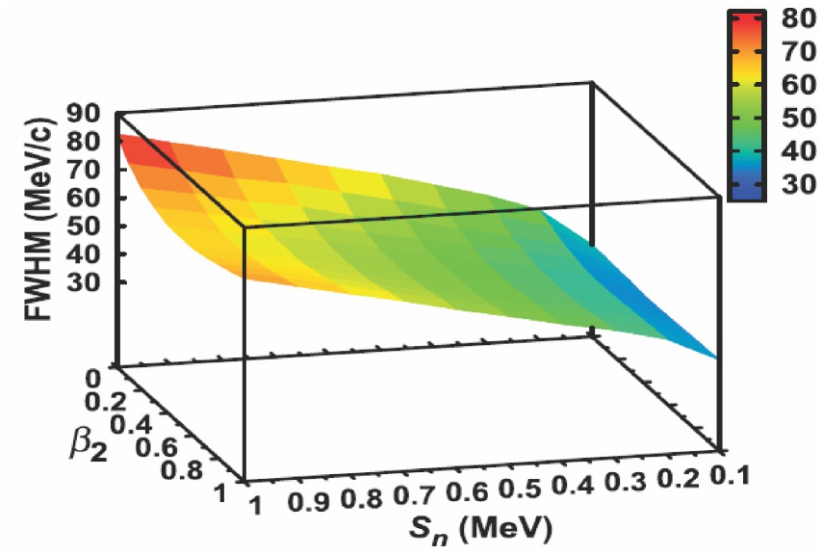
Abstract: We intend to investigate the structure and reactions involving exotic medium mass nuclei by studying their breakup in the *Coulomb* and *nuclear* field of a target nucleus. The associated computational tools, based on the theory developed, will be used to calculate several breakup reaction observables and comparison will be made with newly available data. As an upshot, a systematic study of ***Coulomb-nuclear interference effects in breakup reactions*** can be investigated. Further applications in nuclear astrophysics to calculate cross sections of photo-disintegration and radiative capture reactions which affect the evolution of elements in hydrostatic nucleosynthesis will also be considered.



Full-width at half-maxima (FWHM) in the parallel momentum distribution of the charged fragment in the elastic Coulomb breakup of exotic ^{37}Mg on a ^{208}Pb target at 244 MeV/nucleon beam energy.

If ^{37}Mg has a 'halo' then the corresponding combination of its quadrupole deformation (β_2) and one neutron separation energy (S_n) can be estimated from this calculation.

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