NJIT
New Jersey Institute of Technology

Summer Research Programs

URI Summer Research & Innovation Symposium

Ronald E. McNair Postbaccalaureate Achievement Program

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NSF - REU Optics and Photonics: Technologies, Systems, and Devices

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Heritage Institute of Technology

Summer 2023

July 26 — 27, 2023
8:30 A.M. to 4:00 P.M.
Campus Center • Ballroom A & B

University Heights
Newark, New Jersey 07102
Phone: 973-596-5590
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http://mcnair.njit.edu

“Research is Creating New Knowledge”

- Neil Armstrong

Brochure Creation & Publication
Ronald E. McNair Postbaccalaureate Achievement Program

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Marlon Rodriguez

Brochure Consultant
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Acknowledgements

On behalf of all the participating Summer Research Programs, McNair, NSF REU Site on Optics and Photonics and Heritage Institute of Technology Research Programs we are extremely appreciative of your support and efforts in making this summer program successful. We would like to give special thanks to the following individuals: Marieta Chemishanova, Luis A. Guillen, Mike Dabrowski, Sanjeannetta Worley, Archana Srivastava, Lisa Easton, Jessica Jimenez, Monica O'donnell, Lea Ronchi, Djadji Sylla-Samassa, Tulika Das, Deepak Vungarala, Dimana Kornegay, Stephen Eck, Nellone Reid, Grisele Gonzalez-Ledezma, Shivon Boodhoo, Darnell Simon, Joseph Mercuri, Brenda Gracia and Brain Hart. In addition, we are deeply indebted to the faculty mentors, who have such an important role in our students 'academic, research and social development.

Lastly, we must acknowledge our gratitude to the students for their hard work and perseverance. We encourage you to continue on your path of scholarly inquiry. As you have accomplished a great deal in such a short time with us, we know that you will be successful in your future academic and research endeavors.

NJIT
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Ronald E. McNair
Postbaccalaureate Achievement Program

July 27, 2023

Welcome to New Jersey Institute of Technology's 2023 International URI Undergraduate Summer Research and Innovation Symposium. It is an honor and privilege to be part of this year's Symposium. Ten participants of Ronald E. McNair Postbaccalaureate Achievement Program and two participants from NSF REU Sites on "Optics and Photonics: Technologies, Systems, and Devices" started their summer research program from May 22, 2023. Twelve students from Heritage Institute of Technology (HIT), India started their research from June 19, 2023. The students worked very hard to carry out their research projects with literature review, data analysis and simulation in addition to lab experiments.

The successful student exchange program during summer for research between NJIT and HIT has entered the 16th year this year. It was stopped for three years from 2020-2022 due to COVID19 pandemic. The purpose of this exchange is to promote international understanding, scholarly collaboration, cultural interaction, and friendship by supporting educational professional and cultural activities among faculty and students of the two institutions.

This year's success comes because of Ms. Zara Williams, Assistant Director, Prof. Ashish Borgaonkar, the Faculty Coordinator of the Ronald E. McNair Program, and Prof. Abdallah Khreishah of the NSF REU programs for their efforts in coordinating the overall program. Staff members of Research Office, Admissions, Office of Global Initiative, Budget Office, Housing, Facility Systems, Photo ID & Parking Services, and ECE Department contributed significantly to the success of the Symposium. Efforts of Mr. Marlon Rodriguez of the Ronald E. McNair Program is recognized for their valuable input in producing this program's brochure.

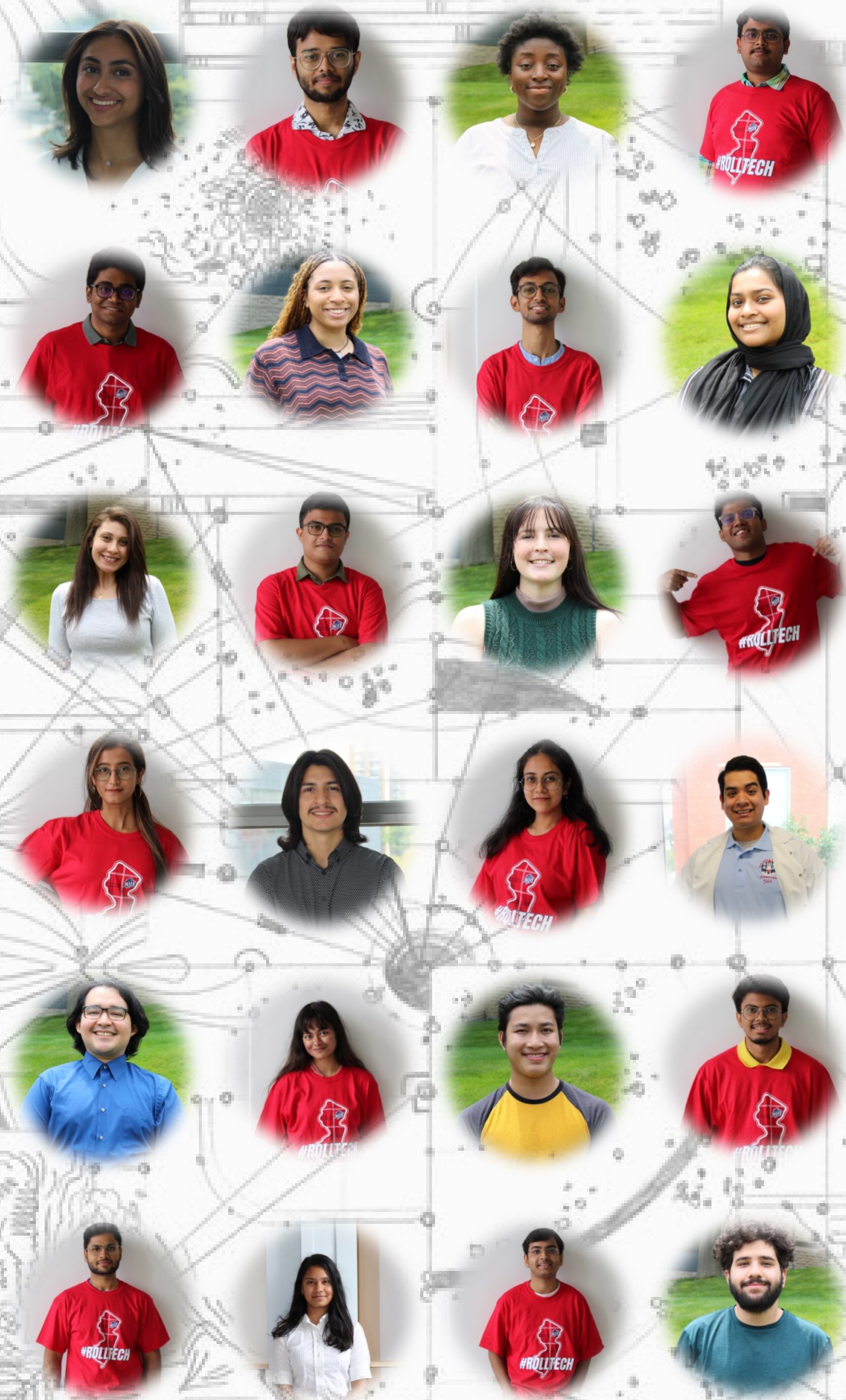
The students in the Ronald E. McNair Program, HIT Program and NSF REU program have the opportunity for presentation of their research accomplishments that was completed under the supervision of dedicated NJIT faculty. Without the time and effort of NJIT faculty and graduate student mentors the outstanding achievement of the students would not have been possible.

We are extremely proud of the research efforts of all the students, the quality of the research presentations and grateful for the support of the NJIT administration, faculty, and staff in contributing to the success of the symposium.

Sincerely,

Durgamahab Misra, PhD
Symposium Co-Chair, McNair Program Director, HIT Program Coordinator
Professor and Chair, Department of Electrical and Computer Engineering

Ronald E. McNair Postbaccalaureate Achievement Program &
NSF - REU Optics and Photonics (OP): Technologies, Systems, and Devices



Sahil Molla

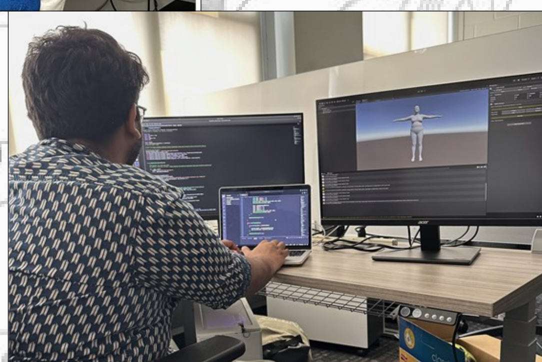
Mechanical Engineering

Shriyans Roy

Electrical & Computer Engineering

Sohom Sen

Electrical & Computer Engineering



Subhodeep Ghosh

Computer Science

Accounting for Mechanical Behavior of Skin to Minimize Harvested Skin Area in Skin Grafting

Chelsea Garcia, Advisor: Dr. Farid Alisafaei, and Mentor: Mohammad Jafari, Ph.D. Student

Each year, 8.2 million Americans experience chronic wounds resulting from burns, diabetic ulcers, skin cancer surgery, or infection. These wounds impede the natural healing process, preventing the body's ability to replace the damaged skin. Typically, chronic wounds are treated with skin grafts, where a section of epidermis and dermis are obtained from one area of the body (Fig. 1A (i)), meshed with small slits (Fig 1A (ii)), stretched (Fig 1A (iii)), and transplanted onto a larger wound site (Fig 1A (iv)). A crucial aspect of skin grafting involves minimizing the size of harvested skin to avoid additional wounds and ensuring sufficient coverage of the wound area after meshing and stretching. Surgeons traditionally determine the skin's expansion ratio, representing the ratio of stretched skin area to its initial area, using a basic geometric equation that assumes square incisions (Fig 1C). However, this equation overlooks the skin's mechanical properties and has proven inaccurate in various scenarios. In this study, we propose a new and simple equation that combines geometric parameters and the mechanical properties of meshed skin grafts to estimate the skin expansion ratio. Through summer research, we utilized finite element simulations to demonstrate that the new approach yields a significantly improved prediction of the skin expansion ratio compared to the conventional method.

Enhanced Biomarker Detection in Microfluidic Biosensing Platforms

Endy Nava, Research Advisor: Dr. Eon Soo Lee, and Mentor: Yudong Wang

The accurate and sensitive detection of biomarkers plays a vital role in early disease diagnosis. Implementing biosensors into point-of-care (POC) devices allows for diagnostic results to be obtained while patients are present. In the case of positive results, patients will be able to receive treatments for their corresponding disease at an early stage. This research focuses on the detection of ovarian cancer antigens (CA-125) using an electrochemical method. By immobilizing the CA-125 antibodies onto the gold nano interdigitated electrodes. The corresponding antigens in the biofluid can be captured by the antibodies and form the antigen- antibody complex on the electrodes' surface. This antigen-antibody conjugation results in a capacitance change that quantifies the antigen concentration in the biofluid and assists in the diagnosis of ovarian cancer. Current studies have utilized a thiourea self-assembled monolayer (SAM) combined with gold nanoparticles (GNPs) for antibody immobilization and antigen detection. The thiol group from thiourea covalently bonds to the gold nano interdigitated electrode resulting in a uniform monolayer. Antibody immobilization is achieved through the utilization of the carboxyl group on the lipoic acid gold nano particles, 1-ethyl-3-(-3-dimethylaminopropyl) carbodiimide (EDC) and N-hydroxysuccinimide (NHS). EDC and NHS activate the carboxyl group forming a peptide bond with the antibodies. These studies used static drop and microfluidic flow of the biofluid with antigen to test antigen-antibody conjugation detection. In the static drop condition, the capacitance of the biosensor before and after antigen binding were measured at 10 kHz resulting in 164.17 pF and 743.29 pF. In the microfluidic conditions, due to the shear stress in microfluidic flow, part of the CA-125 antibodies detached from the biosensor causing a drop in signal readings. The thiol-PEG-carboxyl (SH-PEG-COOH) is introduced to address this problem. This polymer material will replace the thiourea SAM layer and GNPs, insulating the electrodes and acting as an adhesive layer to enhance antibody immobilization. Based on this new method, a comparison study is conducted to analyze various methods of CA-125 antibody immobilization and antigen detection within biofluid.

Investigating EDC-Crosslinked Collagen Scaffolds for Use in Skeletal Muscle Regeneration

Faith L. Adams, Advisor: Dr. Jonathan M. Grasman, Mentor: Natalie G. Kozan, Ph.D. Student

Volumetric Muscle Loss (VML) is a condition where 20% or more of a skeletal muscle's mass is lost and can no longer regenerate itself. VML is often caused by factors such as traumatic injury due to combat or car accidents and must be aided in the repair phase of regeneration by an external source. The current precedent for treatment of VML is in the use of autologous muscle grafts derived from healthy skeletal muscles. However, limitations such as muscle graft failure due to graft rejection exist, resulting in lack of muscle functionality. Utilizing applications of biomimicry, tissue engineering seeks to design biomimetic scaffolds that can be implanted into the injury site. In this study, collagen sponges will be tested for use in skeletal muscle regeneration. Collagen has been chosen for this study due to its biocompatibility for integration within a patient's host tissue and structural integrity. Endodermal collagen is the major protein present in the extracellular matrix of muscle tissue. Collagen sponges also contain a porous structure suitable for myoblast infiltration and proliferation. In this study, we will investigate the enzymatic degradation of crosslinked collagen sponges in collagenase, which specifically degrades collagen. It is necessary to optimize the rate of degradation of a biomaterial scaffold, as the degradation rate should match that of the regrowth of the target tissue. Collagen sponges will be crosslinked in either a high or a low concentration of crosslinker, i.e., EDC and NHS, and their degradation rate in collagenase solution will be assessed to determine which rate is most similar to the rate of skeletal muscle tissue regrowth. Myoblasts will also be seeded on the crosslinked scaffolds to assess whether their proliferation and differentiation are affected by the concentration of crosslinker. Through this research, we hope to optimize sponge degradation and myoblast growth and differentiation to best promote muscle regeneration. Ultimately, this study furthers research in the field of developing a biomaterial treatment for VML.

Viscosity and surface tension measurements of chemical warfare agent surrogates using acoustic levitation

Idalia Warren, Advisor: Dr. Dreizin, Mirko Schoenitz, and Mentor: Elif Irem Şenyurt, PhD Candidate

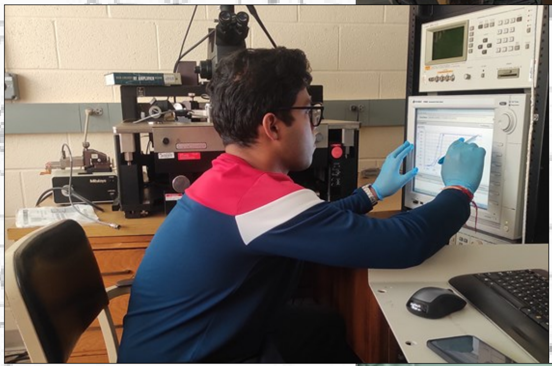
When stockpiles of chemical warfare agents are destroyed, the toxic liquids can escape as aerosols, spills, and vapor. Many harmful effects that this may have on the ecosystem and public health could be quantified and prevented if the formation of such toxic aerosols is understood and described in theoretical models. One of the most important and dangerous chemical weapons is sarin and diisopropyl methyl phosphonate (DIMP) is its surrogate of choice used here, due to their similar chemical structures. The thermophysical properties, viscosity and surface tension, of the toxic agents need to be known to understand formation and behavior of their aerosols. These properties also affect how such aerosols interact with the soil and other particles. In this research, experiments using acoustic levitation are performed to measure both surface tension and viscosity of DIMP using a single liquid droplet. The utilization of acoustic standing waves allowed for a droplet to remain suspended in air while being disturbed at its resonant frequency by an additional soundwave. Deformation of mode 2 was observed, and the droplets freely decaying shape oscillations were witnessed once the source of disturbance was removed. A high-speed camera was used to capture the droplets decaying oscillations as it returned to its equilibrium state. Through careful analysis, the decay constant and frequency of oscillation were determined to calculate the surface tension and viscosity. Three liquids (dodecane, decane, distilled water) with known viscosity and surface tension values were used initially in order to validate the experimental procedure. It was determined that viscosity measurements deviate the most, with stability and circularity of the droplet affecting the results. When introducing solutions of DIMP and water of known concentrations, it was found that exciting droplets at the resonance frequency was not a simple task. This can be due to the unknown properties of the mixture and oscillations observed for undesired modes. Future experiments will focus solely on pure DIMP and mixtures with high concentration of the surrogate.

Rahul Laha

Electrical & Computer Engineering

Rituja Bhattacharya

Electrical & Computer Engineering



Ritvik Bordoloi

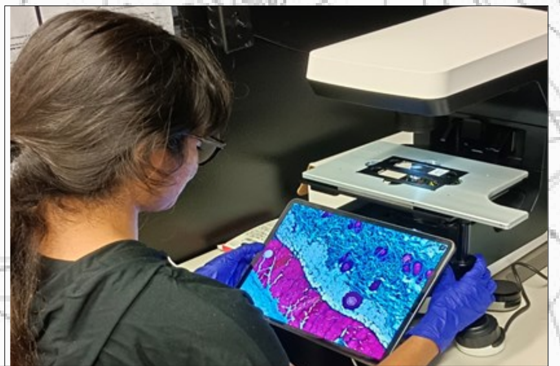
Electrical & Computer Engineering

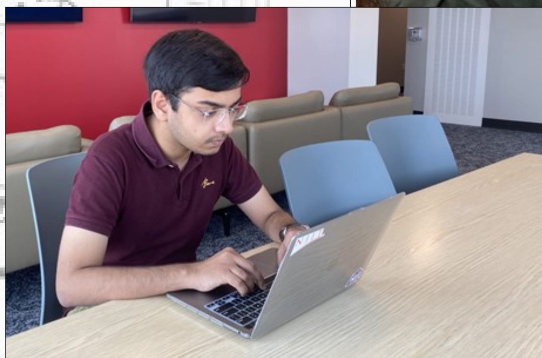
Rohan Ghosh

Electrical & Computer Engineering

Anushri Gupta

Bio-Medical Engineering





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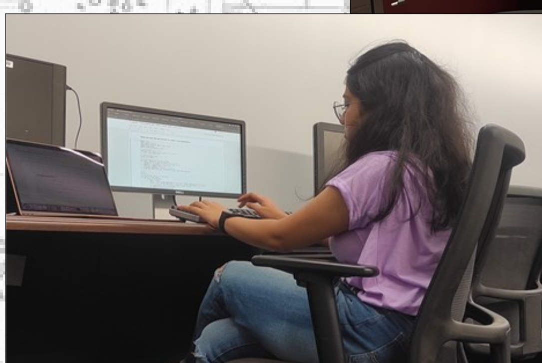
Computer Science

Ayush Kashyap

Electrical & Computer Engineering



Poulami Basu

Electrical & Computer Engineering

Cloning of Knockout Gene Models to Debulk Glycocalyx of Glioblastoma Multiforme

Juan J. Ramirez, Advisor: Dr. A. Buffone and Mentor: Issa Funsho Habeeb, Ph.D. Student

Glioblastoma Multiforme (GBM) poses a significant challenge as a highly aggressive and metastatic form of cancer. It is characterized by excessive expression of cell surface glycoproteins and glycolipids, which are commonly observed in various cancer types. By studying genes responsible for excessive glycosylation events in GBM, researchers can identify novel strategies to disrupt its function, leading to enabling early therapeutic intervention. However, the current research scope is limited, requiring further investigation into the role of glycan structures. To simplify the complexity of GBM's behavior, research needs to determine the specific sugar within the glycan that facilitates metastatic behavior. Existing literature suggests the involvement of three types of glycans—N-linked and O-linked chains on glycoproteins or glycolipids—in GBM growth. Any of these glycan chains may potentially contribute to the aggressive and invasive nature of glioma cells within GBM tumors. Additionally, GBM, like other cancers, exhibits metastatic behavior driven by glycocalyx-induced membrane stress. In this proposal, We hypothesize that eliminating specific genes, either individually or in combination will limit metastasis. This study aims to achieve its objective by introducing glycosyltransferase knockout models through cloning, which will then be transfected into GBM tumor cells to disrupt genes involved in glycan elongation. The anticipated outcome is to ultimately identify the specific genes that significantly influence GBM proliferation, providing a foundation for the development of innovative approaches for future research endeavors.

Reactivity of gaseous mercuric bromide with solid and liquid interfaces

Laila Nashir, Advisor: Dr. Alexei Khalizov

Human activities that involve mining and the burning of fossil fuels release mercury, otherwise found in the earth crust, to the atmosphere. This atmospheric mercury contributes significantly to the burden of mercury cycling throughout various ecosystems and food chains. Most of the mercury in the atmosphere is present initially in elemental form (gaseous elemental mercury, GEM) and can stay there for up to a year, which leads to its transport all around the Earth. During this time, mercury can undergo photochemical oxidation, where sunlight and chemicals from pollution react with elemental mercury to form various forms of gaseous oxidized mercury (GOM). To understand how mercury enters the ecosystems, it is important to understand the removal of GOM from air by various surfaces, including land, cloud droplets, and aerosol particles. The objective of this project is to measure the rate and understand the mechanism of the heterogeneous reactions of GOM on solid and aqueous surfaces. Since at this time we cannot study reactions on aqueous solutions, we will use ionic liquids as surrogates to represent both crystalline and aqueous aerosol surfaces. Preliminary data indicate that the uptake of mercuric chloride is very efficient on ionic liquids in liquid state. The ionic liquid we will use is 1-ethyl-3-methylimidazolium chloride, which can undergo phase changes from solid to liquid states by changing its temperature. This chemical will be applied to the inner surface of a glass tube and placed inside a fast flow reactor. Using experiments in a flow reactor connected to a mass spectrometer, we will determine the rates of adsorption and desorption of mercuric bromide on solid and liquid surface. From this data, uptake coefficients and surface capacities will be calculated. Further investigation must be conducted to better mimic the cycle of phase change of aerosols in the atmosphere. The amount of mercury adsorbed could possibly vary based on completed cycles.

Novel MXene-Based Electrified Surface Coatings for Antiviral Air Filtration

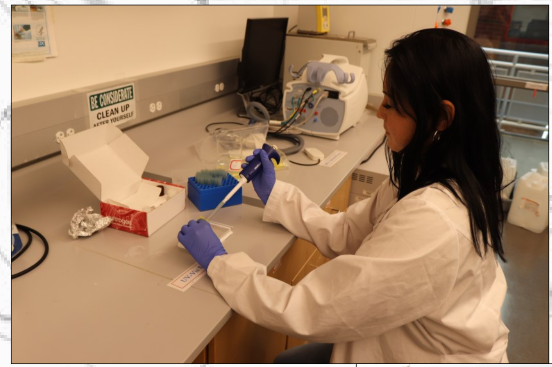
Marina Sefen, Advisor: Prof. Mengqiang (Mark) Zhao, and Mentor: Fang Zhao Liu, PhD student

As the COVID-19 outbreaks and other infectious diseases continue to spread all over the world, the removal of airborne viruses in the confined air such as buildings and hospitals is increasingly important. The most effective way to remove the infectious virus particles from contaminated air can be achieved with air filters. Unfortunately, these filters are expensive and the accumulation and proliferation of viruses within the filters are associated problems. Among different kinds of strategies to combine the viral inactivation with air filtration technology, air filters with electrified conductive coating are more attractive due to high energy efficiency, scalable, and easy installation at a low cost. This project aims to develop efficient antiviral air filtration enabled by electrified MXene coatings. Based on my experience in MXene synthesis, this project will achieve the scalable fabrication of MXene coatings on commercial air filters in facemasks and HVAC systems; evaluate the antiviral performance of the MXene-coated air filters under an applied voltage. This proposed project targets to demonstrate that the MXenes can form a stable surface coating on commercial air filters, which will show promising antiviral performance under a low voltage.

Privacy Aspects of Smart Medical Apps

Ricky Hernandez, Advisor: Dr. Shantanu Sharma, Graduate Mentor: Ethan Myers

With the increasing prevalence of mobile apps and the sensitivity of personal information, they handle, ensuring the protection of user privacy has become a critical concern. This research project investigates the fidelity of mobile app descriptions to the permissions requested by the app logic, focusing specifically on medical health applications. The study is motivated by the need to address potential privacy violations and ensure compliance with privacy laws such as the General Data Protection Regulation (GDPR) and other relevant regulations. The study utilizes the Google Play Scraper API, JADX app decompiler, Python Pandas framework, and a fine-tuned BERT transformer for natural language processing (NLP). Drawing inspiration from the previous work of AC-NET NLP, which addressed similar fidelity issues, our research expands upon their efforts by narrowing down the scope to medical health applications. These apps often handle sensitive personally identifiable information and are frequently subject to legal protections. The research methodology involves analyzing mobile app descriptions and extracting the corresponding permissions from the Android Manifest file. A proof of concept is developed through the creation of datasets suitable for input into our fine-tuned BERT transformer NLP model. The findings reveal that a considerable number of health apps exhibit excessive permission requests that surpass the boundaries outlined in their listed descriptions. This discrepancy highlights potential concerns regarding user privacy and data protection. As a direction for future study, it is recommended to extend the analysis to include the examination of privacy policies and terms of service. This expanded investigation would provide insights into how user data is managed by the app in accordance with legal disclosures. By considering these additional aspects, a more comprehensive evaluation of app behaviors and their alignment with user expectations can be achieved.

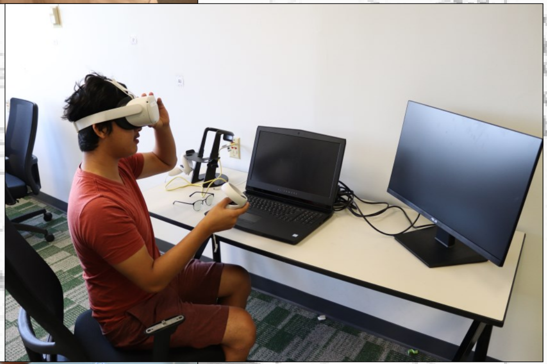


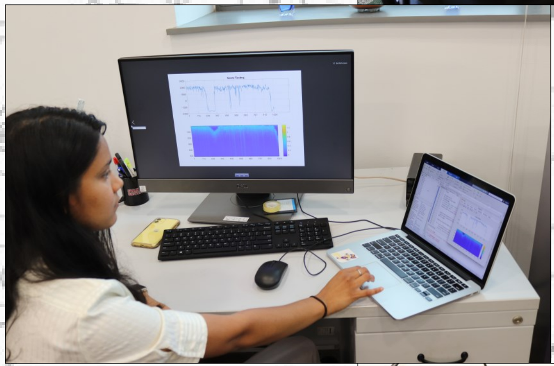
Taylor Pape

Biology

Tsewang Sherpa

Computer Science



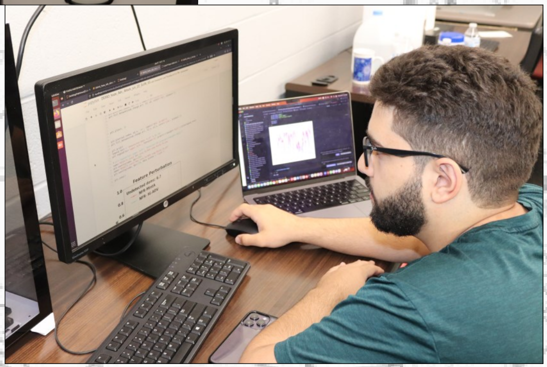


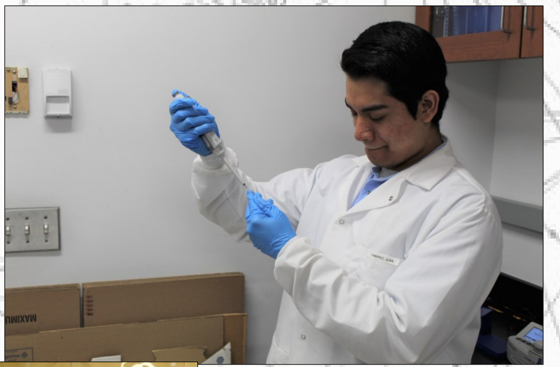
Rajal Vyas

Bio-Medical Engineering

Yousuf Kanan

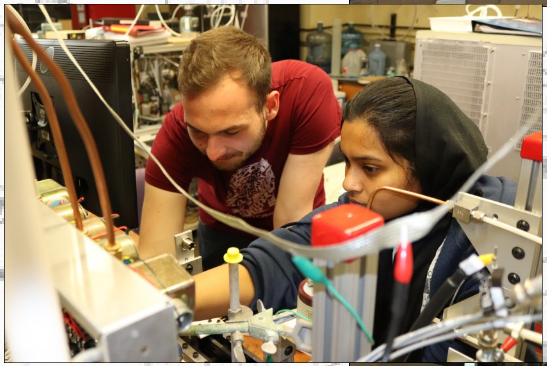
Computer Science





Juan Ramirez

Bio-Medical Engineering

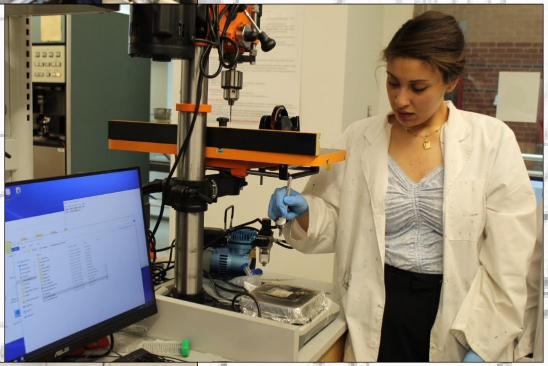


Laila Nashir

Chemistry

Marina Sefen

Chemical Engineering



Ricky Hernandez

Information Technology

Smart Biosensors with Machine Learning for Objective Pain Assessment

Taylor Pape, Advisor: Dr. O. Sadik, and Mentor: M. Mady Ph.D. student

Pain is currently not quantifiable and only identified through subjective patient self-reports for assessment. This leaves clinicians unable to administer proper treatment based on actual pain felt. This research proposes a correlation between patient self-reports on a pain scale (0 being no pain and 5 being extreme pain) and calibratable measures of biomarkers using machine learning to provide a quantified look at pain. Cyclooxygenase-2 (COX-2) plays a critical role in the synthase of prostaglandins (Lipids made at the sites of tissue damage and inflammation). A calibration curve was produced for COX-2 through serial dilutions in indirect-sandwiching ELISA and UV spectroscopy. Concentrations of COX-2 found in the patient's blood samples will be compared to this curve for identification. A Bayesian Networking model can construct a probabilistic graphical model with evidence from the patient self-reports and measurable biomarker levels. During this summer, we focused on finding a method to successfully measure COX-2 concentrations in patient samples. This involved identifying indirect-sandwiching ELISA and creating chemical reagents necessary for this procedure. This experimental technique will be applied to future identified proteins related to the biological processes of pain to further improve the results of our machine-learning model.

VROOM Management System

Tsewang D Sherpa, Advisor: Dr. Margarita Vinnikov, and Mentor: Dr. James Geller

Ontologies are knowledge graphs composed of terms (nodes) and relationships (edges) within a specific domain. Visualizing and manipulating such a network in 2D-screen when it includes more than a few hundred nodes can be challenging. VROOM (Virtual Reality Ontology Object Manipulation system), proposed by Dr. Vinnikov and Dr. Geller, extends the ontology display into the third dimension, allowing an intuitive and immersive way to interact with knowledge repositories. This research contributes to the development of VROOM in Unity Software, with the main focus on three areas: untethered connectivity using Azure, advancements in teleportation functionality, and exploring Unity's Netcode library to adopt multiplayer mode for collaboration. The implementation of a custom class for blob storage in VROOM enables seamless interaction with online files located in Azure Blob Storage, facilitating efficient retrieval and uploading of data. This enhances the system's flexibility and allows users to move freely in real space, thereby reducing motion sickness. In addition, an arc-teleportation mechanism has been implemented as a solution for motion sickness. This technique allows users to experience a more immersive and natural movement in the virtual environment, reducing the discomfort associated with previous flying locomotion. While multiplayer functionality is still under development, efforts have been directed toward improving the system's performance and scalability by replacing the previously implemented Photon 2 with Netcode. This transition aims to simplify access to multiplayer experiences while keeping up with the latest Unity versions. As work on the multiplayer capabilities continues, VROOM looks promising to emerge as a unique and novel Ontology Management System, offering users an enhanced virtual reality environment that fosters user engagement, curiosity, and the benefits of learning/working together.

NSF - REU Optics and Photonics

Machine Learning Algorithm to Detect Skin Cancer Boundary

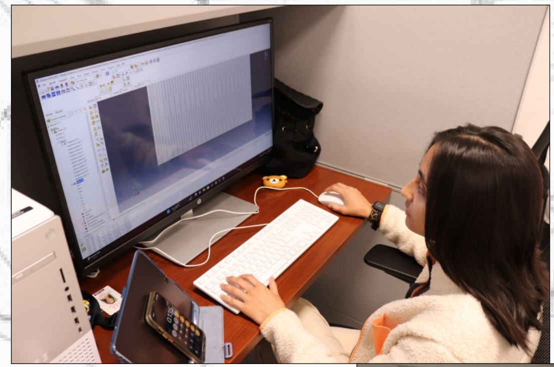
Rajal Vyas, Advisor: Xuan Liu, PhD

Nonmelanoma skin cancer such (NMSCs) as basal cell carcinoma (BCC) and squamous cell carcinoma are common in the . Techniques to extract and detect skin cancer are crucial for efficient diagnoses and treatment of skin cancer. Mohs microsurgery is a treatment procedure that can remove cancerous skin tissue and successfully treat NMSCs. However, Mohs microsurgery is a lengthy process that keeps the patient in the doctor's office for long hours. Thus, better tools that can detect the boundary of skin cancer are needed to make the extraction process more efficient. An imaging tool called optical coherence tomography (OCT) is used to create depth-resolved 2-D cross-sectional images of biological tissue such as skin. OCT is used to create depth-resolved images of skin tissue to diagnose skin cancer. OCT signals are crucial to produce OCT images and detect different characteristics of the OCT image such as the dermis-epidermis junctions. To generate the OCT image, specific characteristics are calculated from the OCT signals. Specifically, average signal intensity, which corresponds to the strength of the signal, and average signal attenuation are calculated and used to reconstruct the image. These characteristics extracted from the OCT signal can be fed into a machine learning algorithm such as the support vector machine (SVM). SVM can be used in MATLAB to perform one-class classification to distinguish normal skin from abnormal skin. In MATLAB, SVM scores are calculated to classify the skin tissue. A score higher than zero means normal tissue, while a score lower than zero means abnormal tissue. The goal of the study was to use an SVM classifier in MATLAB to distinguish abnormal and normal skin tissue and make a clear boundary between normal and abnormal skin tissue. We validated our classifier by making a ROC (receiver operating characteristic curve) which showed the performance of our classifier at different thresholds of classification.

Exploiting Spatio-Temporal Information to Predict Traffic Speeds: a Machine Learning Approach

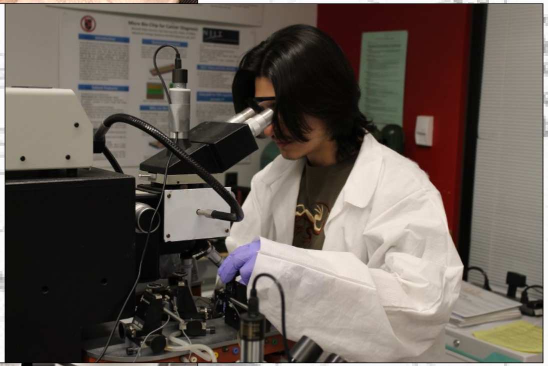
Yousuf Kanan, Advisor: Dr. Abdallah Khreishah, Mentor: Mahmoud Nazal

The prediction of traffic speed is advantageous for ensuring efficient transportation systems and improving road safety. Traditional approaches to traffic speed prediction often rely on statistical models, which may not fully capture the complex spatio-temporal dynamics of traffic patterns. In recent years, a machine-learning approach has been utilized to predict traffic speeds and patterns. We intend to improve the performance of spatio-temporal information through graph neural networks (GNN) and long-short-term memory (LSTM) architectures. This will be achieved by enriching the node features by adding information from both the environment and the measured dataset. The proposed approach considers historically collected vehicle data. This data includes but is not limited to timestamps, longitude, latitude, and speed. We expect that our enhanced dataset will see a significant increase in traffic speed prediction accuracy.



Chelsea Garcia

Mechanical Engineering

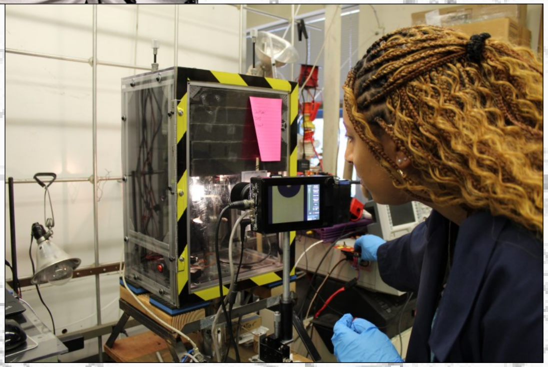


Endy Nava

Mechanical Engineering

Faith Adams

Bio-Medical Engineering



Idalia Warren

Chemical Engineering

"Research is formalized curiosity. It is poking and prying with a purpose. It is a seeking that he who wishes may know the cosmic secrets of the world and they that dwell therein."

-Zora Neal Hurston

Heritage Institute of Technology

Evaluation of Hydrogel Scaffolds for Myocardial Regeneration

Anushri Gupta, Advisor: Prof. Dr. Vivek Kumar, Mentors: Abhishek Roy, Siya Patel

Myocardial infarction, commonly known as heart attack, is a disease where the affected person's heart suffers a shortage of blood supply. This may happen due to a blockage caused by blood clots in the coronary arteries. To treat this disease, the heart needs supplemental blood flow for itself. This project focuses on injecting peptide-containing hydrogels along with cells in the patient's body. These specific peptides are angiogenic peptides, acting as drugs for these patients as they form supplementary blood vessels, supplying the blood the heart requires. This project involves the synthesis of these angiogenic peptides by the method of solid-phase peptide synthesis, introducing them into thixotropic hydrogels produced in this very lab, injecting them alongside stem cells into lab mice in which myocardial infarction was artificially induced. Tissue samples are taken from the heart of these mice on 7 day and 28-day time points, and their sections are stained using H&E and Trichrome stains, mounted and fixated on glass slides with the help of paraffin. These slides are meant to be studied under the microscope, and scanned digitally using the software ManualWSI for quantification with the help of the QuPath software. Quantification involves the analysis of the tissue sections for cell density, neovasculature and wall thickness. It studies the changes (if any) induced in the tissues by the drug, that is the angiogenic peptide-containing hydrogels in this case, that have been introduced into the system. This would further aid in comprehending the effect and inferring the potency of the drug along with its other characteristics.

Literature Review Seminar

A RLHF Framework to Promote Proportionate Fairness in LLMs

Subhodeep Ghosh, Advisor: Prof. Senjuti Basu Roy

Large Language Models or LLMs, such as OpenAI's GPT-3, have achieved remarkable results in a wide range of natural language processing (NLP) tasks like by learning from vast amounts of internet text. However, concerns have been raised about potential biases present in these models, which may lead to unfair or disproportionate outcomes in various applications. The goal of the project is to fine tune LLMs using Reinforcement Learning Human Feedback (RLHF) based computational framework to make the LLM outputs more inclusive to diverse populations. The primary novelty is to incorporate multiple and diverse labellers (users) in the RLHF loop and aggregate their preferences in a principled manner. We build on existing RLHF framework and innovates on how to aggregate diverse ranking from multiple labellers to produce a single ranked order such that the aggregated ranked order satisfies a group fairness criterion, namely proportionate or p-fairness. Then, a reward model is trained that produces a scalar value reflecting the order that the proportionate fair aggregation gives rise to. Given the reward model, the initial LLMs are fine-tuned using reinforcement learning. The proposed framework will be evaluated considering statistical as well hallucination measures using public datasets and open source LLMS (e.g., LLaMA, Koala, etc). The results demonstrate that this approach significantly reduces bias and promotes more proportionate fairness compared to traditional training methods. We also address potential challenges and limitations of the RLHF framework, such as the reliability and subjectivity of human feedback. We propose strategies to mitigate these challenges, including diversity in evaluator selection and careful design of evaluation metrics. In conclusion, the RLHF framework offers a promising approach to enhance fairness in LLMs by integrating human feedback into the training process. By considering multiple perspectives and incorporating fairness objectives, we aim to mitigate biases and promote proportionate outcomes in language generation tasks. The project contributes to the broader goal of developing AI systems that align with ethical principles and societal values.

How to make Effective Oral & Poster Presentations Seminar

Live SMPLX Model control and its applications in the Metaverse

Sohom Sen, Advisor: Dr Tao Han and Mentor: Mingrui Yin

This research aims to combine the capabilities of FrankMocap, a state-of-the-art motion capture tool, with the parametric model SMPLX, to enable accurate and realistic human movement simulation within a Unity Engine-based virtual environment. The project focuses on extracting essential parameters such as beta, pose, and expression from FrankMocap and integrating them into SMPLX for seamless and lifelike virtual character animation. The project follows a comprehensive approach that involves several key steps. First, motion-capture data is captured using FrankMocap, which employs computer vision techniques and deep learning algorithms for precise 3D pose estimation and tracking from monocular RGB videos which may be recorded earlier or live-streamed. From the captured data, beta parameters, representing body shape, and pose and expression parameters are extracted. The extracted parameters are then integrated into the SMPLX model to achieve realistic human movement simulation. SMPLX is a powerful parametric model that accurately estimates joint angles and vertex positions, enabling the generation of lifelike 3D human body shapes and poses. The integration process involves mapping the parameters obtained from FrankMocap onto the SMPLX model, allowing for seamless compatibility and synchronization. To validate the effectiveness of the proposed integration, extensive experimentation and analysis are conducted. Various benchmark tests and comparisons with existing methodologies evaluate real-time performance, accuracy, and visual fidelity. The resulting virtual character animations are assessed for their realism and ability to mimic human movements convincingly within the Unity Engine. The project showcases advancements in real-time performance and accuracy, enabling the creation of immersive virtual environments with highly realistic and interactive virtual characters. The seamless integration of FrankMocap and SMPLX offers a powerful toolset for developers and researchers in the fields of virtual reality, gaming, animation, and biomechanics, facilitating the creation of lifelike human avatars and enhancing user experiences. The integration of FrankMocap and SMPLX presents a novel approach to realistic human movement simulation within a Unity Engine-based virtual environment. By leveraging the capabilities of both tools, this research contributes to the advancement of motion capture technology and its applications in various domains. The findings open new avenues for creating highly realistic and immersive virtual experiences, revolutionizing the entertainment, healthcare, and education industries. Future work may focus on further enhancing the integration, exploring additional parameters, and expanding the applications of this technology to create even more lifelike virtual characters.

Statistics for STEM Research Seminar

Large language models for predicting functional genetic variant candidates

Arin Ghose, Advisor: Dr. Zhi Wei

Large language models have emerged as powerful tools for predicting functional genetic variant candidates, revolutionizing the field of genomics research. These models leverage the advancements in deep learning and natural language processing to capture intricate patterns and relationships within genomic sequences and associated functional annotations. By pre-training on vast amounts of genomic data, these models acquire a comprehensive understanding of the functional language encoded in the genome. We make use of DNABERT, which is a pre-trained Bidirectional Encoder Representations from Transformers (BERT) model specifically designed for analysing DNA sequences, representing the "language" of the genome. DNA sequences contain crucial information that governs the functioning and regulation of genes, and understanding this language is a fundamental problem in genomics research. The model learns to extract meaningful features from DNA sequences, including nucleotide patterns, structural motifs, and regulatory elements. DNABERT has demonstrated promising performance in various downstream genomics tasks, including DNA sequence classification, variant calling, regulatory element prediction, and functional annotation. It offers a versatile framework for extracting meaningful features from DNA sequences, enabling researchers to gain insights into the genomic information encoded within the DNA. Moreover, DNABERT serves as a valuable resource for transfer learning, as it can be fine-tuned on task-specific datasets to boost performance on specific genomics tasks with limited labelled data. The pre-training and fine-tuning processes enable DNABERT to effectively leverage the vast amount of available unlabelled DNA sequence data, making it highly adaptable and capable of capturing the nuances of DNA-language. The application of large language models in functional variant prediction has significant implications for precision medicine, disease research, and drug development. These models provide valuable insights into the functional impact of genetic variants, helping researchers prioritize variants for further experimental validation and guiding the interpretation of genome-wide association studies. Furthermore, large language models foster the democratization of genomics research by facilitating the analysis of genetic variants in non-coding regions of the genome, which were previously challenging to decipher. They provide a comprehensive and interpretable framework for understanding the functional implications of genetic variation, bridging the gap between genomic sequences and their phenotypic consequences. In conclusion, large language models represent a breakthrough in predicting functional genetic variant candidates. Their ability to capture complex patterns, context dependencies, and functional annotations within genomic sequences has transformed the field of genomics research. As these models continue to advance, they hold immense potential for accelerating our understanding of the functional landscape of the genome and facilitating personalized medicine approaches based on genetic variant interpretation.

Simulation & characterization of oxide-based RRAMs

Ayush Kashyap, Advisor: Professor (Dr.) Hieu P. Nguyen
Mentor: Mano Balasankar Muthu, Ph.D. Student

In today's world, humans want their electronic devices to be faster and more efficient in terms of power consumption. The functioning of an electronic device is highly influenced by multiple factors; one of the most important of them is the RAM of the device. The present RAMs that are generally used are Static RAMs (SRAM) & Dynamic RAMs (DRAM). The problem with SRAM is that its structure is pretty big and the Read/Write operations are very slow, whereas DRAM is not only slow but also it needs to be refreshed every few milliseconds. The upcoming solution to these problems is the use of Resistive RAMs (RRAMs). RRAM is considered one of the most standout emerging memory devices owing to its high speed, low cost, enhanced storage density, and excellent scalability. Our research focuses on simulating the RRAM device on the Silvaco software and creating a template for it. The future scope of this research is to make the existing devices faster and enhance their use in the field of neuromorphic computing systems.

Traffic Forecasting in New Jersey using Graph Neural Networks based on vehicle centric data

Poulami Basu, Advisor: Dr. A Khreishah, and Mentor: M. Nazzal, PhD Student

Traffic forecasting plays a crucial role in optimizing transportation systems and improving overall traffic management. With the increased availability of vehicle centric data and advancements in machine learning techniques, Graph neural networks (GNNs) have emerged as a promising approach for traffic forecasting tasks. This forecasting system aims to provide accurate predictions of traffic conditions, including congestion, travel times and potential incidents. This prediction aims to help individuals plan their routes to save fuel, improve productivity and contribute to efficient urban planning and infrastructure development. The objective of this research is to develop an accurate and reliable traffic forecasting model that can effectively capture the complex spatiotemporal dependencies inherent in transportation networks. The proposed approach leverages the power of GNNs to model traffic patterns as a graph, where road segments and intersections form nodes and their connectivity represents the underlying road network structure. This research will develop an architecture that will achieve these objectives. We aim to look closely at the junction points to stabilize our calculations and fix the errors in the existing models. The research methodology involves collecting real world traffic data from various sources using Geojson, to collect the latitude and longitude of the location. This research contributes to the field of traffic forecasting by showcasing the efficacy of GNNs in capturing complex spatiotemporal patterns in transportation networks. The findings provide valuable insights for transportation planners and traffic management authorities in New Jersey and beyond, facilitating the development of more efficient and data-driven strategies to alleviate traffic congestion and improve the overall transportation efficiency by improvement in quality of predictions based on multiple metrics.

On-Chip Blood Plasma Self-Separation for Point-of-Care (POC) Devices

Sahil Molla, Advisor: Prof. Eon Soo Lee, Mentor: Yudong Wang

Point-of-care (POC) devices refer to devices that conduct laboratory testing close to the patient rather than in a laboratory. Human blood is one of the most commonly used analytes for disease detection in the POC devices due to the presence of biomarkers in blood plasma (Fig. -1). In a POC diagnostic device, an efficient, portable, and easy-to-use on-chip blood plasma separation platform is highly desired to broaden its applications. The particles (about 10 μm) are used to mimic red blood cells (RBCs) in the blood flow in a microfluidic platform. This study helps to design microchannels for the POC devices to separate blood plasma from other components of the blood without using any external devices. In the experiments, capillary flow is used in the microfluidic channel to avoid usage of external devices like pumps. The Reynolds number measured at the channel inlet and 20 mm away from the inlet, drops from 8 to 1. In the flow field, both inertia and viscosity of the fluid being finite, the following two effects play critical roles within a spiral channel design (Fig.-2): (i) Inertial migration of the particles, and (ii) Dean vortex effect induced by the curved channel. Inertial migration refers to a phenomenon where disordered particles suspended in channel flow migrate laterally across streamlines at equilibrium positions near channel walls. Additionally, Dean vortices induced by curved channel shape focus the particles to the channel inner side based on particle sizes (size ratio between particle and channel diameter > 0.07). Therefore, using a spiral channel helps in particle concentration in its inner wall and therefore the inner outlet channel has the maximum particle concentration. Based on this result, the microfilters can be integrated into the outer branch outlet. With lower concentrations of the particles/blood cells in the outer outlet, the blood plasma separation efficiency in the microfilters is significantly increased, and the clogging issue in the microfilters gets eliminated.

Design and Evaluation of High-Performance and Energy-Efficient Processing-in-MRAM Accelerators

Shriyans Roy, Advisor: Dr. Shaahin Angizi and Mentor: Mehrdad Morsali, PhD Student

In the upcoming times, as the demand for high-performance and energy-efficient computing systems continue to grow, there is a need for novel accelerator designs that can effectively exploit the benefits of emerging non-volatile memory technologies, such as Magnetic Random Access Memory (MRAM). The objective of this research is to explore the potential of utilizing MRAM as a key component in accelerator architectures, aiming to enhance system performance and energy efficiency. Due to an expansion of data-intensive applications such as Neural Networks, the conventional computing systems based on von Neuman architecture have faced severe bottlenecks because of massive data transfer between separated memory and processing units. In-memory computing is a promising solution to overcome the limitations of conventional computing systems. Among different memory technologies, MRAM, offering non-volatility, high endurance, dense structure, and CMOS compatibility, can be a promising candidate. In this research we leverage the uni- and bi-polar switching behaviour of Spin-Orbit Torque Magnetic Random Access Memory (SOT-MRAM) to develop efficient digital Computing-in-Memory (CiM) platforms. Our platforms convert typical MRAM sub-arrays to massively parallel computational cores with ultra-high bandwidth, greatly reducing energy consumption dealing with convolutional layers and accelerating X(N)OR-intensive Binary Neural Networks (BNNs) inference. We use HSPICE software for simulation of circuits and analysing the different characteristics. The findings of this research contribute to the advancement of accelerator design methodologies by highlighting the potential of MRAM as a key technology for achieving high-performance and energy-efficient computing systems. Future research in high-performance and energy-efficient processing-in-MRAM accelerators can explore optimization, different MRAM variants, integration with emerging technologies, design automation, and reliability considerations.

Design of Core Shell (PbS-CdS) Quantum Dots for Optimizing Energy Transfer

Rohan Ghosh, Advisor: Dr. Leonid Tsybeskov, Mentored by: Rakina Islam

Quantum dots (QDs) have emerged as highly versatile nanomaterials with unique optical properties, making them valuable for a wide range of applications. The most important feature which quantum dots possesses is its size tunable optical and electrical properties. Traditional quantum dots have various defects on the nanoparticle surface which causes the photoluminescence, a significant optical property to decrease to a great extent. There are various ways reported for the passivation of such defects, one such way is the growth of another semiconducting nanoparticle shell over the quantum dots. We are focusing on the production of such quantum dots, generally termed as core-shell quantum dots, to enhance the optoelectronic properties of quantum dots to get a better optical yield which can be used in lasers. In particular, core-shell quantum dots with a PbS (Lead Sulfide) core and CdS (Cadmium Sulfide) shell have accumulated significant attention due to their exceptional photoluminescence properties in the near-infrared (NIR) region. The core-shell structure of these quantum dots involves a PbS semiconductor core, known for its high NIR absorption, encased within a CdS shell. The synthesis of PbS-CdS core-shell quantum dots typically involves colloidal methods. We are employing hot injection method to obtain PbS quantum dots, with precise control over size, shape, and composition followed by a cation exchange process to grow a monolayer of CdS shell over the PbS core. This design enables efficient charge transfer and confinement, leading to enhanced photoluminescence efficiency and improved stability of quantum dots. The optical properties of PbS-CdS core-shell quantum dots are characterized by their strong and tunable NIR emission. The narrow emission linewidths and high quantum yields of these quantum dots further enhance their utility in multiplexed imaging and improved lasing action. Moreover, the unique properties of PbS-CdS core-shell quantum dots have also found applications in optoelectronic devices. Their NIR emission is well-matched with silicon-based photodetectors, enabling the development of high-performance NIR detectors. The field of PbS-CdS core-shell quantum dots is continuously evolving, with ongoing research focusing on improving their stability, and surface passivation. Surface modification techniques, such as ligand exchange and shell doping, are explored to enhance their stability and enable compatibility with various environments and applications. The ongoing research highlights the efficacious composition of such PbS-CdS core-shell quantum dots as a promising class of nanomaterials with the goal to enhance photoluminescence of the quantum dots. Their synthesis, tunable NIR emission, and compatibility with various applications make them highly attractive for optoelectronics, and other fields. Further research in this domain will contribute to the development of advanced technologies and foster their integration into practical applications, thereby expanding the horizons of nanoscience and its real-world impact.

Renewable Energy Systems Monitoring using IoT-Sensing and Digital Twin Platform

Rahul Laha, Advisor: Dr. Philip Pong, Mentor: Dr. Abdellatif El Mouatamid

The world is currently undergoing the industry 4.0 revolution, reshaping industrial production with the integration of data analytics, connectivity and human-machine interaction. The advent of the Internet of Things (IoT) and cloud computing has led to a rapid hike in industrial productivity. With the continuation of rapid globalization and industrialization, meeting the ever growing energy demands has become a major challenge. In order to minimize the stress and dependency on non-renewable energy sources such as fossil fuels, harnessing renewable energy has emerged as the only solution. In this project, the main focus has been on measuring and enhancing the efficiency of solar panels. Multiple sensors for monitoring current, voltage, temperature, humidity and irradiance are deployed alongside the solar panels connected to an Arduino microcontroller. These sensors collect statistical data and real-time conditions, which are directly stored on a cloud platform- Thingspeak. The platform provides a graphical representation of the raw data as well serves as an input for a simulation model developed in Simulink. The output of the simulation model is being recorded for comparison. This comparison between the real and simulated outputs is crucial for improving and maximizing the power output from real systems. The gathered data is used to interconnect the real model with an equivalent virtual model offering the same operation context (e.g., temperature, solar irradiance). The inclusion of IoT and digital twin technologies enables the most up-to-date and cost-effective method for remotely monitoring the performance of a solar plant. It can also provide information regarding maintenance and real-time monitoring. Furthermore, this concept can be easily extended to monitor other renewable energy systems by altering a few parameters and incorporating appropriate sensors. In conclusion, this research proposes a comprehensive approach for monitoring and optimizing renewable energy systems through data analytics, simulations, IoT, and digital twin technologies. These advancements enable effective fault detection and diagnosis in large-scale power systems like offshore wind farms and solar power farms.

Personal Statement Seminar

Trajectory Clustering Analysis for Modelling Human Hand Motion Skills in Robotics

Rituja Bhattacharya, Advisor: Dr. Cong Wang, and Mentors: Dr. Sergei Adamovich, Muhaiminul Islam Akash, Zurzolo Jr. Lorenzo, PhD students

The analysis of trajectory data, particularly trajectory clustering, plays a significant role in the field of machine learning for enhancing the physical skills of robots. This research project aims to investigate the potential of trajectory clustering as a technique to model and understand the motion skills of human hands, thereby enabling the development of autonomous robot hand functions. The motion skills of robots can be represented as trajectories in high-dimensional spaces. By recognizing patterns, such as clusters of trajectories, it becomes possible to develop models that accurately describe these physical skills. Consequently, robots can autonomously plan and execute similar skills based on the learned models, leading to more efficient and adaptive robotic manipulation of objects. To gather real trajectory data for analysis, our focus lies specifically on collecting motion trajectories of fingers during object manipulation. Among the candidate equipment options available, including the Leap Motion controller, Ultra LEAP (an advanced version of Leap Motion), Oculus Quest VR headset, and a marker-based motion capture system, the Leap Motion controller was chosen due to its ability to capture subtle details of human finger motion. The collected high-resolution trajectory data will be subjected to segmentation and clustering algorithms to identify distinct clusters that represent different hand motion patterns. The outcomes of this research project are expected to significantly contribute to the advancement of machine learning techniques for physical skills in robotics. By accurately recognizing clusters of trajectories, we can develop models that provide valuable insights into the underlying structure and patterns of human hand motion. Ultimately, these models will empower robots to mimic and master human-like hand motion skills, thus enhancing their capabilities for object manipulation. In conclusion, this research project focuses on leveraging trajectory clustering analysis to model and understand the motion skills of human hands. By utilizing the Leap Motion controller to capture real trajectory data, combined with advanced segmentation and clustering algorithms, this research aims to pave the way for the development of autonomous robot hand functions that can effectively manipulate objects based on the learned human motion skills.

Funding Graduate School Seminar

CHARACTERISATION OF RRAM DEVICES FOR NEUROMORPHIC COMPUTATIONS

RITVIK BORDOLOI, Advisor: Dr. (Prof) Durga Misra and Mentor: Aseel Zeinati , PhD Student

Research activities in the field of brain-inspired computation (also termed Neuromorphic Computation) have received a lot of importance in recent years. Resistive memory devices are considered best to show the biological synaptic characteristics at nanometre scale, because of the fact they offer the possibility to modulate their conductance by applying low biases, and can be easily integrated with CMOS-based neuron circuits. These applications required multilevel cell (MLC) characteristics that can be achieved in RRAM devices. One of the methods to achieve low power switching behaviour is by applying an optimized electrical pulse. The RRAM device structure is basically an insulator between two metals as metal-insulator-metal (MIM) structure. Where one of the primary challenges is to assign an RRAM stack with both low power consumption and good switching performance. By analysing the distribution of defects and oxygen vacancies in the switching layer and using the plasma treated HfO_2 devices show a promising conductance quantization with low power consumption. The performance can be further enhanced by engineering the bottom electrode. The impact of introducing additional nitrogen at the bottom electrode, TiN shows additional reduction in the switching power of the plasma treated devices. The device we worked on has a bottom electrode with 5 nm Ti and 50 nm TiN and a top electrode with 5 nm ALD TiN and 50 nm PVD TiN. The switching layer was plasma treated HfO_2 shown on the left figure below. The device switched at a compliance current of 600 nA shown on the right figure below. Our device seems to be a promising device for neuromorphic application.

Abstract Critique Seminar