Collaborative Research and Innovation Partnerships

# *New Jersey Institute of Technology's*
# 2023 Undergraduate Summer Research and Innovation Symposium

## July 26-27, 2023
# Book of Abstracts

# 2023 Undergraduate Summer Research and Innovation Symposium

## July 26-27, 2023

# Program

Undergraduate Research and Innovation (URI)
Office of Research
New Jersey Institute of Technology

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# 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**

Department of Biomedical Engineering

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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.

# Protein Engineering Using Directed Evolution for Bioremediation

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Abstract: Plastic manufacturing has accrued plastic waste in the environment that is difficult to break down. Polyethylene terephthalate (PET) is an inert and semicrystalline polymer globally synthesized to package many consumer products. Accordingly, PET is becoming an emerging pollutant in marine ecosystems that contributes to 80% of plastic debris in surface waters and deep-sea sediments. With approximately 14 million tons of plastic winding up in the ocean annually, one million marine animals are killed each year. Fortunately, enzymatic routes have been discovered for bioremediation, and an enzyme capable of hydrolyzing PET is called Leaf-branch Compost Cutinase (LCC). In nature, LCC enzymes are extracellular enzymes secreted by microorganisms that can degrade plant cell walls by catalyzing the cleavage of ester bonds of cutin. Natural evolution is being mimicked in a test tube in order to develop evolved LCC enzymes that can hydrolyze a PET analog called mono-4-nitrophenyl terephthalate (MpNPT). Random mutations will be generated through error-prone PCR or recombination to accrue variants of the LCC enzyme. Then high-throughput screening will be performed in order to identify the improved mutant(s). Lastly, the genes are isolated from the evolved mutant(s) to create gene libraries, and the cycle repeats in an effort to evolve an enzyme with optimized activity. Over the summer, the lab has been developing a reliable high-throughput screen, which is the most important step in a laboratory evolution experiment. A protein assay requires a low coefficient of variation (10-20%) of kinetic rate or endpoint. This step is crucial because reducing the CV among the enzymes will reduce the probability of selecting a false positive before creating mutated enzymes with improved properties. The latest data revealed that the CV was 16%, indicating the enzyme activity of each enzyme in the developed MpNPT screen was similar.

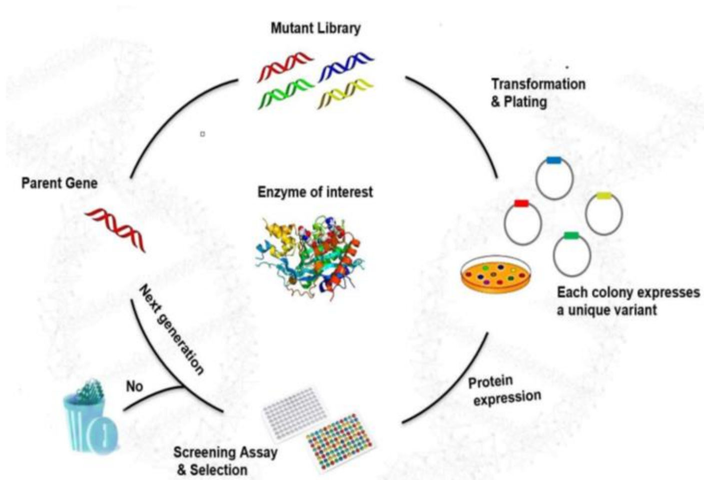


**Figure 1:** Experimental design for protein engineering using directed evolution.

## 3D Muscle Shape Reconstruction to Establish the Relationship Between Muscle Shape and Function

**Marissa Christenson & Dr. Jongsong Son**

Biomedical Engineering

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The gastrocnemius muscle is a powerful muscle in the calf that plays an imperative role in lower limb movement and stability. In patients with neurologic conditions, gastrocnemius muscle structure and function are sometimes compromised, leading to motor impairment. Current treatments include medications to reduce symptoms and rehabilitation to maintain motor function, though there is no clinical treatment to reverse the disorders. In this study, we propose to quantify the morphology of the gastrocnemius muscle using 3D ultrasound imaging technology to propose a relationship between muscle shape and muscle function. With this insight, we can further efforts to develop novel and clinically relevant rehabilitation therapies for neuromuscular disorders.

**Investigating the Effects of Optogenetically Activating Dmrt3a in Larval Zebrafish**

**Evan Correa, Dr Kristen Severi**

**Department of Biological Sciences**

**New Jersey Institute of Technology, Newark, NJ 07102**

Neurons are the fundamental unit of the brain and spinal cord, which are responsible for coordinating the execution of a multitude of complex functions. Neurons can form complex networks called neural circuits, wherein a population of neurons are connected through synapses and can respond to either internal or external stimuli and execute a specific response. This project will focus on *Dmrt3a,* a gene that is expressed in spinal interneurons in larval zebrafish. This gene has already been identified as a key player in coordinating locomotion in mice and horses. Of particular interest is our ability to optogenetically activate this neuron (stimulate it using a specific wavelength of light) and observe its effects relative to a control, non-expressing group. This project investigates the role of activating the gene in larval zebrafish and develops an experimental paradigm to investigate the role of other similar motor neurons.

# Applying Ultrafast Microdroplet Protein Digestion to Hydrogen-Deuterium Exchange Mass Spectrometry (HDX-MS)

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Hydrogen-deuterium exchange mass spectrometry (HDX-MS) has been gaining popularity for providing information on protein 3D structures and protein interactions. HDX-MS involves the exchange of hydrogen atoms with deuterium atoms on protein surfaces exposed to deuterated water (D2O). Bottom-up proteomics techniques can then be used where proteins are digested into smaller peptides and analyzed with liquid chromatography mass-spectrometry (LC-MS) to determine which amino acid residues were exposed to the solvent. Typically, proteins are digested online via a cold pepsin column, separated on an analytical column, and then detected by MS. However, typical HDX-MS workflow poses opportunities for back exchange, i.e., deuterium re-exchanges for hydrogens. This occurs when too much time elapses during protein digestion and when a low temperature is not maintained. To avoid these issues, online microdroplet digestion may be a viable alternative. Previous research suggests that by conducting microdroplet protein digestion, enzymatic reactions can be accelerated and completed within less than 1 millisecond. In this study, online microdroplet digestion was evaluated on deuterated insulin samples to determine the method's viability. Currently, it was determined that 30 minutes provided sufficient exchange time. Immediate future work includes optimizing digestion and ionization efficiency and finding software to assign peptide peaks to the mass spectra. Long term future application work includes analyzing tau protein interactions for Alzheimer research.

In preparation for HDX-MS, three samples of insulin from bovine pancreas were prepared. By exposing one of the samples to water and the latter two to deuterium oxide, a sufficient HDX labelling time was uncovered (30 minutes) (Figure I). Utilizing this procedure, HDX-MS was performed with the implementation of microdroplet protein digestion. This workflow involved sample preparation, HDX labelling, quenching, microdroplet protein digestion, and mass spectrometry analysis. Data analysis was conducted by comparing the undeuterated and deuterated samples. This revealed that the selected protein was efficiently digested into microdroplets and that there was an evident difference between the structure of the resulting deuterated and undeuterated peptide samples (Figure II). Future research should further optimize protein digestion in HDX-MS, validate findings with a known system, and apply findings to anti-Alzheimer's Disease drug development.

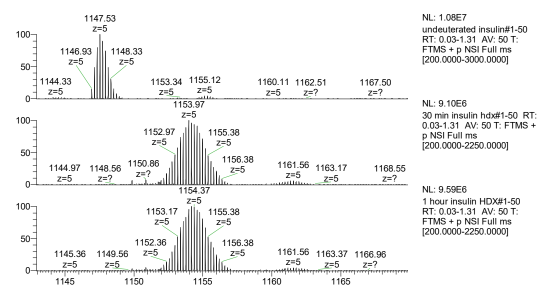

**Figure I.** Conducted method development to observe what time length of HDX labelling would be ideal for HDX-MS. Performed HDX labelling for 30 minutes and 1 hour and compared to undeuterated sample.

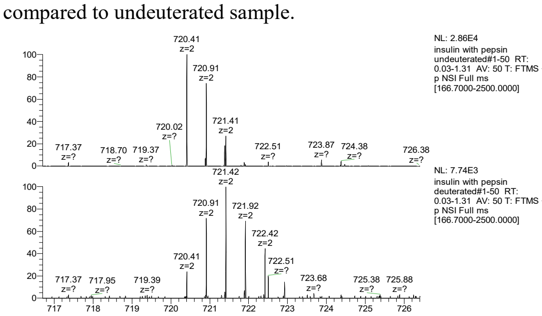

**Figure II.** Performed microdroplet protein digestion for HDX-MS to compare undeuterated and deuterated peptide samples. Peptide sequence of m/z 720.

# 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**

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Department of Mechanical and Industrial Engineering

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.

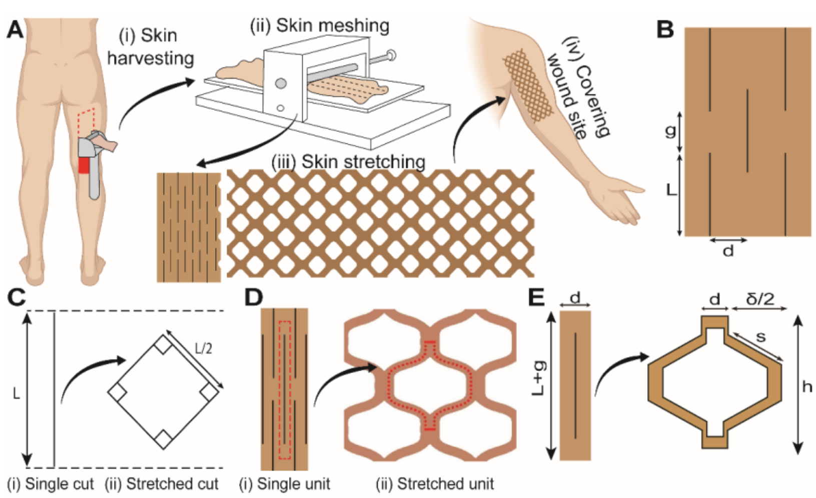


Figure 1: Illustration of the sequential steps involved in skin grafting.

# Epigenetic Signatures for Age-At-Death Estimation in Human Remains

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Forensic Science, Biology

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Currently, there are approximately 15,000 unidentified human remains in the US. One of the key steps in identification is the determination of the biological profile: biological sex, age, population affinity, and height. Age constitutes one of the key parameters for human identification. However, this estimation in adult individuals, from the point of view of forensic anthropology, is less precise. Thus, new methodologies are needed. Current criminalistics research applies epigenetics, especially DNA methylation for estimation of age from biological evidence left at the crime scene, which results in more accurate age estimates. Epigenetics is the study of heritable changes in gene function that do not change the DNA sequence, describing also the mechanisms that enable cells to respond quickly to environmental changes and provide a link between genes and the environment. Among different epigenetics modifications, DNA methylation is the most studied. This is a chemical reaction which adds a methyl group to a cytosine which usually leads to silencing of the methylated gene. There has not been much research into the application of DNA methylation for age estimation in human remains. As a result, the main goal of this study is to assess new DNA methylation markers in tooth tissues (dentin and pulp) to improve age estimates in human remains, providing a more accurate biological profile for identification. Dentin and pulp were isolated from teeth and DNA from them was extracted based on silica columns. The DNA was quantified using fluorescence quantification. Then, the gold standard technique for DNA methylation, bisulfite conversion, was applied to convert unmethylated cytosines into uracils with different concentrations of DNA from 200 ng to 25 ng. PCR of CpG sites of ELOVL2 and NPTX2 was carried out, producing the change in the sequence. DNA methylation levels were later assessed by pyrosequencing. Our results indicated that it is possible to use as little as 25 ng of DNA to perform the bisulfite conversion, PCR amplification, and pyrosequencing, obtaining comparable methylation results among the different concentrations. Additionally, it is feasible to correlate the levels of DNA methylation with age even with this low concentration. These findings indicate that when dealing with severely decomposed human remains, it is possible to apply epigenetics for age estimation, leading to an increased accuracy on this estimate. Future research will be able to expand this result, increasing the number of teeth, applying to bones, and assessing more methylation markers.

# Targeted Drug Delivery: Investigating Protein Corona Behavior

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Abstract: Conventional chemotherapy is often nonspecific and toxic to both targeted and non-targeted cells. To overcome this limitation, targeted drug delivery through nanoparticles is studied to reduce toxicity and improve selectivity. When a nanoparticle enters the bloodstream, a protein corona coats the nanoparticle. The protein corona can determine the nanoparticle's fate with cells in a way that could be harmful and affect its targeting abilities. The objective of this project was to investigate the impact of the protein corona on nanoparticle behavior by using a nanoparticle tracking analysis (NTA) system to monitor the behavior of polystyrene particles (PS) in plasma.

The experimental conditions included various ratios of saline mixed with bovine plasma with Alsever's solution, bovine plasma with sodium citrate, goat plasma with Alsever's solution, and goat plasma with sodium citrate. The particle size was measured under these conditions using 1) different syringe pump speeds (0, 10, 20, and 30) and 2) over a duration of 24 hours. Two separate experiments were conducted: (1) assessing the effect of syringe pump speed on nanoparticle size, targeting a speed at which particles would travel across the screen within approximately 10 seconds, followed by a reduction in speed, and (2) conducting a 24-hour study with samples of each plasma type under physiological conditions, while recording particle size measurements after specific intervals of time. Our results uncovered that (1) higher syringe pump speeds generally result in a slight reduction in particle size, and (2) particle size reflects the Vroman effect of proteins with varying ratios of plasma types and saline. With this information, we can infer that the protein corona comprises of diverse proteins. Ongoing and future research will focus on the characterization of the protein corona using techniques such as ultraviolet-visible spectroscopy, Fourier transform infrared spectroscopy, and protein assays.

# Evaluation of Hydrogel Scaffolds for Myocardial Regeneration

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Abstract: 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.

# Extraction of Heart Rate and Respiration Rate from Raw Optical Intensity Signals in Pediatric Populations: An fNIRS Study

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Functional Near-Infrared Spectroscopy (fNIRS) is a brain imaging technique that has seen increased use within neuroimaging research due to its benefits compared to other imaging techniques. fNIRS, in particular, is more portable and more resilient to motion artifacts in its imaging, making it ideal for younger subjects and studies focused on motor skills and everyday activities. fNIRS works using a series of source and detector fiber optic optodes that form channels that measure light intensity data that is eventually processed into the changes in hemoglobin (Hb) concentration over time. This data is then typically used to see the brain's neural activity. However, previous studies have shown that fNIRS change in Hb data can be used to extract the heart rate (HR) and respiration rate (RR) of a subject from a recording.

This study instead aims to extract HR and RR values from the raw fNIRS light intensity data. This methodology would be beneficial as it would allow fNIRS studies to quickly determine HR and RR without needing external devices. It could also allow for real-time, continuous reading of HR and RR during a scan rather than extraction after processing the data into Hb concentrations. This study then aims to apply these HR and RR extractions to determine if there is a correlation between HR, RR, and age. To perform this study, a dataset of 107 subjects, ages 6-13, was used where each subject was asked to complete a resting state task where they stared at a blank screen and were told not to think about anything in particular for 10 minutes. This data was then processed in four steps: selection of the best channel from each subject, extraction of HR and RR values, determination of analysis window size, and correlation analysis between HR, RR, and Age.

To determine the best signal for each subject, the channel with the least amount of noise was selected for analysis to ensure the best HR and RR values while preventing unnecessary data averaging. HR and RR were extracted through a spectral analysis technique called Welch's Method, whose parameters were varied to select the optimal window size for analysis. Using this optimal window size, the resulting HR and RR measurements were plotted with respect to the subjects' age, and a linear correlation was performed, as seen in Figure 1. While there was a decrease in HR and RR as age increased, it was only found to be statistically significant between HR and age. In the future, studies can use the methodology developed in this study to further investigate the relationship between HR, RR, and other variables and neuronal activity to further understand the interconnections between the systems of the body and show the role that such physiological signals play in our cognition.

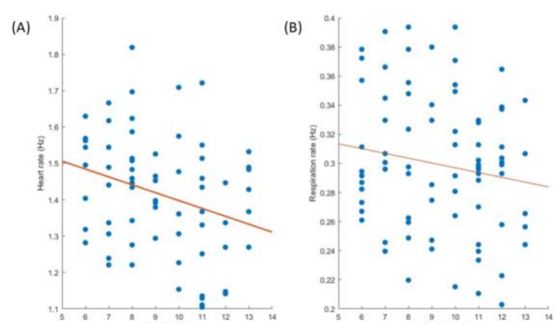


**Figure 1:** Analysis of the correlation between age and HR (a) and age and RR (b). Red lines indicate the linear regression of the HR and RR data (HR: R= -0.29/ p= 0.012, RR: R= -0.16/ p= 0.17)

# Identifying the Distribution of Nanoplastics in Mouse Placenta

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The rate at which humans use plastics has quadrupled over the past 30 years. This has become increasingly concerning since plastics degrade over time into tiny particles known as nanoplastics. Humans are constantly and unavoidably exposed to nanoplastics through food, air, water, and consumer products. Recent research reveals that microplastics reach the placenta in humans. Yet, the impacts of these plastic particles on human health are still unknown. To investigate this, pregnant CD-1 mice were orally dosed with fluorescent nanoplastics at environmentally relevant concentrations (5 mg/kg/day at 50 nm and 200 nm diameter) or vehicle ($dH_2O$). Dosing started on gestational day 8 and continued for 7 days until euthanization at gestational day 15. Placentas were fixed and embedded in paraffin for histological and immunofluorescence analysis. This is vital to identify the presence and distribution of nanoplastics in the placenta. We will use immunohistochemistry to visualize the impacts of nanoplastics on vital placental proteins and cellular structures. Determining the layers of placenta that are affected by nanoplastics will enable us to better understand the mechanisms by which nanoplastics affect placental growth and development. This research will provide insight into the possible health impacts of nanoplastics in humans.

# Electrospun PVDF Nanofibers for Early Cancer Detection via Acoustic Wave Sensing

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Abstract: For 2023 alone, the American Cancer Society estimated over 600,000 projected cancer deaths and nearly two million new cancer cases. Early cancer detection is an important factor of successful treatment, helping cancer deaths enter a continuous decline of 32% since 1991 as of 2019. However, there are barriers to early diagnosis: accessibility to and affordability of resources. Conventional screening devices for cancer are bulky, expensive, and require trained professionals to administer the tests and interpret results. Even cell culture growth methods used to observe the rate of cell growth can take as long as a week in a clinical lab to show results for a single patient. Improvements and alternatives to these issues include enabling portability or utilizing implantable or wearable devices. Wearables such as biosensors are generally smaller, rapid, and cheap, and are therefore well suited to be adapted to an affordable alternative for early cancer detection. In this lab, we electrospun polyvinylidene fluoride (PVDF) nanofibers and encapsulated them in a biocompatible elastomer polydimethylsiloxane (PDMS) with carbon nanotubes (CNT) as electrodes to fabricate a flexible and wearable biosensor. The PVDF nanofibers serve as the functional layer to convert acoustic waves into electrical signals for measurement. By utilizing the piezoelectric effect, the flexible and wearable biosensor can characterize and quantify the carcinogenic particles located underneath the epidermis as the acoustic wave vibrations travel through the cells and change by specific mass densities, therefore altering frequency responses. Two types of fiber arrangements have been fabricated and tested: highly aligned nanofibers and randomly aligned nanofibers. Voltage characterization and acoustic wave testing were also achieved to evaluate the biosensor's electrical performance and sensitivity. PVDF has yet to be used as a flexible and wearable acoustic wave sensor for early cancer detection applications, and its highly desirable properties such as biocompatibility, high flexibility, and great processability make such devices capable of transforming point of care for cancer patients and increasing accessibility to cancer detection technology at low cost.

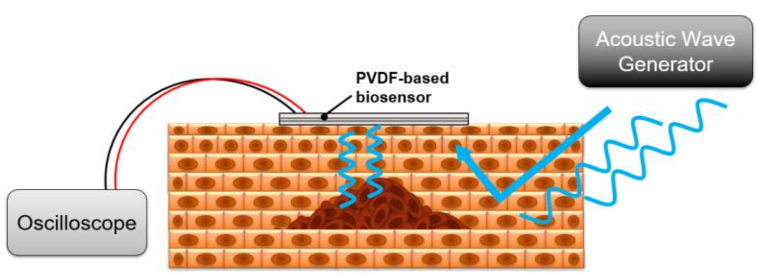


**Figure 1**: Schematic of the PVDF-nanofiber-based biosensor and its proposed method of utilizing acoustic waves for detection of cancerous growth in and near epithelial tissue.

# Exposure Guidelines For Dermal Diffusion of Chemical Warfare Agents

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Chemical and biological warfare agents have been commonly used to promote health hazards on account of their mass destruction capabilities [3]. With the new threats of skin penetrating agents, further assessments to scrutinize long-term effects became imperative. Researchers developed skin permeation models to determine the level of chemical exposure required to penetrate the dermal barrier and diffuse into the bloodstream. These evaluations help trace chemical effects on the body and provide an estimated timeframe for public health agencies to respond to a threat. Furthermore, previously found data on Acute Exposure Guidelines Limits (AEGL) will serve as a tool to measure the impact of chemical warfare agents absorbed through the respiratory tract. [7,8] The AEGL values will be adapted to simulate skin permeation data and determine Permissible Exposure Limits (PELs) through the stratum corneum. The PEL values will be estimated using Fick's first law of diffusion [4] and databases such as CompTox and Pubchem.

*Figure 1. Exposure Guidelines for Chemical Warfare Agents*

| Chemical | Acute Exposure Guideline Limit [mg/m^3] | Timeframe to reach AEGL [hr] | Permissible Exposure Limit [mg] | Timeframe to reach PEL [hr] |
|---|---|---|---|---|
| Soman | 0.0007 | 4 | 0.0015 | 102.24 |
| Sarin | 0.001 | 8 | 0.0043 | 139.68 |

# The Order of Madness: Patient Categorization in the Toptasi Asylum

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**Abstract:** There are numerous historic architectural works that remain undervalued and unrecognized. The Toptasi Mental Asylum located in Istanbul, Turkey, currently a university, has virtually no traces of its past as an institution to help the mentally ill during the Ottoman Empire from 1873 to 1924. Many of the evidentiary documents of the Asylum's operations, as well, have been lost, making it even harder to actually understand its existence. Due to lack of ample evidence and documentation, our research has taken an unconventional route to understanding the asylum and its functionality by reconstructing the asylum using the theoretical framework proposed by the French philosopher Micheal Foucault: Regularity, Discipline, and Order. In the past, our research group has worked on characterizing the Discipline and Regularity of the asylum with the help of patient and staff daily schedules and reports about the various treatments administered using Agent-Based Modeling (ABM) in Unity. Our work focuses on the Order component that aims to understand and model the underlying network between patient condition, activity, staff, and Asylum's architecture.

The limited documentation of the asylum provides us with statistical data about the patients in the facility (gender, age, marital status, ethnicity etc) and diagnoses using contemporary disease categories. This type of medical record keeping was fairly standard in Western Europe and America alongside the late Ottoman Empire. To add, we also found that the female patients were divided into four wards, but the details of the patient-ward assignment, which was one of the main criteria that affected the patient experience, remain unknown. In this project we create a multi-step sorting process and mathematical algorithm that considers attributes such as Mobility Index (MI), Degree of Treatment & Level of Agitation which enables us to better predict where patients with different conditions and symptoms were placed among the four main wards. The Mobility Index (MI) is a hospital grading technique we have adapted in order to quantify the patient's level of physical independence from a scale of 1-7.

The MI in our model, not only plays an important role in determining ward placement, but it also optimizes patient behavior in the three-dimensional ABM simulation of the asylum. By using the MI to assign varying physical abilities to each patient, we will improve the ABM simulation by accounting for the nature and speed of patient interaction.  We hope our approach of interpreting and visualizing historical records can also be utilized in other medical studies and settings.

# Dural Electrical Stimulation to Motor Cortex after Fluid Percussion Injury Results in Motor Function Improvement

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Traumatic brain injury (TBI) is a growing concern in the United States, with over 1.5 million Americans suffering TBIs annually. The lateral fluid percussion injury consists of a craniectomy and rapid pulse of fluid pressure just over the dura, which produces a brief depression in the tissue. This model is capable of producing similar neurological deficits to those found in TBI patients. A theorized method of treating this injury is through external and noninvasive dural electrical stimulation.
2 groups of 16 male Sprague-Dawley rats aged 8 weeks at the start of the experiment were trained on the Harvard PanLab Rotarod apparatus at constant and increasing speeds respectively. The first group stayed at a constant speed of 4 RPM, while the second group had a constant acceleration of +1 RPM and started at 4 RPM. The time that each animal successfully stayed on the Rotarod was measured. Afterwards, a craniectomy and fluid-percussion injury were delivered to each rat over the premotor and primary motor cortices while anesthetized. An electrical conduction implant was installed with dental cement over the dura for all rats. 8 rats from each group were left with the injury, while 8 were treated with a single round of electrical stimulation. Subsequently, time successfully spent on the Rotarod was measured.
Injured animals that underwent external, noninvasive electrical stimulation through an electrical implant on the surface of the dura over the primary motor cortex showed significant reductions in motor deficits compared to the injury group. The treatment group, subjected to a lateral fluid percussion injury and electrical stimulation, recovered from motor deficits significantly faster than the injury group alone. In the acceleration model, treatment groups were not able to completely recover normal motor function. In the constant speed model, the treatment and control group reached a statistically similar competency level.

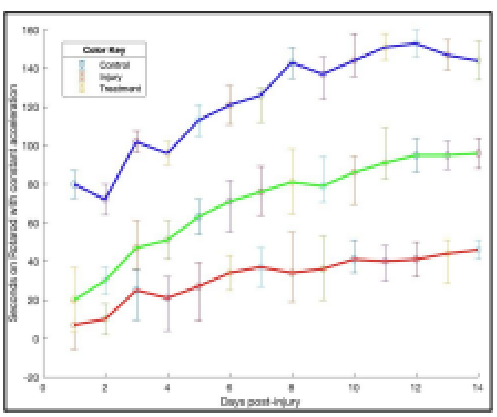


Fig. 1. Time that each group stayed on the Rotarod with constant acceleration in seconds.

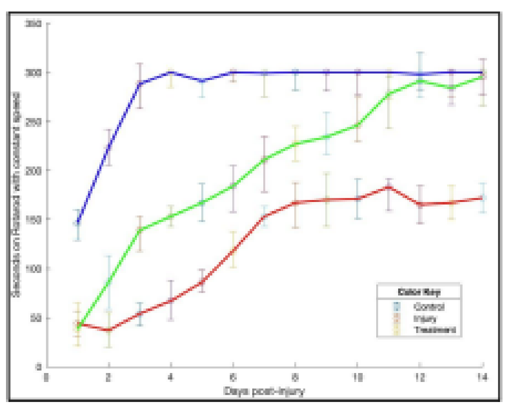


Fig. 2. Time that each group stayed on the Rotarod with constant speed in seconds.

# The Inattentional Blindness Paradigm: Can You See the Forest for the Trees?

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From reading mammograms to driving a car, the inattentional blindness paradigm plays a large role in our world. This paradigm revolves around the concept that when people focus intently on a particular task, they sometimes fail to perceive unexpected stimuli present around them. It is almost as if the individual is put into a type of trance when performing a task with increased focus, leading them to allocate less attention to other stimuli. By studying this phenomenon, our investigation will be able to further understand how this concept works and affects people in their everyday lives. Our study uses search tasks, particularly Al Hirschfeld's caricatures in the New York Times newspaper. We specifically aim to understand the limitations of the human visual periphery, and how these limitations impact an individual's ability to process information. Through this study, we hope to determine the criterion to predict memorability in individuals, particularly how the level of effort affects memorability. To accomplish this, we will instruct participants to find the hidden NINAs, the name hidden in the drawings, within the different images shown and will ask them to recall details about the overall image. We expect that as the need for effort increases in the search task, the participants will remember fewer details about the image as a whole.

# Traumatic Brain Injury Simulating Blasting Device Characterization

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Abstract: The goal of this project was to characterize a blasting device modeled to simulate traumatic brain injuries (TBIs). To date, no interventions exist for the treatment of TBI, despite it accounting for more than 223,135 hospitalizations in 2019[1]. Those who suffer from mild TBI have been shown to undergo cognitive and motor deficits long-term. *In vitro* systems have been created to study the mechanistic underpinnings of TBI. One of these systems blasts cellular wells with compressed $CO_2$ gas, causing a thin silicon film to bubble and spread, mimicking the reaction of the human brain to a traumatic brain injury. The goal of this study is to develop a consistent method to blast said injury wells without inconsistencies appearing in the resultant data set.

To date, parameters that most closely mimic the effects of a traumatic brain injury have been established, with strain rates ranging from 40-50%. Despite the efficacy of such devices in modeling traumatic brain injury, they are inconsistent, with results varying between each blast. A stretch device using a $CO_2$ tank was used to stretch multiple cell wells filled with trypan blue, as a control group. A high-speed 4000 frames per second camera was used to capture video of each blast. This video was run through an analysis code in MatLab to measure strain rates consistently. Upon blasting, further inconsistencies appeared. The trypan was then warmed to 37 degrees Celcius to mimic cell cultures being removed from incubation. Further tests included blasting neurobasal medium at both room temperature, and 37 degrees Celcius to mimic cell culture conditions.

**Figure 1:** Blasting device highlighting well expansion after blast

# Virtual Analysis of Exoskeletal-Assisted Walking

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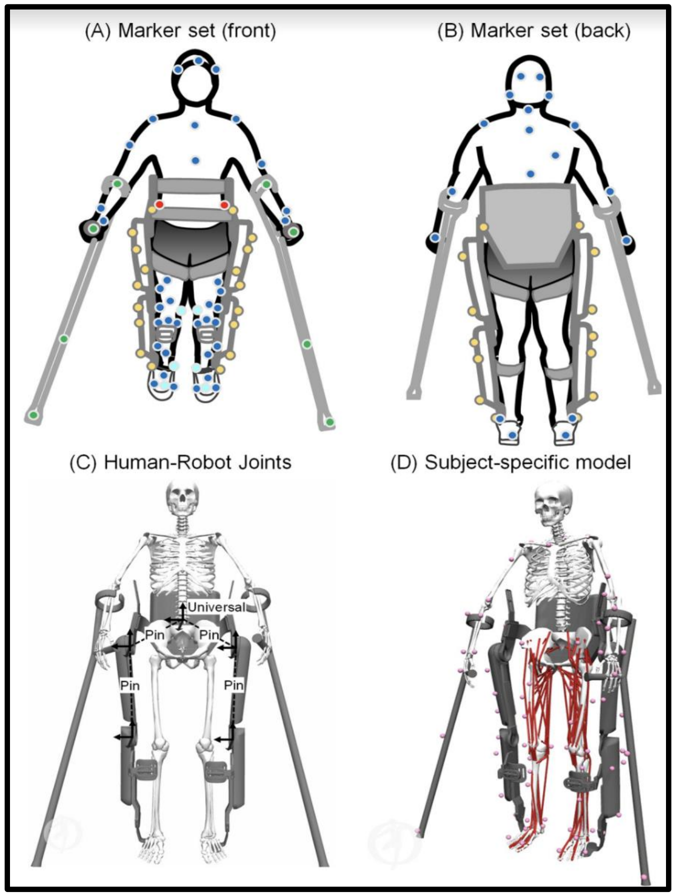


Robotic exoskeletons have considerable, but largely untapped, potential to restore mobility in individuals with conditions that result in partial or complete immobilization. The growing demand for these devices necessitates the development of technology to characterize the human-robot system during exoskeletal-assisted walking to accelerate robot design refinements. The aim of this project is to combine controlled experiments with noninvasive computational modeling to build a virtual simulator of exoskeletal-assisted walking that will quantify the forces imparted onto the subject's joints during the movement. An able-bodied participant was trained to walk in an FDA-approved exoskeleton, the ReWalk P6.0 with simultaneous measurements of three-dimensional marker trajectories, ground reaction forces, and exoskeleton encoder data. The participant then conducted the trials without exoskeletal assistance. Using a virtual simulator created with Opensim, the peak compressive forces were found to be 3.5-4.9 times the subject's bodyweight (BW) at the hips, 2.5-5.4 BW at the knees, and 4.0-4.2 BW at the ankles during exoskeletal-assisted walking. During unassisted walking, the peak compressive forces were 3.2-3.8 BW at the hips, 3.1-3.4 BW at the knees, and 4.5-5.0 BW at the ankles. This work provides a foundation for parametric studies on the effects of human and robot design variables in predictive modeling and optimization.

**Figure 1:** (A, B) Placement of retro-reflective markers on the human, exoskeleton, and crutches to track the position and orientation of all the segments of the human-robot system. (C) The human-robot model in the virtual simulator comprises a universal joint (six degrees of freedom) at the pelvic band to anchor the exoskeleton to the participant, and a hinge joint (one degree of freedom) each at the hips and knees of the exoskeleton. The locations of the joint axes are shown. (D) A generic musculoskeletal model was scaled to the proportions of the subject's body measurements.

**Determining the Synergistic Effects of ECM Coating on Axonal Growth in Collagen Gel 3D-Model**

Peter Kutuzov and Tamara Bacsik
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Abstract Most existing models employed to study peripheral nerve regeneration are limited in their ability to capture the full range of biological complexities associated with the extracellular matrix (ECM). This research project proposes a novel biometric model aimed to mimic the ECM environment which can be utilized to study peripheral nerve repair. This research project proposes a novel biometric model to mimic the ECM environment which can be utilized to study peripheral nerve repair. This project investigates the interactions of ECM molecules (collagen, laminin, and fibronectin) in a facile 2D system followed by a 3D collagen model with dorsal root ganglion (DRG). We hypothesize that the collagen gels coated with a blend of laminin or fibronectin with supplemental addition of growth factors would enhance axonal regeneration. The average axonal length was determined through immunostaining of the DRG culture and used to gauge the extent of peripheral nerve regeneration. The development of a more realistic in vitro model will allow for more efficient screening of potential drug treatments for various neurodegenerative diseases and the construction of more effective tissue grafts, resulting in improved clinical outcomes and overall prognosis of PNIs. Furthermore, after the conclusion of this study, a more comprehensive understanding of the neuropathophysiology of peripheral nerves and the intricacies of peripheral nerve regeneration will be achieved. Keywords: peripheral nerve repair, tissue engineering, collagen model, growth factor signaling, extracellular matrix

# Therapeutic Function of Liraglutide for Hearing Restoration in Repeated Blast Traumatic Brain Injury

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Blast-induced traumatic brain injuries (bTBIs) result from explosions exerting air pressure force on the brain, resulting in damage to neural structures. Both civilians and soldiers exposed to prolonged periods of high blast overpressures (BOPs) experience these injuries. Even when ear protection is utilized, repetitive low-level blasts progressively harm brain structures responsible for auditory processing. However, there is a lack of effective treatments, and research on the chronic effects of low-level blasts is limited. Liraglutide, commonly prescribed for type 2 diabetes, shows promise in preventing such injuries by reducing neural inflammation. To evaluate liraglutide's potential in reversing auditory deficits from low-level BOPs, researchers at the CIBM3 lab utilized adult chinchillas, which have similar neural auditory structures to humans. The chinchillas underwent three consecutive BOPs at 15-25 psi with five-minute intervals between each. Divided into five groups, some were dosed with liraglutide before and some after the blast, each with two subgroups sacrificed after two or four weeks. An untreated control group was sacrificed 14 days after the blasts. Brain slices of the chinchillas were stained using IBA1 and GFAP markers to measure inflammation indicators (microglia and astrocytes). We used ImageJ software to quantify cell count, fluorescent intensity, branch lengths, and average cell size. Promising results (fig.1) indicate reduced brain inflammation in liraglutide-treated chinchillas compared to the control group. If liraglutide continues to show potential in decreasing neural inflammation after BOP exposure, it could offer hope for preserving hearing in war victims.

# Role of Collagen in Hair Follicle Regeneration

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Across the world, 100 million people develop new scars every year with causes ranging from burns and surgeries, to childbirth and illness. These scars result from large wounds and remain with the individual *permanently* and there is yet to be a solution to fully reverse scarring. Hair follicle regeneration is an essential step to scar reversal but there is little known on how to induce this process. Dermal papilla formation is an indicator of hair follicle regeneration, which means that it is essential for scar reversal. Previous research suggests that collagen may be involved in hair follicle regeneration. Discovering the role of collagen in hair follicle regeneration can help the millions of burn victims suffering from scarring, patients with scarring hair loss in *Cicatricial alopecia*, and patients suffering from *Scleroderma* where irregular collagen levels cause skin hardening and damage organs.

Mice were used as mammalian models with wounds harvested in each of the mice. One set of mice had the collagen gene, *Col1a1,* intact whereas the other had *Col1a1* deleted. The epidermal tissue from mice in the experimental and control groups were then compared using DAPI immunostaining to observe cell morphology. The results showed that the mice lacking collagen did not show invagination of the hair follicle, indicating that there was no hair follicle regeneration at that site. In order to further analyze the effect of collagen on hair follicle regeneration, the number of dermal papilla cells at the site of the wound in each set of mice were counted by using in vivo confocal microscopy. It was concluded that mice without the *Col1a1* gene - indicated by *Col1a1* fl/fl - had a statistically significant decrease in the number of dermal papilla cells compared to mice with collagen. Based on this, it is clear that collagen is imperative and a necessary component of hair follicle regeneration. Further experimentation can be done using collagen growth factor treatment on mice to detect whether there is a significant increase in hair follicle regeneration. Drug therapies acting on collagen can be formed as an innovative solution to scar reversal and hair loss.

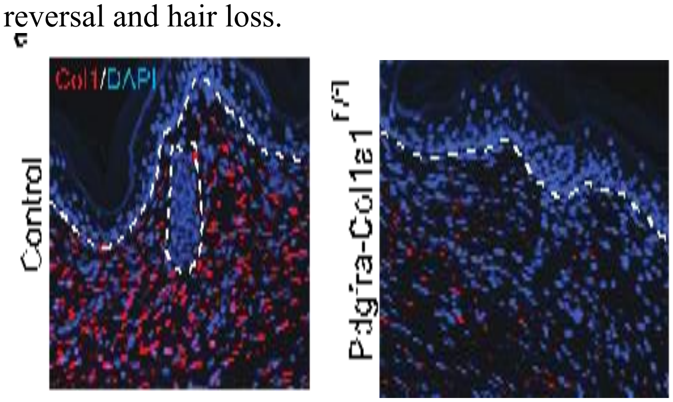


**Figure 1.** DAPI immunostaining of epidermis with collagen (left) vs no collagen (right).

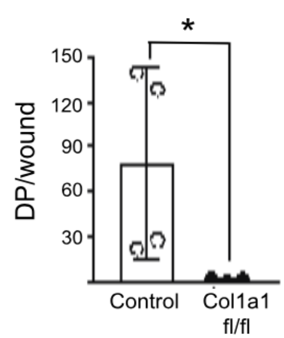


**Figure 2.** Statistically significant difference in number of dermal papilla cells with collagen (left) vs without collagen (right).

# Manipulation of Burst Pressure within FRESH vascularization.

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Abstract: Tumors create negative pressure gradients within vascularized tissue, leading to adverse effects such as low concentrations of oxygen, acidity changes and low perfusion in the blood. The goal of this project was to recreate the tumor microenvironment using hydrogels and explore burst pressure, which is the maximum pressure before a vessel ruptures due to the negative pressure gradients. To achieve this, a multifaceted burst pressure design was created. Vascularization within the hydrogels was achieved through the Freeform reverse embedding of Soft hydrogels (FRESH) technique and the subtractive needle method. The gel bath consisted of 4.5% Gelatin, while 5% Alginate served as the protrusion material. Calcium Chloride was used as the crosslinker, and needle gauges ranging from 14G to 27G were employed. The burst design approach involved conducting a consumer's needs analysis and literature review to fabricate several designs, aiming to find the most optimal approach. Notable implementations included the use of Piezoelectric film, which exhibits transduction properties between mechanical and electrical inputs, enabling it to function as both a sensor based on vessel bulge strain. Additionally, a 3D-printed channel adapter was fabricated, and a camera setup was used. A syringe pump was employed for controlled fluid delivery. Burst pressure was measured in mmHg using an Integrated Development Environment (IDE) for data acquisition and control. The results consist of a max burst pressure, a burst pressure range based on the data we find, a max bulge pressure and a max bulge strain.

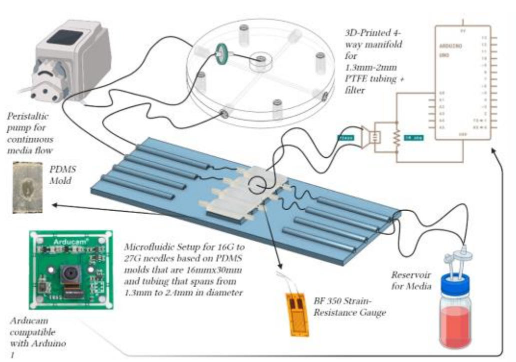


**Figure 1.** Burst Pressure Design.

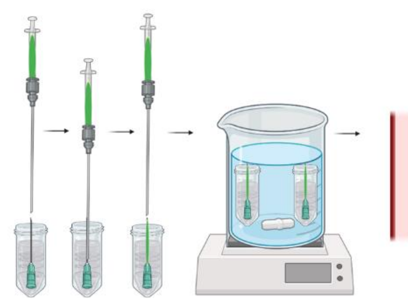

**Figure 2.** FRESH and Needle Subtractive method.

# Peptide-Peptide Interactions that Account for Multicomponent Fibrils

**Jadhy Michalowski, Advisor: Dr. Cristiano Dias**

Department of Physics

New Jersey Institute of Technology, Newark NJ 07105

The biomechanical process involved in wound healing is complex; but can be defective in individuals with underlying conditions, e.g., type II diabetes. Accordingly, researchers are attempting to construct organic structures to assist with wound healing. These efforts often rely on assemblies of DNA and peptides. Some options for tissue engineering contain biological epitopes that can aid the skin's wound-healing process by providing a sterile and supportive environment. However, compared to a single peptide, fibrils made from two peptides can result in structures with more functionality to mimic additional properties of the skin.

The goal of this project at Dias Lab is to understand the interactions between two peptides, specifically the hydrogen bonds forming between either peptide. Due to variables including solvent composition, temperature, and preparation methodology, computationally simulating the peptide interactions provides stronger control over the aggregation. Peptides were designed using Chimera and the molecular dynamic simulations were executed through the GROMACS software. Two bash scripts from the simulation of a single peptide were altered to allow for the analysis of an additional peptide. One script allows for the preparation of peptide A and peptide B being alternatively added into a virtual cube measuring 6.0 nm in length with water as the solvent. The second script calculates the hydrogen bonds between each individual peptide and the hydrogen bonds between peptides A and B. These numerical results along with Visual Molecular Dynamics (VMD) quantified and visualized the interactions between the peptides.

We performed simulations of 15 pairs of peptides. Peptides in 9 of these simulations show a clear tendency to self-sort into fibrils from just peptide A and just peptide B. Peptides in 6 of these simulations tend to co-assemble into fibrils where peptide A interacts with peptide B. Our results indicate that utilizing peptides that have previously shown likeness to form fibrils is likely to have more interaction between either peptide. Additionally, recurring phenylalanine amino acids show higher success with co-assembly. Future work consists of more computational simulations with different peptide pairs to determine the effects of different amino acids on peptide-peptide interaction.

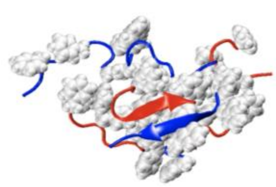

**Figure 1.** Peptide FFKFEFKE and FEFKFEFK interaction shown in VMD

# Establishing an Aassay for Visual Desensitization in Larval Zebrafish

**Saad Mohammed, Advisor: Dr. Kristen Severi**
**New Jersey Institute of Technology, Newark, NJ 07102**

Establishing an assay for visual desensitization in larval zebrafish Abstract Animals need to make the right decisions to stay alive, so their brains process information from their senses and choose the best actions. This research project aims to explore how animals adapt to different experiences by studying the brain circuit that controls their actions in response to danger. The brain processes sensory information and selects the most appropriate actions for survival. However, the mechanisms underlying how the brain circuit adapts to new experiences are not fully understood. Specifically, this project will investigate how the circuit responsible for quick responses to danger changes based on sensory experiences. This circuit uses specialized cells that inhibit other cells from firing, and the study will analyze changes in cell activity and connectivity resulting from different experiences. By examining this circuit, this research seeks to provide insight into how the brain integrates information from different senses and adapts to new experiences to improve survival. We hypothesize that exposure to visual stimuli will lead to changes in the escape response behavior of larval zebrafish. Specifically, we predict that the response time and magnitude of escape behaviors will be different between fish that have been exposed to visual stimuli will become desensitized compared to those that have not, and that the neural mechanisms underlying this learning process will involve similar pathways to those involved in auditory escape responses which are already known to be subject to desensitization.

# Machine Learning Algorithm to Detect Skin Cancer Boundary

**Rajal Vyas, Advisor: Xuan Liu, PhD**

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Nonmelanoma skin cancer such (NMSCs) as basal cell carcinoma (BCC) and squamous cell carcinoma are common in the United States (1). 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 signals are crucial to produce OCT images and detect different characteristics of the OCT image such as the dermis-epidermis junctions. Specific characteristics are calculated from the OCT signals. These features include average signal intensity which corresponds to the strength of the signal, and average signal attenuation. These characteristics extracted from the OCT signal can be fed into a machine learning algorithm such as the support vector machine (SVM). In this study, SVM is implemented 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 positive score means normal tissue, while a negative score 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.

Reference

1) Chuchvara, N., Rao, B., & Liu, X. (2021). Manually scanned single fiber optical coherence tomography for skin cancer characterization. *Scientific Reports*, *11*(1). https://doi.org/10.1038/s41598-021-95118-z

# Identifying a Novel Concussion Metric through Foot Tapping Measurement

**Stuti Mohan, Advisor: Dr. Chang Yaramothu**
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Abstract: Approximately 3.8 million concussions occur annually in the United States. Of these, ~50% of concussions are unreported or undetected. This results from a lack of a standardized diagnostic process for identifying signs and symptoms of concussions. Our lab has developed a diagnostic protocol and tool: the MoVES (oculomotor and vestibular endurance screening) protocol using the OculoMotor Assessment Tool (OMAT) to fill this gap in the standard of care. The aim of this project is to continue the standardization of concussion diagnosis by identifying a novel concussion metric: foot-tapping periodicity. The goals of this project include developing a MATLAB code to collect data from research grade force plates and conducting frequency spectrum analysis on time stream foot-tapping data, substantiating the periodicity of foot-tapping as an index of concussion injury based on healthy controls, and mentoring high school students who will aid in the improvement of the companion smartphone application.

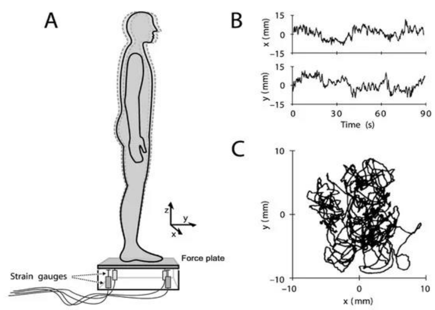



**Figure 1.** Research Grade Force Plates (Bertec Corporation, Columbus, OH)

Force plates are useful tools to measure the ground reaction forces and moments generated by human movement (A, above). These mechanical sensing systems can represent movement in the x, y, or z directions as a function of time (B) and can be used to graphically map the position of a subject (C). This study is using a novel approach to graphically visualize and analyze healthy controls' foot-tapping frequencies in order to examine their PFT. Even the knowledge that foot-tapping rate is useful as a reliable measure of concussive injury can significantly improve concussion management by spreading awareness. With an increased cognizance of their injury, patients are more likely to seek medical attention and improve their medical outcomes. Furthermore, this work can encourage the integration of foot-tapping rates in routine exams. Following the establishment of such a control, clinicians can monitor developments in patients' baselines. Significant changes can be used as a basis of concern, which can inform the need for further medical attention, and enable early detection. Additionally, the creation of this new index can lead to a product development pathway where an automated device can be developed for performing the assessment and producing results that can be interpreted by a clinician.

# Combinatorial SAPs with Tunable Anti-Microbial Effect

**Josuel Morel, Advisor: Dr. Vivek Kumar**

Department of Biomedical Engineering
New Jersey Institute of Technology, Newark, NJ 07102

Cationic amphiphilic self-assembling peptides (CASPs) have been designed to possess antimicrobial properties, using their positively charged ends to attract and disrupt negatively charged pathogenic cell membranes, causing cell death. CASPs have the ability to cause pathogenic cell death without causing eukaryotic cell death because eukaryotic cells do not attract CASPs due to their neutrally charged membranes. CASP technology has the potential to combat antimicrobial-resistant pathogens due to CASPs not being receptor-based antimicrobial agents. This enables the CASPs to remain effective despite bacterial and other microbial adaptations that receptor-based antimicrobials cannot handle.

The two CASPs focused on during this project were the K1 and K6 CASPs. In past testing, it was found that the six charged ends on K6 make it antimicrobial, unlike K1. The additional positive charge of K6, however, partially hinders its self-assembly and cytocompatibility. In light of this information, K1:K6 combinations were tested to determine how K1 and K6 characters affect the self-assembling secondary structure and cytocompatibility of the CASPs.

For this project, in-vitro testing, computational simulation, and peptide characterization were done to assess K1, K6, and their combinations in the following K1:K6 ratios: 1:9 1:4 1:1 4:1 9:1. First, a computational simulation was performed using K6 against the membrane of C. Auris, an antifungal resistant pathogen. This simulation indicated that K6 is antimicrobial. On the other hand, K1, through previous testing, was found not to be antimicrobial. Instead, K1 showed strengths in cytocompatibility and hydrogel formation when compared to K6. The combinations were then tested for cytocompatibility using CCK8 dye in the ratios mentioned above. It was found that K1 was cytocompatible, as predicted. K6 unexpectedly indicated levels of potential cytotoxicity. Future testing needs to be done to confirm this data on more cell types and under different media conditions. The ratio that showed the most cytocompatibility was 9:1. In addition, characteristic testing was done on K1, K6, and the combinations. The self-assembly of CASPs typically displays as a beta-sheet, as indicated by the results of circular dichroism (CD). CD was performed for all combinations at 0.01mg/ml and 0.1mg/ml, and trends emerged. It was shown that K1 formed better beta-sheets than K6 and thus is more likely to form a stiffer hydrogel; the combinations with more K1 character also formed stiffer beta-sheets, as expected.

Moreover, CASPs can serve as a solution to antimicrobial-resistant pathogens, which current methods of receptor-based antimicrobials cannot effectively treat. The combination of K1 and K6 CASPs can combine the beneficial structure and cytocompatibility of K1 with the antimicrobial efficacy of K6. Future live/dead and CCK8 assays on K1:K6 combinations using human cells and varying media conditions could show which combination is most useful. Further computational simulations on eukaryotic and bacterial cell membranes would prove past CCK8 results for K1:K6 combinations. From there, anti-microbial testing would help narrow down which combination of K1 and K6 possesses optimal cytocompatibility while still showing antimicrobial efficacy.

# Enhancing Skin Grafting Efficiency: A New Method for Estimating Skin Expansion Ratio Based on Skin's Geometric and Mechanical Properties

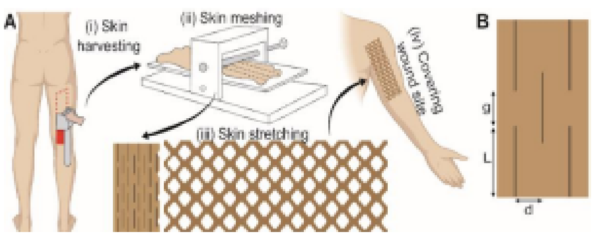
**Aliza Mujahid**

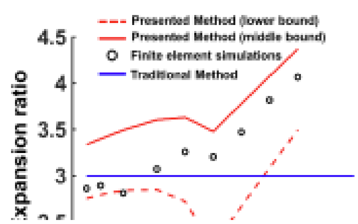
Advisor: Dr. Farid Alisafaei; Graduate Advisor: Mohammad Jafari

Biomechanical Engineering Department

New Jersey Institute of Technology, Newark NJ 07102

Abstract: Each year 8.2 million Americans suffer a chronic wound arising from burns, diabetic ulcers, skin cancer surgery, or infection. These wounds fail to pass through the normal healing process and the body is not able to replace the damaged skin at the wound site. To protect the wound from the environment and pathogens, chronic wounds are often treated with skin grafts which consist of the epidermis and dermis taken from one part of the body (Fig. 1A (i)), and then meshed with rows of small, interrupted slits (Fig. 1A (ii)), stretched (Fig. 1A (iii)), and transplanted over a larger wound site (Fig. 1A (iv)). One crucial aspect of skin grafting involves minimizing the size of the skin harvested from a healthy area. This is required to prevent the creation of additional wounds. Also, it is important to ensure that the harvested skin adequately covers the wound area after it is meshed and stretched. To accomplish these objectives, surgeons must possess knowledge of the skin's expansion ratio, which represents the ratio between the area of stretched skin and its initial area. Traditionally, this expansion ratio has been determined using a basic geometric equation that assumes each incision will result in a complete square (Fig. 1C). However, this equation fails to consider the mechanical properties of the skin, and our finite element simulations have demonstrated that it provides inaccurate predictions in numerous scenarios (Fig. 2). By incorporating both geometric parameters and the mechanical properties of meshed skin grafts, we have devised a novel, simple, and straightforward equation that enables surgeons to estimate the skin expansion ratio (Fig. 1D-E). Our findings reveal that this new equation exhibits significantly improved agreement with finite element simulations compared to the conventional equation (Fig. 2).



# Testing the Toxicity of Nanoplastics in the Ovary

**Maira Nadeem, Advisor: Dr. Genoa Warner, and Mentor: Hanin Alahmadi, PhD Student**

Department of Chemistry and Environmental Science

New Jersey Institute of Technology, Newark, NJ 07102 USA

For over a century, plastic has been in mass production and is now a major cause of environmental pollution. Plastics have been breaking down into nanoparticles which have been found in human bodies and are suspected to affect human health. This research looks into the effects that nanoplastics have on the female reproductive system, specifically the ovary, and how nanoplastics can disrupt functions such as gene expression. Previous studies investigated the effects of nanoplastics on other organs such as the kidney, spleen, testes, and intestinal tract, but little is known about the effects nanoplastics have on the ovary. I hypothesized that nanoplastics administered at environmentally relevant doses affects the expression of genes relating to cell cycle regulation, apoptosis, and oxidative stress. To test this, I am conducting quantitative polymerase chain reaction (qPCR) on RNA extracted from murine ovarian tissue cultured in 0.05% Tween20 (vehicle control) or 200 nm nanoplastics at different doses for 96 hours. The doses were as follows: control, 1 µg/mL, 10 µg/mL, and 100 µg/mL. After the culture was complete, RNA was isolated, and reverse transcribed to cDNA for the qPCR reaction. Then the samples were analyzed using qPCR. This research will better our understanding of the negative effects that nanoplastics can have on human health by focusing on the ovary.

# Enhanced Biomarker Detection in Microfluidic Biosensing Platforms

**Endy Nava, Research Advisor: Dr. Eon Soo Lee, and Mentor: Yudong Wang**
Department of Mechanical and Industrial Engineering
New Jersey Institute of Technology, Newark NJ 07102

Abstract: 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.

# Assessment of Photobase Generator BODIPY-TMG for Cancer Treatment

**Anne Nong[1], Advisor: Yuanwei Zhang[2], Mentor: Shupei Yu[2]**

[1] Department of Chemical Engineering

Rowan University, Glassboro, NJ 08028, USA

[2] Department of Chemistry and Environmental Science

New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: Photopharmacology has been studied for cancer treatments due to its minimally invasive nature, including photodynamic therapy (PDT) and photothermal therapy (PTT). By triggering the pH imbalance inside cells, photoacid generators (PAGs) have been used for cancer treatment, however photobase generators (PBGs) have not been investigated for this purpose. PBGs are light sensitive organic compounds that generate a base upon irradiation of light at a specific wavelength. The PBG, BODIPY-TMG was previously synthesized with the purpose of being used in photopolymerization. In this study, upon irradiation, trimethylglycine (TMG) is released from boron dipyrromethene (BODIPY), which can induce apoptosis in cancer cells due to the sudden pH increase inside cells. Using an MTS assay and cell imaging, dark cell viability can be assessed on human cervical cancer cell HeLa. Using colocalization tests we could also see how BODIPY-TMG accumulates inside cells compared to commercial probe LysoTracker-Red. To determine cell viability over time while exposed to light, phototoxicity tests can be performed.

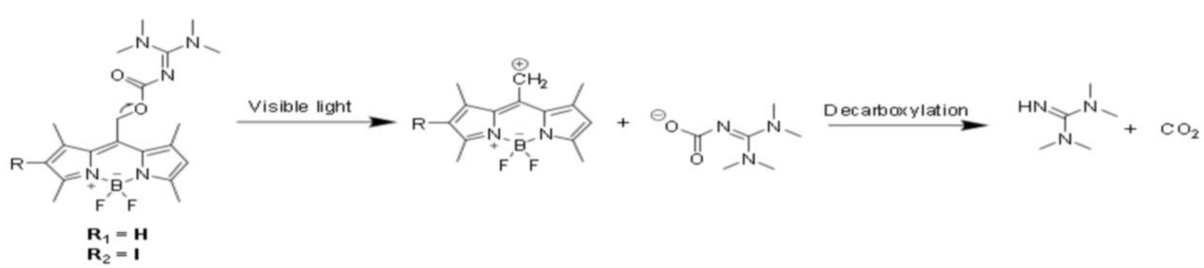



**Figure 1**: Possible pathway for the photolysis of photocaged TMG

# Effects of EMFs on PME and T47D Cells

**Ricardo Otake[1], Luis Medina[2], Nellone Reid[2]**

[1]Department of Chemical Engineering

Rowan University, Glassboro, NJ 08028

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New Jersey Institute of Technology, Newark NJ 07102

Abstract: Cancer is a leading cause of death, with breast cancer specifically resulting in the deaths of more than 600,000 people as of the year 2023. Electromagnetic Fields (EMFs) show potential to be a normalized noninvasive treatment, as they have anti-inflammatory properties which correlates to the inflammation caused by cancer. The objective of this project is to 1) observe effects of EMF exposure to healthy cells (primary mammalian epithelial [PME] are the healthy cells used) and cancer cells (T47D which were was type of breast cancer cells used) using a phase contrast microscope; and 2) to conduct a live cell count using Trypan Blue and a hemocytometer. A Helmholtz coil was used to produce an EMF that was exposed to the cells for 6 to 12 hours by running a current of 0.7 amps to produce approximately 2 to 10 mT of EMF intensity. By testing EMF exposure, we expect to observe 1) apoptosis of T47D cells and minimal detriment to PME cells; and 2) a decreasing quantity for live cell count during EMF exposure.

# Probing the Stereospecific Rearrangements of Secondary Carbocations

**Alexis Palmere, Advisor: Dr. Pier Alexandre Champagne**
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Our current knowledge of how carbocation intermediates are formed in nucleophilic substitution reactions that employ an $S_N1$ mechanism may be inaccurate. Textbook knowledge shows that secondary carbocations are minima that rearrange through a hydride shift to form tertiary carbocations in a two-step process. However, based on previous research, there is enough computational evidence to believe that secondary carbocations might not exist as intermediates. Consequently, more experimental evidence would further support the hypothesis that the rearrangement of secondary carbocations in an $S_N1$ mechanism occurs in one concerted step with the loss of a leaving group instead of a two-step hydride shift mechanism. By first studying how the target probe can be synthesized, my project could help establish a better understanding of how carbocations react and undergo rearrangements as well as completely alter the way that textbooks present how $S_N1$ mechanisms happen.

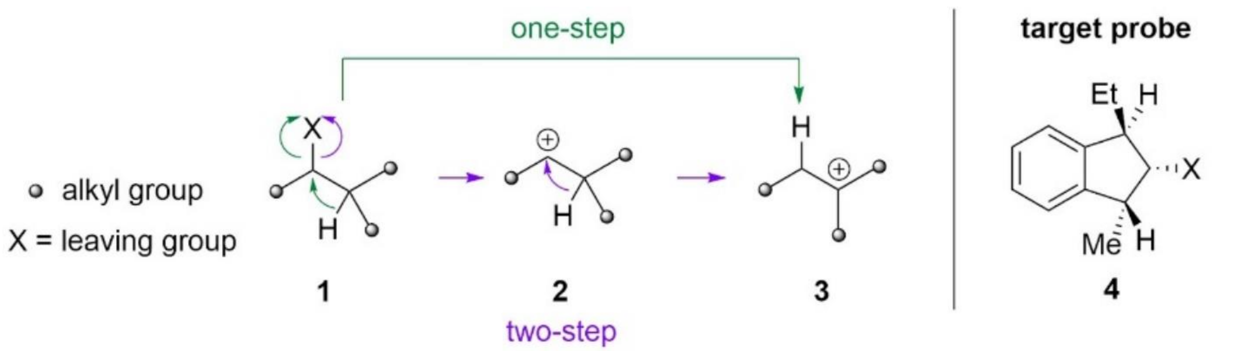


**Figure 1:** Synthesis of Secondary Carbocations

# Smart Biosensors with Machine Learning for Objective Pain Assessment

**Taylor Pape, Advisor: Dr. O. Sadik, and Mentor: M. Mady Ph.D. student**
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New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: 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.

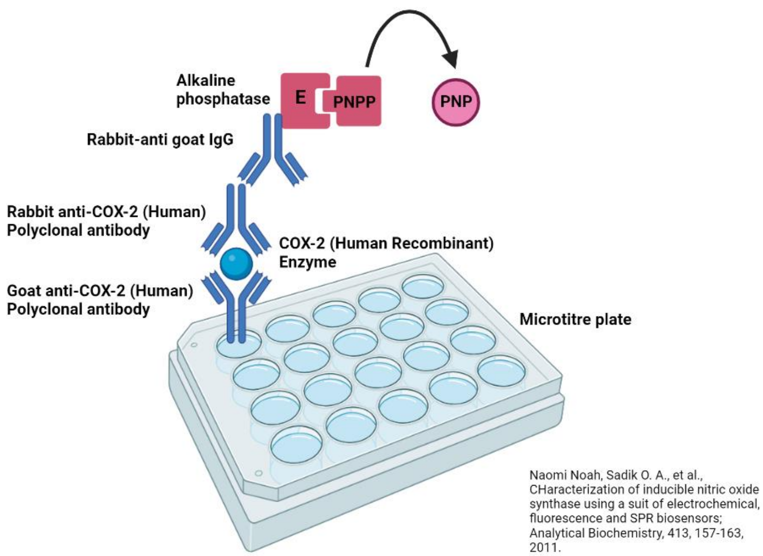


**Figure 1:** A schematic diagram illustrating ELISA sandwiching protocol which took place in each sample well.

**Reference:** Omowunmi Sadik, J David Schaffer; Walker Land; Huize Xue, Idris Yazgan, A Korkut, Kafesçilere, Mürvet Sungur, A Bayesian Network Concept for Pain Assessment ***(JMIR Biomed Eng 2022;7(2):e35711)*** doi: 10.2196/35711

# The Effect of Immunopeptides on the Triple-Negative Breast Cancer T-Cell Activation Pathway Mediated by CD45

**Suhas Parise, Advisor: Dr. Horacio G. Rotstein**
Federated Department of Biological Sciences
New Jersey Institute of Technology, Newark NJ 07102

Abstract: Triple-negative breast cancer (TNBC) is an invasive cancer that is difficult to treat via hormone therapy or chemotherapy since it lacks estrogen and progesterone receptors and produces low amounts of the protein HER2. TNBC also suppresses the immune system by secreting an immunopeptide called galectin-3, which binds to T-cells and inactivates them via a novel pathway. Currently, this inactivation pathway is unclear and needs to be further investigated. Another immunopeptide called C24D has been recently shown to bind to the same receptor as galectin-3 and reverse its effects. Using MatLab and chemical kinetics, we will build a mathematical model that reflects the immunopeptide T-cell suppression pathway. We will use data from an experimental collaborator. Some variables and parameters include concentrations of CD45, Csk, Lck, TCR, ZAP70, LAT, ERK, galectin-3, and C24D. The model will encapsulate currently known behaviors of the pathway to predict the final T-cell activation. During the summer, the model has been expanded using the TNBC-specific suppression schematic to include different isoforms of CD45, including a galectin-3 threshold system, and competitive ligand binding by C24D. The model also now includes dissociation kinetics between C24D and galectin-3. The model can be used to uncover unknown details of this pathway, ask further questions about immunosuppression, and make predictions that can be tested experimentally. This will ultimately help us understand how TNBC suppresses the immune system and help reverse this to ultimately increase the survivorship and longevity of TNBC patients.

# Characterization of Apoptotic Peptides to Attack Triple Negative Breast Cancer

**Siya Patel; Advisors: Dr. Vivek Kumar, Joseph Dodd-o**

Biomedical Engineering

New Jersey Institute of Technology, Newark NJ 07102

Abstract: Triple Negative Breast Cancer is an aggressive form of breast cancer that lacks Estrogen Receptor, Progesterone Receptor, and Human Epidermal Growth Factor Receptor (HER2) expression. As these hormone receptors are absent, hormone therapy and some forms of chemotherapy are ineffective treatments. Therefore, other forms of treatment must be explored. Peptide therapies are novel in their approach as they show greater precision in targeting the intended cells compared to existing small molecule therapies. Therefore, we synthesized thixotropic peptide hydrogels with apoptotic and anti-angiogenic signaling domains. To determine the effectiveness of the peptide hydrogel, its structure, purity, and overall characteristics must be analyzed. Therefore, this project aims to synthesize and characterize three apoptotic peptide hydrogels SLAPOP3, SLAPOP2, and K6 as well as an anti-angiogenic peptide hydrogel, SLKr5. These peptides were also analyzed *in vitro* environments. The peptides are synthesized through solid-phase peptide synthesis. To characterize the peptides, the purity, and molecular weight was measured through High-Performance Liquid Chromatography and Mass Spectroscopy, respectively. The secondary structures of the apoptotic peptide hydrogels were analyzed through Circular Dichroism and Fourier-Transform Infrared spectroscopy. *In vitro* cytocompatibility was measured using live/dead viability, CCK8 proliferation, and Fibroblast. In the future, subcutaneous injections will be performed on rat animal models to test compatibility with an in vivo model.

# Integrated Electronics and Pulsed Electric Generators to Mimic Tumor Cell Response to Electrical Stimulations

**Riya N. Patel[1], Aydasadat Pourmostafa[2], Amir K. Miri[2]**
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New York University, New York, NY 10012
[2]Department of Biomedical Engineering
New Jersey Institute of Technology, Newark NJ 07102

Abstract: Malignant tumors, such as certain types of cancer, present challenges in treatment due to their resistance to conventional therapies and complexity of surgical removal. Pulsed electric fields (PEF) are gaining prominence as an effective approach overcoming the limitations of traditional treatments for cancer, including standard chemotherapies. Our research proposes incorporation of electrodes into a bioreactor for studying the tumor cell response to electrical stimulation. This design will enhance monitoring of electrical signals within the bioreactor system and facilitate the development of innovative therapeutic strategies, such as electrotherapy, that can selectively target and inhibit tumor growth while minimizing damage to healthy tissues. Our focus consists of using electrodes in the bioreactor to deliver PEF to the cells. Experimental design began with using computer-aided design to create molds through stereolithography 3D printing. The molds are filled with polydimethylsiloxane (PDMS), a versatile biomaterial in which cells can be seeded. Stainless steel electrodes are integrated in the PDMS prior to curing, to ensure stable delivery of an electrical pulse. The PDMS bioreactor is surface engineered, using plasma and collagen treatment, to gain adherent properties for cell and glass slide attachment. The electrodes are connected to a function generator to deliver an electrical stimulus to induce effects in the cells, which will be studied and analyzed. Our studies consist of using rat muscle cells and later cancer cells. For muscle cells, we expect to see twitches in response to stimulation while cancer cells should result in eventual cell death, implying a decrease in the size of a tumor. The overall goal of this research is to increase productivity and efficacy in studying the effects of electrotherapy.

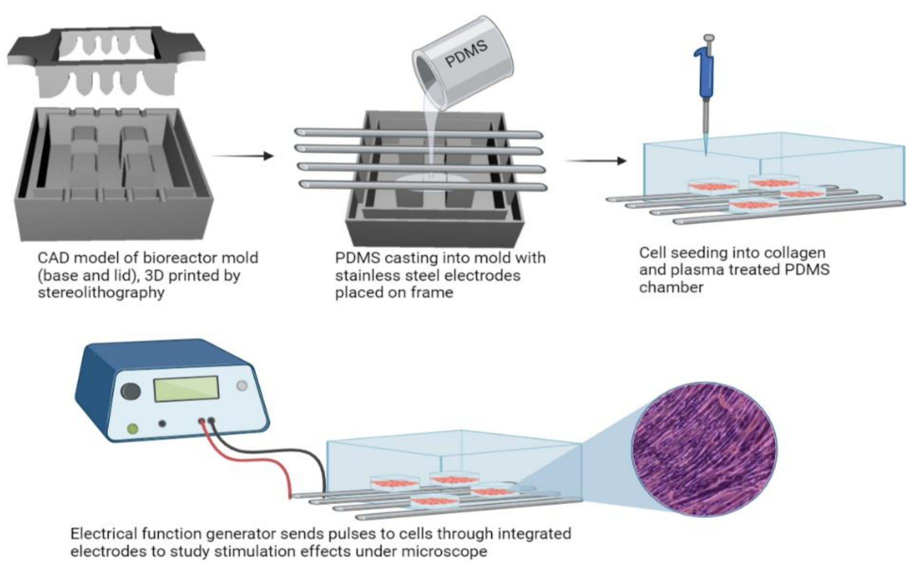


**Figure 1:** Experimental design of electrical stimulation bioreactor fabrication and application.

# Using DTI to Study Changes in White Matter Tracts in the Brain to Identify Mild TBI

**Disha Patil, Advisor: Dr. Bharat Biswal**
Department of Biomedical Engineering
New Jersey Institute of Technology, Newark NJ 07102

This research project aims to address the problem of undiagnosed mild traumatic brain injury (mTBI) by utilizing Diffusion Tensor Imaging (DTI) scans to detect microstructural changes in the brain. Conventional imaging techniques often fail to identify these subtle changes, leading to premature discharge from the hospital and insufficient medical care. The objectives of the study are to identify structural changes in white matter tracts indicative of mTBI, determine the most susceptible brain tracts, and explore the role of DTI in aiding mTBI diagnosis.

The significance of this research lies in the need for a reliable diagnostic method for mTBI. Undiagnosed cases often lead to long-term complications, such as amnesia, headaches, and difficulty concentrating. DTI scans in conjunction with clinical evaluations can be used to provide patients with the care they need when they need it. The interdisciplinary applications of this research extend to sports-related head trauma and military contexts, where it is essential for medical personnel to quickly and accurately diagnose mTBI.

DTI scans, obtained from mTBI patients, will be processed and analyzed using software such as FSL and MRtrix. Data analysis will focus on creating Fractional Anisotropy (FA) data for the scans. The mean FA data for the control group will be compared with the FA data derived from the scans of each patient in the experimental group.

Currently, the research is in progress, analyzing DTI scans to identify changes in white matter tracts associated with mTBI. Future work entails expanding the sample size and using different DTI metrics in conjunction with FA analysis. Further research is also required to refine the use of DTI in combination with clinical evaluations to enhance the accuracy of mTBI diagnosis. By offering a promising alternative to conventional neuroimaging techniques, DTI analysis has the potential to reduce the burden of mTBI on individuals, families, and society as a whole.

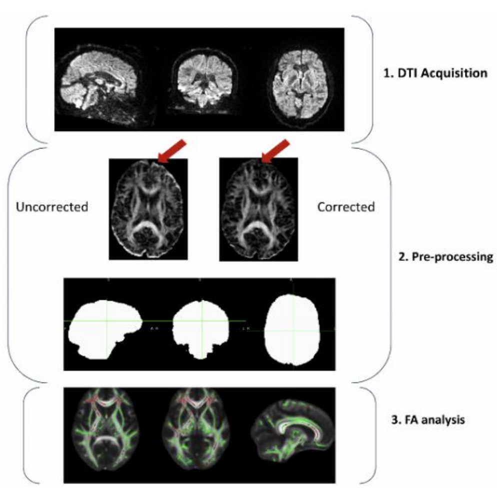


**Figure 1:** Overview of Procedure for DTI Analysis

# Smartphone Application For Warning Vulnerable Users (Bicycles) of Vehicles in Blind Spots

**Matthew Fleishman, advised by Dr. Branislav Dimitrijevic and Dr. Joyoung Lee**
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New Jersey Institute of Technology, Newark NJ 07102

Abstract: Bicycles are an ideal mode of transportation: they do not produce carbon emissions or contribute to traffic congestion, are an affordable transportation option, and do not take up much roadway or parking space. Additionally, they provide health benefits to their users in the form of exercise. However, the cyclists are incredibly vulnerable in motor-vehicle accidents, and this prevents many people from commiting to bicycle transport. For this reason, it is of paramount importance to develop technologies that make bicycle transport safer. Many different methods have been developed towards this goal in the past, and my objective this summer has been to design a mobile application that will use the data collected by LiDAR to warn bicyclists if there is a motor vehicle approaching them from the rear, in their blind spot, or is about to cross in front of them. I envision that the prototype application would be developed in Android Studio for Android phones. My concept and design for this application has been informed by the background research and literature review, including research papers on bicycle safety and LiDAR data processing.

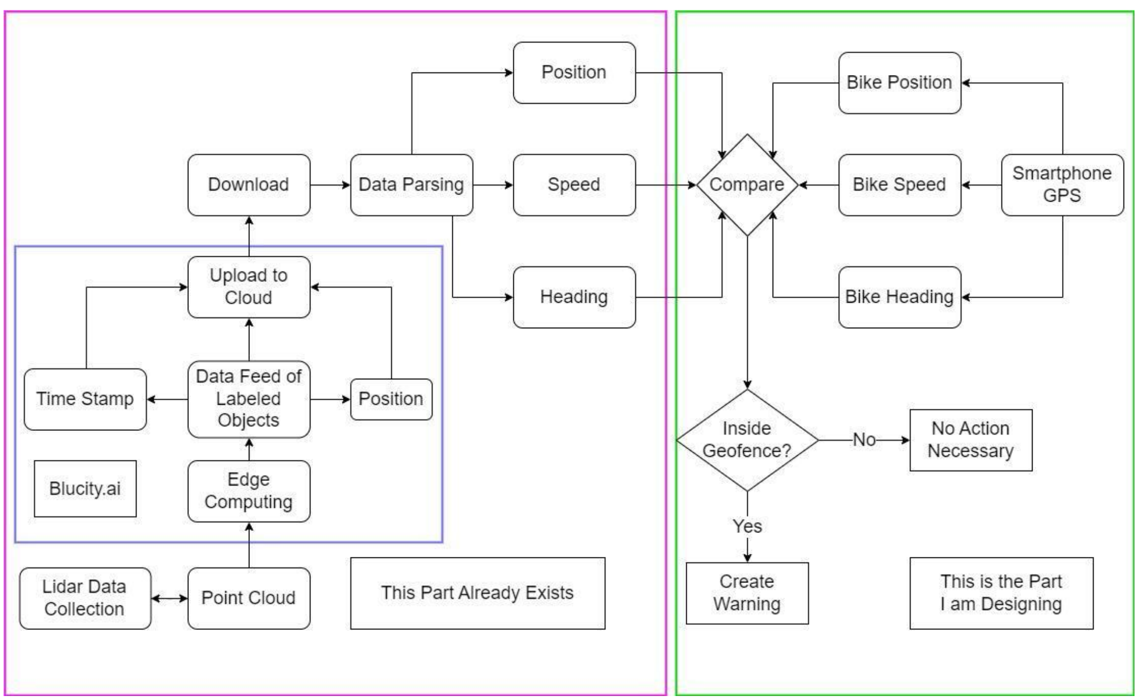


Figure 1: Conceptual Map for Application

# Investigation of Polymer Nanoparticles for Drug Delivery

**Nicole Piccininni, Advisor: Dr. Kathleen McEnnis, Mentor: Atharva Markale**

Department of Biological Sciences and Department of Biomedical Engineering

This research studied the interactions of polymer nanoparticles with blood plasma using nanoparticle tracking analysis (NTA) for drug delivery applications. NTA functions when particles in liquid suspension are loaded into a chamber that is illuminated by a laser beam. Particles in the path of the beam scatter the light and can be viewed by a camera. The NTA software captures videos of the particle movement and uses the Stokes-Einstein equation to analyze their motion to determine the size of the particle. This project utilized NTA to investigate the protein corona (PC), a layer of proteins that attaches to nanoparticles when they are introduced to a biosystem. Investigation of the PC is necessary because it is believed that the PC influences nanoparticle aggregation, which would render nanoparticles useless or harmful. We hypothesized by increasing the syringe pump speed, the PC thickness would decrease because the flow rate of plasma would be increased and there would be a shorter residence time for the nanoparticles in plasma. We also compared the thickness of the PC between goat and bovine blood at different flow rates. Both samples that were analyzed in these experiments were treated with sodium citrate as an anticoagulant. The samples had a concentration of 50% plasma and were heated to 37.°C to simulate human blood conditions. This research is significant because it emphasizes the criticality of studying the PC before the implementation of nanoparticles for treatments in vivo. It is imperative that we analyze the PC in different blood species to further gauge an understanding of the PC and its formation. This knowledge can lead to improved drug delivery systems, which would result in treatments with reduced drug toxicity, improved efficiency, and positive patient results in medicine.

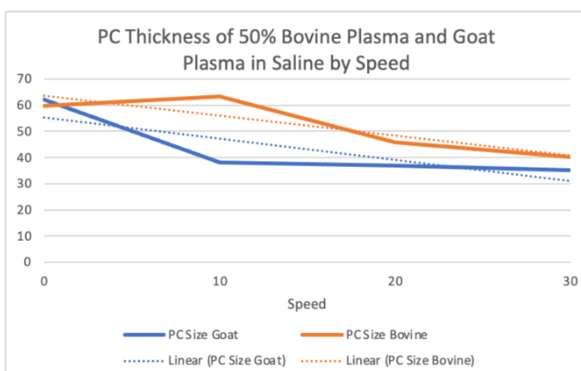


**Figure 1:** Graphically compares the protein corona (PC) thickness of two different species (goat and bovine) plasma at 4 different speeds. Both samples have a 50% plasma concentration in saline and were treated with sodium citrate as an anticoagulant.

# Impact of Nanoplastics on Ovarian Hormone Production

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**Mentor: Dr.** Genoa Warner

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Abstract: In the last century, the overconsumption of plastic has created a large supply of microplastic (MP) and nanoplastic (NP) particles as these not only come from degrading plastic objects in landfills, but are also fabricated at the microscopic level for commercial purposes. Previous studies have identified microplastic particles in human placentas, but it is unknown how this may affect maternal health or the developing fetus. As humans are constantly exposed to nanoplastics, it is likely that health impacts begin long before conception. How these nanoplastics are affecting the female reproductive system, especially hormone production, is an understudied area. The goal of this research project is to determine the effects of NP exposure on ovarian function in adults. Ovaries are responsible for the production of sex steroid hormones and the maturation and release of the oocyte (female gamete), through processes known as steroidogenesis and folliculogenesis. Hormones play an important role in fertility and reproductive health. We expect ovaries exposed to NP to show a significant change in hormone production compared to unexposed controls. To test this, ovarian follicles were dissected from adult female CD-1 mice and cultured with 1–100 µg/mL nanoplastics made of polystyrene or vehicle control, 0.05% tween20, for 96 hours. At the end of the culture period, follicles and culture media were collected for analysis. To determine the concentration of hormone levels, media was subjected to enzyme-linked immunosorbent assays (ELISAs) . The hormones of interest for analysis are estradiol, testosterone, progesterone, androstenedione, estrone, and pregnenolone. The data collected will come from five separate experiments (n = 5). We expect our results to show the impact of NP exposure on ovarian function. A significant change in hormone production will suggest that NP exposure is interfering with the biological processes of the ovary and causing adverse effects.

# A Smart and Portable Peristaltic Pump for Small-Volume Liquid Handling

**Samuel Landestoy, Areej Qamar, Advisor: Dr. Amir K. Miri**
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Many point-of-care (POC) diagnostic tools utilize liquid flow operation through microfluidic devices for the acceleration of clinical diagnosis time, drug delivery, or organ-on-chip models. POC microfluidic systems are often designed to interface with separate devices for liquid handling; this results in an increase in the cost and complexity of these systems, effectively limiting their application in under-resourced healthcare settings. Therefore, there is a clear need for cost effective devices for precise low-volume liquid handling with controllable flow rates into POC tools. To fulfill this need, this project proposes a smart, portable, and cost-effective peristaltic pump for small-volume liquid handling in POC diagnostic tools.

Fundamentally, this device is a 3D-printed peristaltic pump that provides a controllable output of liquid flow. The peristaltic pump is designed to be 3D-printed for simplistic replicability and cost-effectivity. The device employs a roller design for extended lifetime of internal tubing before replacement or repair of the tubes is required and also incorporates an internal multi-channeled pump assembly for controlled fluid flow into multiple microfluidic devices. This will maximize utility and accelerate workflow during device operation. The device also utilizes interchangeable modular gear sets to control liquid flow both electrically and mechanically, allowing for manual adjustment of flow rates and interface with a microcontroller, providing the capability to control fluid flow through separate microfluidic devices. The device will include a custom mobile application for wireless control and monitoring of pump operations, allowing for the user to easily customize the flow rate and duration of fluid flow into the POC device. The complete device design is shown below in Figure 1. This project is expected to result in a device ideal for adoption in areas with limited healthcare resources.

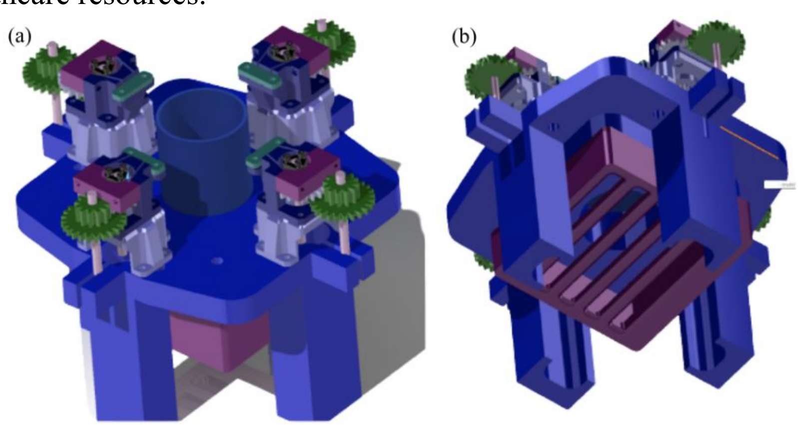


**Figure 1:** (a) top and (b) bottom views of the final design, incorporating a central cylindrical reservoir surrounded by four individual pumping channels with interchangeable gears and a single electronic holding case attached to the bottom of the complete unit.

# 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**
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Abstract: 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.

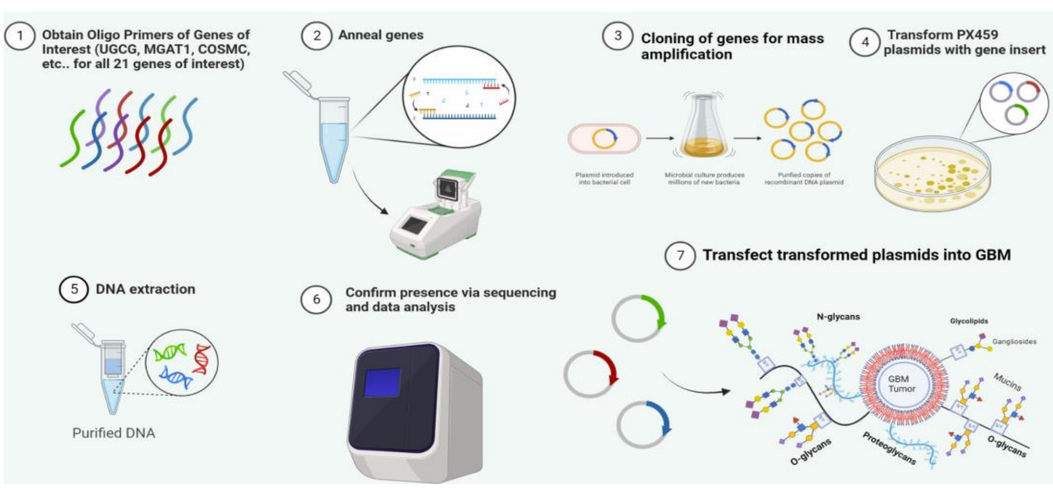


**Figure 1: Proposed protocol for "Knockout Gene" development**

# Electromagnetic Field Effects on T47D Cells with 17b-estradiol as Pathway for Improving Drug Delivery Systems and Non-invasive Breast Cancer Treatments

**Dinora Rivas Rodriguez[1], Luis Medina[2], Nellone Reid[2]**
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**Abstract:** Breast cancer, a prevalent and life-altering disease, affects approximately two million women globally. Conventional medical treatments for breast cancer, including chemotherapy, surgery, and radiotherapy, are invasive in nature and often result in adverse effects that can significantly impact patients' quality of life. Prominent studies have suggested that electromagnetic field (EMF) therapy has potential as a noninvasive treatment modality for breast cancer. This study focuses on the use of T47D cells, representative of breast cancer cells, which were subjected to treatment with 17b-estradiol, a steroid hormone primarily produced by the ovaries during the reproductive lifespan, and are then exposed at different time points under the EMF. The effects of EMF exposure were investigated through phase contrast microscopy with brightfield and fluorescence settings were employed to analyze the morphological changes occurring in T47D breast cancer cells *with and without* the exposure to EMF. Additionally, Treating breast cancer cells with 17b-estradiol illustrates how EMF amplifies the effectiveness of drug delivery systems. Utilizing low-frequency electromagnetic waves, EMF therapy targets the metabolic pathways of cancer cells while preserving the integrity of healthy cells, making it a highly targeted and selective approach to breast cancer treatment.

# Utilizing Apoptotic Peptides to Combat Triple Negative Breast Cancer

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Abstract: Triple Negative Breast Cancer (TNBC) is a breast cancer subtype that is characterized by its lack of three receptors: estrogen, progesterone, and HER2. This aggressive cancer does not respond to hormone therapy or therapies targeting these receptors, making chemotherapy the primary option. Unfortunately, more than half of women with TNBC relapse or develop resistance to chemotherapy. Peptides have recently emerged as promising therapeutic potential due to their ability to selectively target specific cells, their biocompatibility, and their ease of production. More specifically, apoptotic peptides have the ability to induce cell cancer death through various mechanisms. The KumarLab at NJIT focuses on peptides that self-assemble into β-sheet fibers, enabling both tissue engineering and localized signaling applications. The objective of this research project is to develop a peptide hydrogel that can spontaneously assemble into a viscous hydrogel for localized apoptotic signals. To do so, the project consists of 1) synthesizing and characterizing four apoptotic peptides: SLAPOP2, SLAPOP3, SLKr5, and K6. We will do this by conducting Mass Spectroscopy to determine the molecular weight of each peptide. To evaluate the secondary structure, we will use Fourier-Transform Infrared Spectroscopy and Circular Dichroism; 2) We will analyze the cytocompatibility of the peptides using mouse myoblast cell culture. We will use a Live/Dead Assay as well as Cell Counting Kit 8 to determine the viability and test the cells' proliferation in the presence of the peptides; 3) We will analyze the cytotoxicity of the peptides on the MDA-MB-23 breast cancer cell line through the TUNNEL Assay. Based on the characterization data, we were able to determine that 1) the peptides were accurately synthesized and formed expected β-sheet fibers. Based on the cytocompatibility data, we were able to determine that 2) SLKr5 had the highest cell viability when normalized to serum-free media. In the future, we plan to vary the concentrations of the best performing peptide(s) based on the experimental results as well as begin in *vivo* studies to further explore the potential of this therapy.

# Confined Collective Motion of Bristle-Bots: Modeling and Experiments

**Shalom Salvi**
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Collective motion is a phenomenon found from the treadmilling of microtubules and swarming of microbes, to the behavior of fish schools and large crows of humans. It refers to the behavior of a group of individuals, each mobbing independently, and arises due to the interactions of these 'active agents' with each-other and the surrounding environment. Intricate dynamics emerge in these biological and artificial collective systems even though the units are not 'thinking' and are not guided by an organizer. The resulting collective behavior is trivial and difficult to understand, let alone predict, especially in complex geometries. Understanding the effects confinement has on collective motion of microorganisms has, thus, become a central topic of research. Understanding ways to control and direct their self-propelled motion not only can help in the understanding of our natural system but it can also come in use in developing future technologies. Patterns of behaviors have been found, but it is still not obvious what factors help the formation of this collective motion. The work carried through in this project aims to answer this question by analyzing the influence the shape and radius of the confinement together with the active agents' density and shape have on the emergence of collective motion.

To analyze the different factors and produce simulations, we built on the MATLAB models developed by Dr Lushi's group for the collective motion of active agents in confinement as well as those in the existing literature. The models trace the dynamics of the center of mass and the orientation of the active agents and account for factors such as forces and torques generated from the collisions with other agents and the boundaries. The model excludes noise and friction. The model contains a circular confinement, of which the diameter was varied, and elliptical shapes to represent the active agents. In addition to the diameter of the circular confinement, the number of active agents in the confinement (also known as the area fraction) and the ellipse's aspect ratio were also altered to further understand their influence.

After numerous simulations modifying the different parameters, we noticed that particle alignment and organized motion is prevalent in simulations with higher aspect ratio as shown in figure 1 and 2. In low aspect ratio, the simulated particles are moving, but no collective motion is noticeable. It is also visible that we required a high enough density for this collective motion to happen. At low density, particles attach to the boundary and no interaction happens between the different agents, since they slowly come to a haul at the boundary.  Preliminary experiments supported our findings. The next step is to continue to develop simulations to account for friction and noise with the end goal being one where we set up the simulations as an online tool for the general public to use.

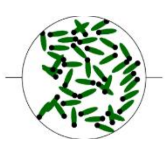

Figure 1: active agent confinement simulation at time=0
(Diameter=6, aspect ratio=4, area fraction=0.299)

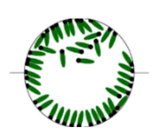

Figure 2: active agent confinement simulation at time=4s
(Diameter=6, aspect ratio=4, area fraction=0.299)

# Long-Term, Reversible, Low-Impact Bioinspired Adhesive Attachment For Marine Mammal Biotelemetry Applications

**Danna V. Sanchez, Advisor: Dr. Brooke Flammang**
Department of Biological Sciences
New Jersey Institute of Technology, Newark NJ 07102

Abstract: Electronic marine animal tagging is used to watch behavioral patterns, analyze geolocation, and conserve marine organisms, but it needs hydrodynamic and robust adhesion devices. State of the art long-term tagging methods are invasive and use heavy-load equipment, thus there is no specialized adhesive device that can safely provide telemetry and biologging. . The proposed bioinspired remora adhesive device design, incorporates a previously drafted adhesion disk by Gamel et al. 2019, was improved with lightweight material to observe the drag force and adhesion force of the device with fidelity to large marine species. The proposed design will lead to a bioinspired remora apparatus for biologging analysis, with optimized mechanical properties in different artificial skin parameters whilst minimizing interference with the hosts' habitual behaviors and/or for hydrodynamic purposes. During this summer, we have been testing the throughput from the prototype development perspective. Future research will concentrate on field testing and pressure testing.

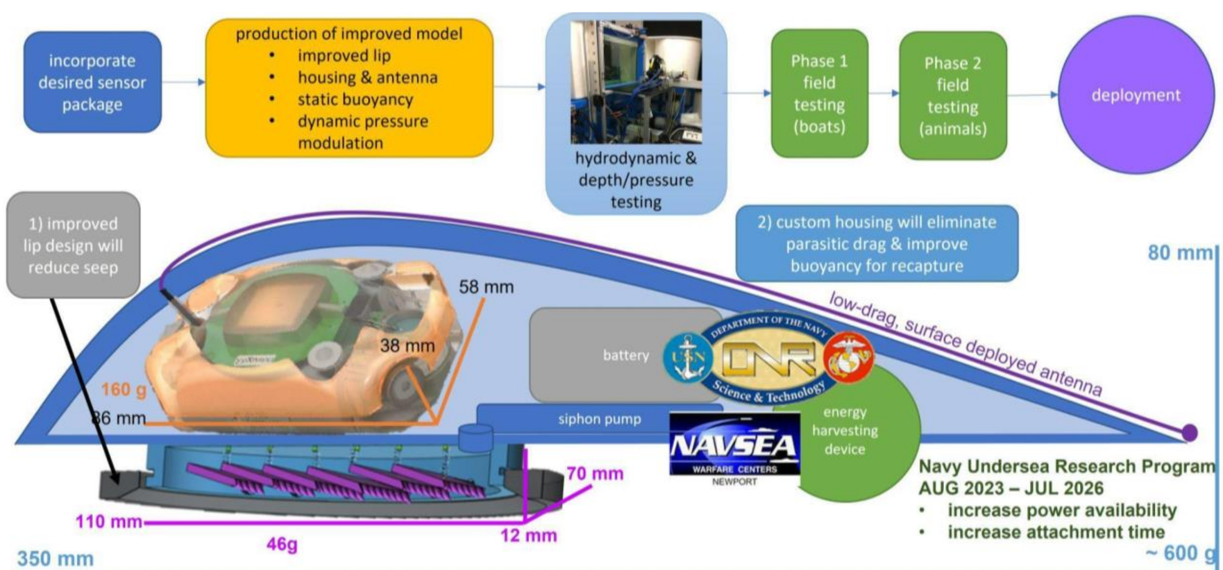


Figure 1. Overall research objective for the full scope of RAD improvements. The proposed work herein will specifically address the components relating to (1) lip design, (2) custom housing design, and the hydrodynamic, pressure, and boat field testing phases.

# Assessment Of Cognitive Decline Biomarkers In Alzheimer's Disease And Substance Abuse Patients

**Mira Sapozhnikov, Advisor: Dr. Sara Casado Zapico, & Mentor: Dr. Francisco Medina Paz**

Department of Chemistry and Environmental Science

New Jersey Institute of Technology, Newark NJ 07102

Abstract: Cognitive decline is one of the defining characteristics of Alzheimer's disease (AD), but it is also a prevalent medical issue among chronic drug and alcohol abusers. However, substance abuse patients are frequently understudied due to stigma and are likely to be younger than classic dementia symptom-presenting patients, meaning the underlying etiology for memory loss, altered behavioral states, and deteriorated cognitive function in substance abuse cases is relatively unknown. Receptors for advanced glycation end products (RAGE) are transmembrane receptors involved in the initiation of signaling pathways relating to oxidative stress and inflammation. Previous studies have linked RAGE to AD; RAGE activation leads to the production and accumulation of β-amyloid, a protein commonly associated with many of the harmful neurophysiological conditions present in AD patients. This study analyzes RAGE expression in 39 healthy, 60 substance abuse, and 107 AD patient plasma samples by Western blot. The effects of RAGE on reactive oxygen species (ROS) were also examined through fluorescent assay to evaluate RAGE levels and activity in Alzheimer's patients versus substance abusers. Apolipoprotein D (ApoD) levels were analyzed to assess their value in being used as a biomarker for AD per previous literature and to determine whether elevated ApoD levels are also present in substance abuse patients. Results showing elevated RAGE expression and increased ROS suggest that it is possible that cognitive decline in substance abuse patients can be triggered by the same neuroinflammatory pathways as in AD through oxidative stress-induced RAGE activation; conversely, ApoD levels thus far have not presented as significantly different in AD patients versus healthy ones, but were significant in drug/alcohol abuse. Thereby, these findings suggest that it is possible that RAGE can be utilized as a universal biomarker to analyze and examine cognitive decline. Additional research is needed to determine DNA changes in these pathways related to cognitive decline for potential treatment targets.

# Does mitochondrial DNA activate immune responses during TB infection?

**Vijay Subramanian; Advisors: Dr. Mary Konsolaki[1], Dr. Samantha Bell[2]**
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Mycobacterium tuberculosis (Mtb), the intracellular bacterial pathogen that causes tuberculosis (TB), remains one of the deadliest infectious diseases worldwide and killed 1.6 million people in 2021. Mtb evades killing in the macrophage by secreting bacterial proteins into the host cytosol that promote its own survival and replication. However, in doing so, Mtb also releases DNA into the cytosol, which is sensed by the macrophage via the cytosolic DNA sensor cyclic GMP-AMP synthase (cGAS). Upon binding DNA, cGAS activates the STING/TBK1/IRF3 signaling axis, which causes an immune response marked by increased expression of interferon-β (IFNβ). IFNβ is a type I interferon (IFN) traditionally associated with antiviral defense mechanisms, but this antiviral response is often detrimental during bacterial infections. Type I IFNs inhibit the activity of critical antibacterial cytokines like IFNγ and IL-1β, both of which are essential for responding to bacterial pathogens like Mtb. Previous work has shown that in addition to detecting cytosolic bacterial DNA, cGAS can detect other types of host DNA such as cytosolic mitochondrial DNA (mtDNA); therefore, the precise origin of cGAS-bound DNA during Mtb infection remains unclear.

To better understand the respective contribution of host and bacterial DNA, we are assessing how the depletion of mtDNA in macrophages (RAW 264.7, immortalized bone marrow-derived macrophages (iBMDM), and U937 macrophage cell lines), affects activation of the cGAS/STING/TBK1 signaling axis during Mtb infection. We depleted macrophage mtDNA by growing cells in the presence of 2′-3′-dideoxycytidine (ddC), which preferentially inhibits DNA replication in mitochondria, thus diluting their mtDNA as the cells grow and divide. We analyzed the mtDNA content of ddC-treated cells via qPCR and found they had less than 2% of their initial mtDNA content. To measure the baseline type I IFN responses of mtDNA-depleted macrophages, we stimulated them with cytosolic double-stranded DNA and measured type I IFN induction. Both control and mtDNA-depleted macrophages had about 3,000-fold induction of IFNβ and 30-fold induction of IRF7 upon stimulation, demonstrating that depleting mtDNA in macrophages does not inherently affect this signaling axis. Future work will use these mtDNA-depleted macrophage cell lines to investigate their type I IFN expression in the context of bacterial infection, where mtDNA has the potential to contribute as a cGAS ligand. Ultimately, we will use these studies to define the source of the cGAS-activating DNA during Mtb infection, where we predict that both bacterial DNA and mtDNA contribute, possibly with differing dynamics and magnitude. Together these results will inform the mechanism by which the STING/TBK1/IRF3 axis is activated during Mtb infection and reveal novel host targets for future therapies to treat Mtb infection.

# The Occurrence of Collective Behavior in *Astyanax mexicanus*

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Recently, 78 people lost their lives and 77 people were injured due to a stampede in Sanaa, Yemen. Deadly mass panic events such as these occur all over the world, however, the causes behind individual panic responses are only partly understood. It has been difficult to analyze these events in humans because it is nearly impossible to account for every factor that influenced the stampedes that have occurred in the past, and creating a mass panic is immoral and can be deadly, as seen previously. Through the use of both surface (seeing) and cave (blind) morphs of *Astyanax mexicanus* in a controlled environment, the interactions that occur between the fish can be studied, and the origins of their panic events can be ascertained to a greater extent. I took preliminary videos of the separate morphs in petri dishes at 7 dpf (days post fertilization) with approximately 120 surface fish in the largest surface grouping and 8 cave fish in the largest cave grouping. From what can already be ascertained, it seems as though the *Astyanax* prefer swimming along the outer wall (the part with the largest radius) of their arenas. I will use image and video analysis software, which I am currently coding in R, in order to track the fish's movement patterns further. Once I finish preliminary trials, I will take videos in which various mixes of both morphs are present. In understanding which of these interactions eventually lead to group panic responses in the fish, I can understand how panic responses emerge in humans as well. Eventually, this work can be used to prevent dangerous mass panic events from occurring in the future.

# Designer Peptide Signaling Quantified *In Vitro*

**Owen West, Dr. Vivek A. Kumar**

**Department of Biomedical Engineering**

New Jersey Institute of Technology, Newark NJ 07102

Peptide-based therapeutics are a widely-recognized and respected class of medicine, with over 30 FDA approved non-insulin peptide drugs currently on the market. Engineering medicines using peptides is a well-validated and vast area of research, as the characteristics of peptide medicines, as well as their overall biocompatibility, allow for many areas of innovation. Some of the approaches presented in this research include nanostructural coordination, protein mimicry, cyclization, and computational modeling and design. For one, important proteins in the body can be mimicked, such as insulin-like growth factor 1 (IGF-1), and conjoined with self-assembling peptide nanofibers. This construct, coined "SLGIGF", serves as a localized, systemic, and long-term platform for upregulating the IGF-1r signaling pathway. Its signaling capabilities are comparable to that of whole-Growth Factor, as experimentally demonstrated via Western Blot and *in vitro* cellular differentiation assay, and is synthesized and prepared at a much cheaper cost. Another method of peptide engineering discussed in this research is the computational design of anti-inflammatory cyclic peptides. The complement-5a signaling pathway is a pro-inflammatory, innate immune signaling pathway whose overactivation during periodontitis serves as a significant blockade for developing periodontitis medicines. Previous peptide macrocycles have been described as viable orthosteric inhibitors of the complement-5a receptor. Using molecular modeling and iterative computational protein design, competitive inhibitors of the complement-5a receptor can be created with optimal folding thermodynamics and conformational rigidity, thus improving binding characteristics potentially surpassing biological barriers.

# Use of Machine Learning Models to Predict Breast Cancer

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Abstract: The need for accurate and fast medical predictions to diagnose medical ailments is on the rise. Timely diagnosis of illnesses is proven to be important in the treatment of these diseases. Technology, and specifically, machine learning models, is effective at analyzing and predicting very good outcomes. This begs the question; can accurate deep learning models be built to help ensure the timely diagnoses of patients? To answer this question, machine learning models were built to diagnose breast cancer. Machine learning and deep learning models, such as convolutional neural networks (CNN), are programmed to detect certain features that can help diagnose malignant and benign tumors. The research is divided into two because of the data used. The first dataset is a numerical dataset obtained from previous Fine Needle Aspirate (FNA) research. This data is used to train and test models such as Logistic Regression, Random Forest and XGBoost Classifier. The aim of this aspect of the project is to perform Recursive Feature Elimination (RFE) to identify the important features that determine if a tumor is malignant or benign. The best model, Logistic Regression model, had a 98% accuracy and was used for RFE. The most important features were the worst measurements, specifically, radius, perimeter, and concave points.  The effect of the different balancing techniques on the accuracy of the model is also tested. Different techniques affect the accuracy of the model prediction; the best technique for the Random Forest model was Borderline SMOTE 1 and SMOTE ENN was the best technique for the XGBoost Classifier model. The second part of this project uses a dataset of ultrasound images. The aim of this second project is to build a convolutional neural network (CNN) model that can accurately predict breast cancer. The expected accuracy of the model is about 80% accuracy.

# Tax Fraud Detection Using a Machine Learning Approach

**Don Bonifacio, Advisor: Dr. Ming F. Taylor**

Martin Tuchman School of Management

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**Abstract:** Tax fraud is a significant issue among businesses and governments worldwide, contributing to an estimated half-trillion dollars in lost tax revenue annually. As a result, the detection of tax fraud is a key objective among tax authorities to address this loss in revenue and promote tax compliance. Traditional methods of identifying fraudulent behavior often require more resources as they lack the adaptability of data-driven algorithms. Machine learning technology has shown promising results in some fraud detection applications. Although, techniques like supervised machine learning have been difficult to apply to corporate tax fraud detection due to limited labeled data. To account for these issues, this research seeks to develop models to predict the proxy of Internal Revenue Service (IRS) attention, derived from IRS acquisition of firms' public financial disclosures, as a source of accessible labeled data. Public financial information and datasets from existing research are utilized to develop a dataset on which financial variables are extracted. Supervised regression models can then be trained on the extracted variables to predict for IRS attention. Subsequent analysis aims to evaluate and compare various regression models for IRS attention prediction. Financial variables and ratios included in the training set are informed by existing tax and financial fraud literature. Regression models including linear regression, random forest, XGBoost, and others were trained and evaluated; however, further optimization and analysis are still needed for the study. The results of the study will contribute to the growing field of machine learning approaches to tax fraud detection. The development of these tools could allow agencies, investors, and other stakeholders to efficiently identify potential corporate tax fraud on a large scale. Future work into the project would concentrate on the further improvement of machine learning methods used and the development of an updated IRS attention dataset to potentially improve relevance and performance of these models as well as for use in future research.

# Soundly Detecting Memory Leaks in the Linux Kernel

**Kevin Diggs, Advisor: Dr. Martin Kellogg**
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Abstract: The Linux kernel is the core of the Linux operating system and millions of devices and servers rely on it. Since high performance is essential for kernels, the Linux kernel is written in C, a language where memory needs to be managed manually. Manual memory management can lead to memory leaks, which can cause programs to perform worse or crash, and can also be exploited by attackers to cause severe damage. Current state-of-the-art tools for the Linux kernel are useful in finding memory leaks, but are not sound, meaning they do not guarantee that all memory leak bugs are detected. Our research project aims to develop a sound, static program analysis tool for detecting all memory leak bugs in the Linux kernel. The tool's design is based on a tool for detecting resource leaks in the programming language Java called the Resource Leak Checker (RLC). This tool used a new, sound, analysis design, accumulation analysis, to detect resource leaks; it was able to run just as fast than existing un-sound tools for Java and found many real resource leak bugs in widely-deployed software. Our tool will be for the programming language C, but due to the many differences between Java and C, translating from Java to C would not be straightforward. Additionally, the resources being used in Java operate at a much higher level than the memory that is manually managed in C. Since we can consider memory to be a type of resource, we can still use the RLC's design to detect memory leaks, but specific implementation details between Java and C would differ considerably. Once our tool is fully developed, we expect it to run as fast as other state-of-the-art memory leak tools, but with a soundness guarantee. So far during the summer, one-third of the analysis has been completed, and future research will continue building and optimizing the analysis.

# The Implications of Visual Stimuli on Conferencing Platforms

**Fatimah El-Belkasi**
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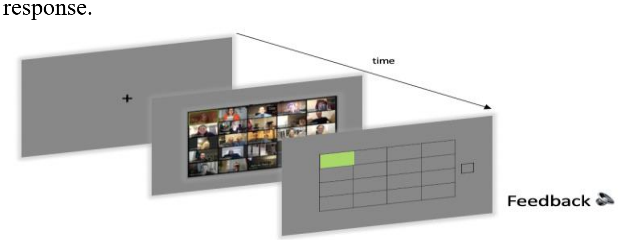
An indirect result of Covid-19 safety precautions was the redefining of the workplace, whether it be an office space or a classroom. As it was dangerous to step foot outside the household, it became necessary to step foot into the future. What emerged as a result of balancing safety practices and remaining faithful to responsibilities was the concept of video conferencing. Platforms such as Zoom, Cisco Webex, Google Meets, Microsoft Teams and many others were utilized in order to have the workplace continue from a safe distance. With the increased usage of these video conferencing platforms arose a new term, "Zoom fatigue". Zoom fatigue refers to the symptoms associated with excessive usage of video conferencing platforms. The symptoms include but are not limited to feelings of fatigue, worry, exhaustion, burnout etc. Previous studies regarding causation have been conducted regarding, asynchronicity of communication, lack of body language, lack of eye contact, self-awareness, unnatural interaction with multiple faces and multitasking during videoconferences, with limited studies regarding visual stimulation. The goal of this study is to apply what is known about fundamental processes of the human visual system to more complex real-word settings such as video conferencing tools to investigate the usability of designs and how these interact with the video conferencing experience. The tool that will be focussed on in this study is background usability. This is tested through a search task, a participant will choose an individual, one that they will need to locate amongst a zoom call with many others. This will be performed twice, once with abstract backgrounds and a second time with all natural setting backgrounds. This study will be able to inform all on whether or not background usability is efficient in a virtual environment, and potentially it's contributions towards zoom fatigue.

**Figure 1:** Example timeline from the planned search experiment. Participants start the trial by looking at the center cross. When they press a key, the image is displayed. The task is to find the highlight which indicates the current speaker. Participants press a key when to terminate the search and we record their reaction time. Then, they look at the location corresponding to the highlight and press another key and we record their accuracy. If there is no highlight, they look at the extra box outside the array. We give them real time feedback using the eye tracker to show them which box they are selecting. They also hear sound feedback to indicate the accuracy of their response.



**Large language models for predicting functional genetic variant candidates**

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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.

# A RLHF Framework to Promote Proportionate Fairness in LLMs

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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.

# Computational Methods for Human-Centered Perceptual Analysis of Work Spaces

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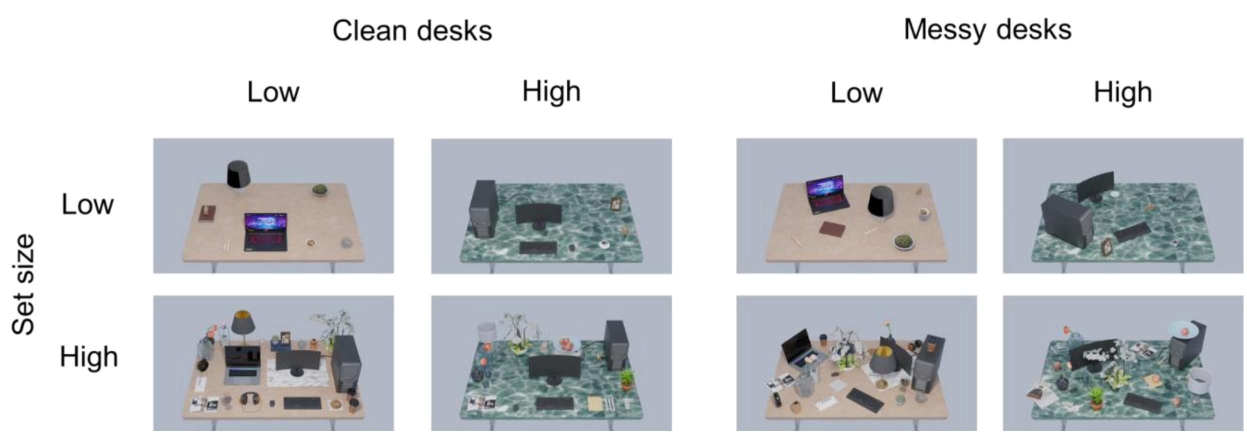
Abstract: In everyday life, we are surrounded by spaces that affect our well-being and quality of life. Due to the Covid-19 pandemic, we are spending more of our time in virtual spaces which in turn are becoming realistic and immersive. Demand for virtual content is rising, and projected to reach $46.54 Billion by 2026 (Businesswire, 2020). To address such demand, researchers have proposed multiple computational methods for creating virtual spaces. However, there are no comprehensive quantitative ways for measuring the quality of virtual spaces. Without an effective way to measure spatial quality, it is difficult to create satisfactory virtual spaces for different needs. To that end, our central hypothesis is that visual clutter is critical in defining the quality, usability, and functionality of a space. Several metrics have been developed to quantify the degree of clutter in scenes, however, existing metrics for assessing the quality of spatial layouts rely on hard-coded geometrical rules that must be predefined for each layout type. We will analyze these metrics to determine which factors contribute to the clutter. These factors include numbers of items, organization of items, and complexity of surface. We have a set of commuter generated images where we change the items and their arrangements, the number of items, and the complexity of the surface. We have humans rate the clutter of these images and run the images through the models. We will then create a search task where we place the letter "F" in these images and ask humans to try to find the letter. Images that are very cluttered will have a longer search time and images with minimum clutter will have shorter search times. We will then compare if the models and humans predicted the image with longer search times to be more cluttered or not.



# Privacy Aspects of Smart Medical Apps

**Ricky Hernandez, Advisor: Dr. Shantanu Sharma, Graduate Mentor: Ethan Myers**
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New Jersey Institute of Technology, Newark NJ 07102

Abstract: 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.

Keywords: Mobile app descriptions, Permissions, Android Manifest, Medical health applications, Fidelity, Fine-tuned BERT transformer, Natural language processing, User data management. `

# Identifying Fashion Trends Utilizing Color Analysis

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This research applies color analysis on clothing images available online and distinguish the different trends in fashion to an underexplored domain. Color trends provide valuable insights to fashion designers, retailers, and industry professionals about the preferences and choices of consumers. By analyzing color trends, fashion brands align their designs and product offerings with the current market demands, enhancing their competitiveness and staying ahead in the industry. Consumers can utilize this research to receive inspiration for their own personal style as well.

Different methodologies are used to determine a comprehensive understanding of the color scheme of various datasets. Every image from multiple datasets is processed so that the background is removed, for the focus of this study lies solely on the colors of the outfits. Conclusions about the prominence and variety of colors are made to produce various types of data visualizations. Utilizing photos created and posted by individuals from various backgrounds exemplifies the diversity and creativity of fashion. The research also promotes inclusivity by demonstrating that determining future clothing trends or patterns does not require professionally taken photos.

The outcome of this research is a comprehensive understanding of color analysis techniques for fashion trends. Considering the popularity of social media platforms, researchers can apply this research methodology to explore the color analysis of clothing outfits across various social media channels. Its findings can contribute meaningfully to the knowledge surrounding fashion trend analysis and inform industry practices and consumer choices. It is important to acknowledge a limitation pertaining to the accessibility of up-to-date clothing images because publicly available datasets often consist of outdated images. Future work will focus on curating more modern datasets and providing insight into fashion trends beyond color. However, by bridging the gap between data-driven analysis and the ever-evolving world of fashion, this research establishes a strong foundation and paves a way for future research in applying advanced color analysis techniques to online clothing images.

# Shrines in the Ironbound:
# A Geospatial Analysis of Modern Displays of Faith

**Fernando Mantilla, Advisor: Dr.** Louis Hamilton
History Department, Computer Science Depa
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Abstract: While church attendance and religious affiliation continue to decline in the US, there is a distinct lack of investigation into religious urban areas of the United States. The Ironbound in Newark, a melting pot of Italian, Portuguese, and Latino culture, typically practices votive art in the form of tile paintings and statues, each with their own significant story. For such a historically religious community, its current devotional state is a perfect candidate for investigation on the question of declining faith. This research aims to survey 50 participants on their experiences with street shrines and tile paintings from different communities in the Ironbound. These communities will be organized by a geospatial analysis of a detailed map of the Ironbound shrines, each community separated by characteristics of their respective shrines. The characteristics used to distinguish the communities will be by type of figures, proximity to religious institutions, and other such factors. By comparing the results of the survey to predictions made from the map analysis, we can understand how the religious decline has affected the Ironbound. The collection of interviews will be stored within a database to create an online exhibition. The exhibition, hosted on a website, will allow outsiders and other residents to obtain a deeper insight into the history behind their community. By understanding the present devotional state of the Ironbound, a snapshot from the present will be created for future projects to create a trend, all in an effort to record this growing decline in religious faith.

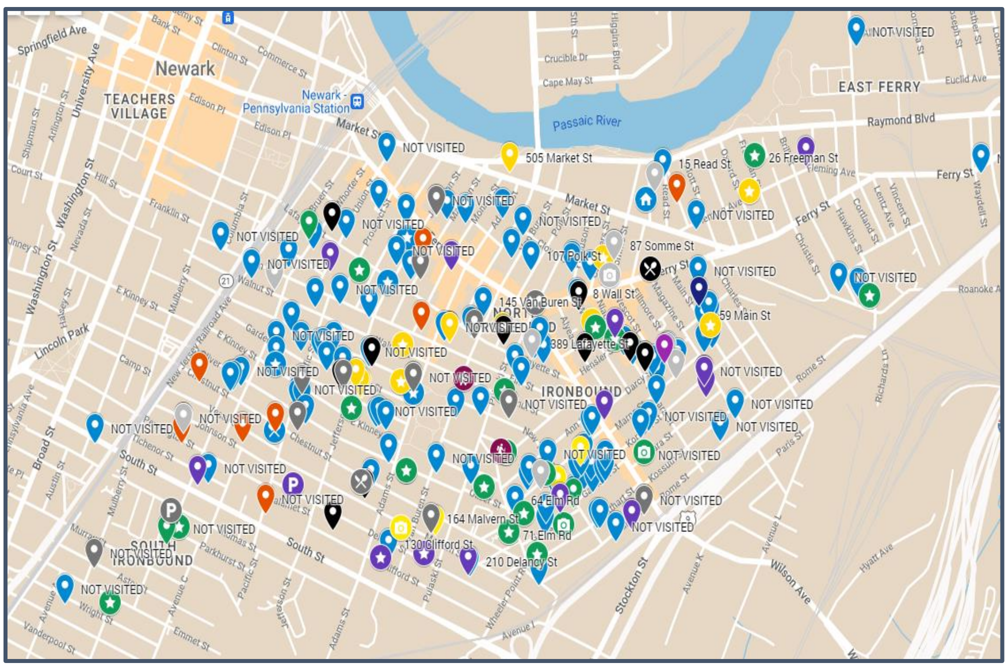


Figure 1: A map of the tiles in the Ironbound.

# Probabilistic Programming With Linear Systems

**Erik Mattson**
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After encountering many of the problems with Monte Carlo for stochastic simulations, I looked into calculating them computationally for performance boosts. My initial solution was to calculate them with linear systems, as in using matrices, vector spaces, and probability transition matrices. This approach, while viable, did not provide the speed or flexibility needed for a general-purpose tool. Instead of using vectors, I found great improvements in working with state-probability pairs to represent random variables.

The proof-of-concept code was very promising, so with spare time, expanding upon it seemed like a good idea. I could create something that would benefit me when calculating random systems, and therefore provide others with those benefits. Of course, being intuitive and clear were the main goals, especially when working in a language like Julia.

Not only did the program run faster than a Monte Carlo equivalent in some cases, but it is also possible to calculate exactly in some discrete systems. Another benefit is being able to use variables in calculation. Even though the initial calculation can be costly, repeated substitutions can reduce time, as seen in Figure 1. This can have applications from just being more convenient to other uses like potentially function fitting.

Of course, this would not be helpful if it were not accessible. I have open-sourced this project on GitHub at ErikTheBlacksmith/Stochastic-Determinism along with more technical information. As for still being a concept, it is complete, but will likely receive more features as needed.

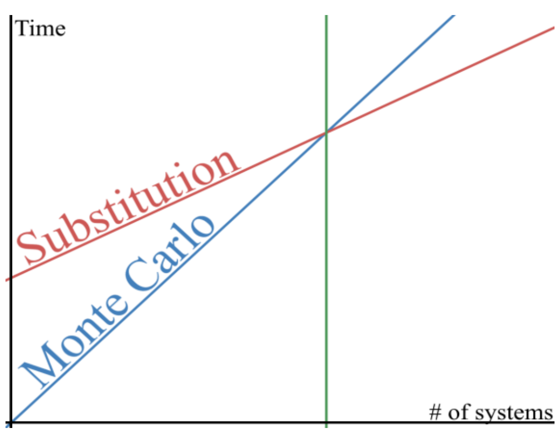


**Figure 1:** Example of calculator time between a calculation /substitution method (red) and a Monte Carlo method (blue). Depending on the system one is always faster than the other, but often substitution is quicker in the long run.

# Chaotic Scattering of Vortex Dipoles

**Ellison O'Grady, Advisor: Roy Goodman**
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Abstract: The vortex interaction problem has a 150-year history and has produced a detailed body of work. Among these studies are examinations of the leapfrogging motion of vortex dipoles, mathematical analysis of three-vortex systems, and numerical studies of chaotic scattering of dipoles; however, the mechanisms of dipole scattering have yet to be fully analyzed mathematically. In dipole-dipole interactions, frequently two like-signed vortices will pair up during the interaction and behave similarly to a single larger vortex, as seen with the two negative (blue) vortices in Fig[1](a). To capitalize on this behavior, this research aims to represent the four-vortex system as a three-vortex system plus a small correction. Such a reduction will require a new coordinate system that will enable the extension of the three-vortex body of work to the dipole scattering case.

During this summer, our focus has consisted firstly of reproducing previous results in the areas of leapfrogging and three-vortex scattering, as well as revisiting the numerical study of the four-vortex system and the dependence of the final state of this system on the input parameters - see Fig[1](b). From there we are moving on to the development of the coordinate system required to represent dipole-dipole scattering as three-vortex dynamics with a correction. With these developments, we aim to set up the analysis of the results to enter into later stages of this research and derive mathematical models for the reduced four-vortex system.

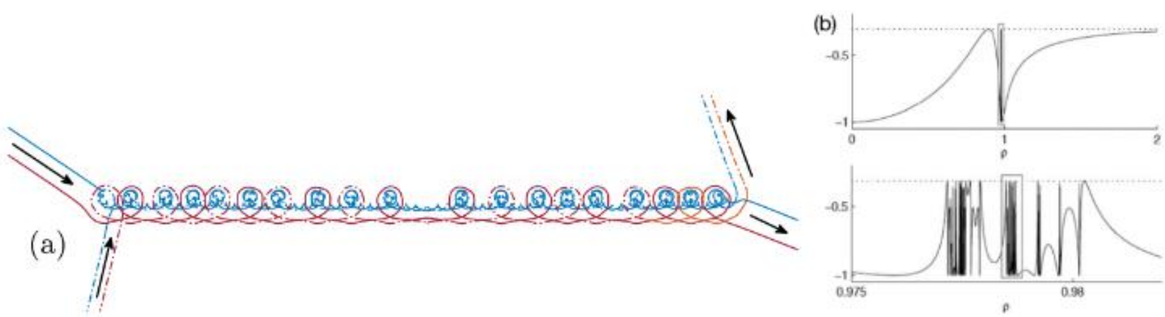


**Figure 1: (a)** Scattering behavior of two vortex dipoles, **(b)** dependence of this behavior on the input parameter ρ.

# Roman Street Shine Database and Querying Interface

**Alex Patchedjiev, Advisor: Dr. Vincent Oria**
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Abstract: Within the city of Rome lies innumerable Christian "street shrines." A phenomenon dating back to the medieval period, these Christian shrines have historically been and continue to serve as a way to weave spirituality into the urban landscape of Rome. They receive faithful devotion from Romans, though the nature of that devotion has changed over time. The Rome Research Group (RRG), led by Dr. Louis Hamilton investigates the potential factors that influence devotional activity at these shrines. The RRG has compiled data on more than 650 of these shrines, incorporating the shrine's geographical, architectural, iconographic, and devotional characteristics. This project is constructing a shrine database that encapsulates the RRG's pre-existing data and an associated web-based querying interface that will function as a tool to guide future research and engender collaboration with other researchers. This interface is to be open for the public to view, accessible through the web, and allow for registered users to contribute to the database. The interface allows users to query the database for certain shrine attributes, providing a data summary and visualization. This visualization displays data about the relevant shrines and the Roman streetscape over a map of Rome, allowing the comparison of heatmaps and weighted centers for shrines with specific attributes. The interface, by enabling in-depth queries, can be used to test hypotheses by the RRG and for investigations that can point to new directions for research. Moreover, it will also function and continue to grow as a comprehensive and presentable summation of the RRG's work. The database would be the largest published modern database on these shrines. Its ability to engender collaboration can allow the database to expand beyond the city of Rome, incorporating shrines from other cities.

# VROOM Management System

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

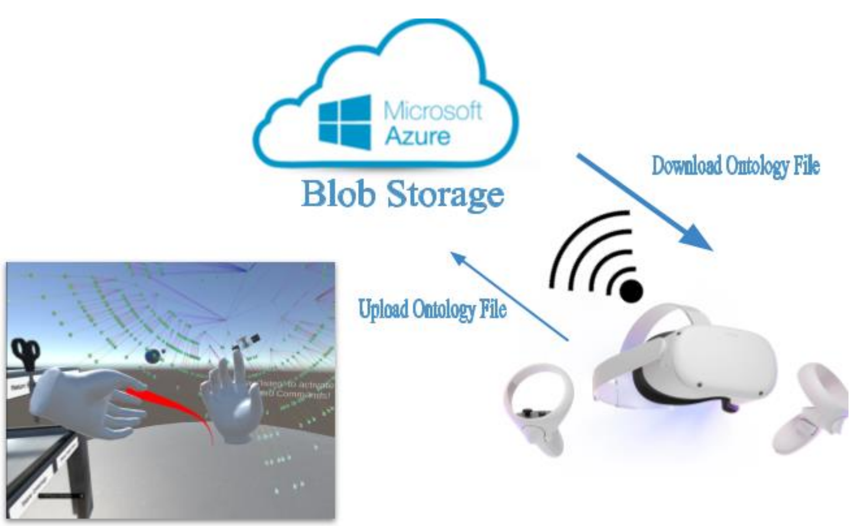


**Figure 1:** Blob Storage and Arc-Teleportation

# Porous Hydrogels As A Transducer Material In Microfluidic Electrochemical Cells

**Amina Anowara[1], Zhenglong Li[2], Sagnik Basuray[2]**
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Abstract: Electrochemical microfluidic sensors would allow for rapid detection of various diseases in a cost-effective, resource-efficient manner. However, the current design of the microfluidic devices includes a carbon nanotube (CNT) transducer that is sandwiched between non-planar microelectrodes. Development of these devices requires the CNT to be packed by hand, which introduces human error into the production of the devices. This decreases the reliability of the results from these sensors, which limits the use of electrochemical sensors in fields where sensor reliability is critical.

To improve the current microfluidic sensor design, an alternative transducer material is proposed. Use of hydrogels instead of CNT increases the degree of consistency with which each device is produced because it is possible to 3D-print the hydrogel into the device. To validate the use of hydrogels as a transducer, 2 criteria must be fulfilled: 1) it must have a porous microarchitecture that allows for the flow of biomolecules, and 2) it must be functionalizable. The methods used to develop the porous hydrogel and to functionalize the hydrogels to detect a desired target molecule are shown.

The porous hydrogel was developed by experimentally determining the concentration of porogen (calcium carbonate particles) that needed to be added in order to achieve a highly permeable structure. Porosity was qualitatively assessed using scanning electron microscopy, and a mass of 1g of $CaCO_3$ yielded desirable results. However, further work will be completed to achieve higher porosity by increasing the concentration of porogen. Ultraviolet radiation at a wavelength of 365 nm for 2 minutes, along with acid treatment using 2M hydrochloric acid to dissolve the porogen were used to arrive at the final transducer material.

Incorporation of either metal-organic frameworks (MOFs) or CNTs into the prepolymerized hydrogel solution are the next steps to functionalizing the hydrogel. It is expected that electrochemical impedance spectroscopy will confirm the device's selectivity and sensitivity. In conclusion, 3D-printed hydrogels are a viable transducer material, as it can be packed in an automated manner and is able to be functionalized. By attaching a probe onto the functionalized hydrogel, many diseases - from COVID-19 to breast cancer - can be detected using this device.

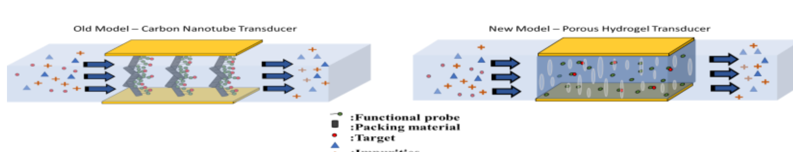


**Figure #1:** Graphic representation of the currently used model with a carbon nanotube transducer, in comparison to the new proposed model with a porous hydrogel transducer.

# Chemical Vapor Deposition as a Method of Synthesis for Titanium-carbide MXenes

**Shayna Gentiluomo[1], Advisor: Dr. Mengqiang (Mark) Zhao[2], Mentor: Mr. Joy Datta[3]**
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[2] Otto H. York Department of Chemical & Materials Engineering,
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Abstract: MXenes are a new family of two-dimensional carbides and nitrides that exhibit significant potential across a wide range of applications, particularly in energy storage systems. These materials are typically synthesized using a method that is difficult to scale and requires hydrofluoric acid, which is extremely toxic. Our goal is to synthesize Titanium-carbide based MXenes via chemical vapor deposition (CVD), which has the advantage of being much faster, greener, and more scalable. This new procedure, first outlined by researchers at the University of Chicago in 2023, offers a bottom-up method of directly growing Titanium-carbide MXenes based on CVD that does not require the etching step, is substantially less time-, energy-, and resource-intensive, and produces MXenes with unique structural features [1]. Here, I aim to achieve the CVD growth of Titanium-carbide MXenes in the lab. The reaction will be based on the CVD of C and Ti on a Ti foil protected by Ar and $H_2$, during which $CH_4$ will serve as the C source and $TiCl_4$ or $TiCl_3$ will serve as the Ti source. Preliminary results indicated that lamellar structures were successfully obtained, and further characterizations are needed to confirm their composition and atomic structures. In addition, when tuning the growth conditions to flow rates of Ar/$H_2$: 285 sccm, 15 sccm, Ar/$TiCl_4$: 120 sccm, $CH_4$: 0.05 sccm, under 950°C for 30 minutes, one-dimensional, vertically aligned carbon nanotubes were obtained on the Ti foil, which also have promising applications in energy storage applications like supercapacitors and batteries.

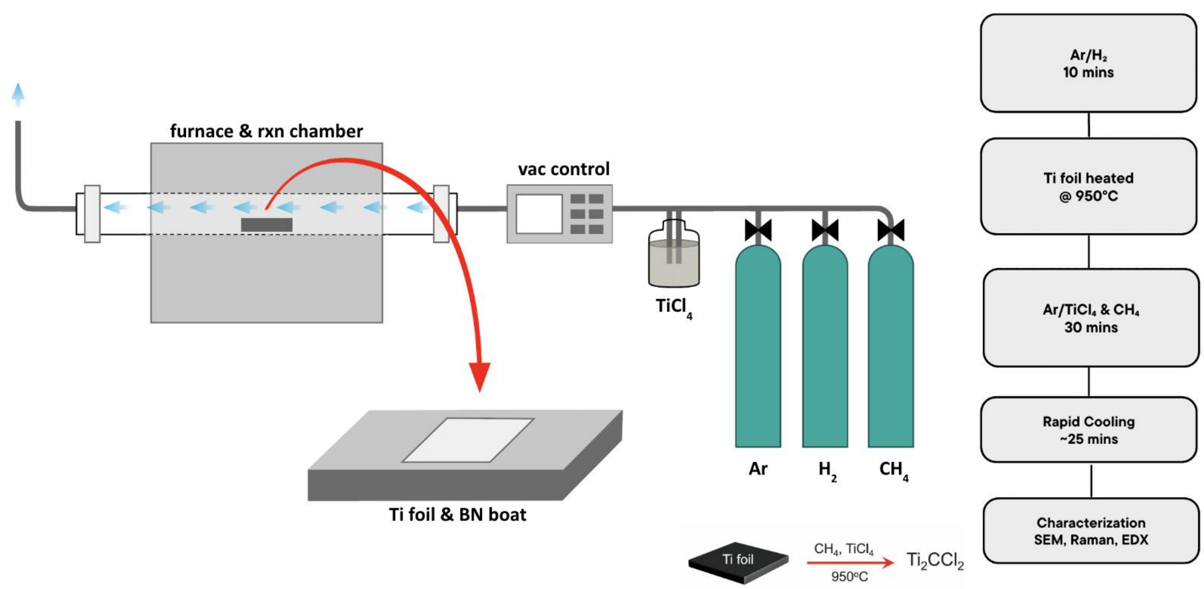


**Figure 1:** Schematic outlining CVD MXene synthesis procedure using $TiCl_4$ solution.

[1] Di Wang et al., Direct synthesis and chemical vapor deposition of 2D carbide and nitride MXenes. Science 379,1242-1247(2023). DOI: 10.1126/science.add9204.

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

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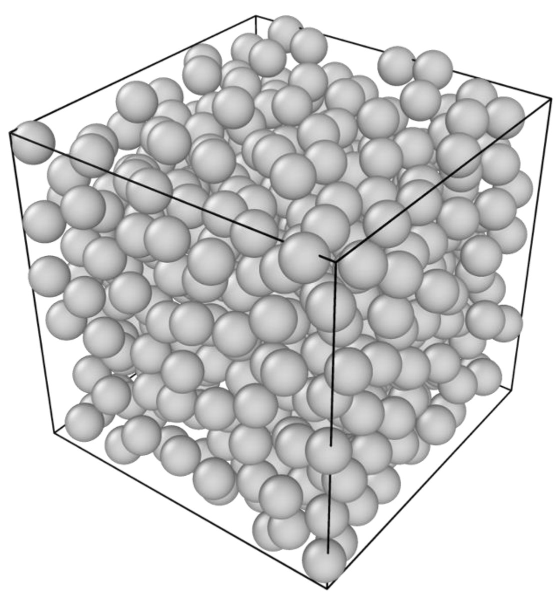
New Jersey Institute of Technology, Newark NJ07102

**Abstract:** 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.

# Computational models for liquid gallium

**Geordy Jomon, Advisor: Dr. Gennady Y. Gor, Mentor: Santiago A. Flores Roman**
Otto H. York Department of Chemical and Materials Engineering
New Jersey Institute of Technology, Newark NJ 07102

**Abstract**: Gallium is an anomalous metal, which makes it difficult to predict its thermodynamic properties. It is important to be able to predict the thermodynamic properties of liquid gallium, as it is the only metal that is both nontoxic and liquid at near room temperature. The thermodynamic properties of liquid gallium were predicted using computational models like equations of state and Molecular Dynamics simulations. The equation of state by *Li et al.* (Li EoS)[1] was found to be the most suitable; however, Li EoS failed to provide a quantitative result. Molecular Dynamics simulations were performed using LAMMPS[2] (Large-scale Atomic/ Molecular Massively Parallel Simulator). The accuracy of the simulations was verified by calculating the density and comparing it with experimental data[3]. An attempt was made to calculate the chemical potential of liquid gallium, but the results had large error bars. The large error bars are a result of short simulation with a small number of particles. For future work, a different software called Chainbuild[4] can be used which can reduce the simulation duration, which would allow running longer simulations reducing the error bars. Predicting chemical potentials is important because there is no experimental data, and it is required for research in adsorption and nanoporous materials.



# Simulation and Characterization of Oxide-based RRAMs

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

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Abstract: 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. Resistive Random Access Memory (RAM) devices play a crucial role among others. The present RAMs that are generally used are Static RAMs (SRAMs) & Dynamic RAMs (DRAMs). The problem with SRAM is its large size 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 oxide-based RRAM device performance using Silvaco simulation 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.

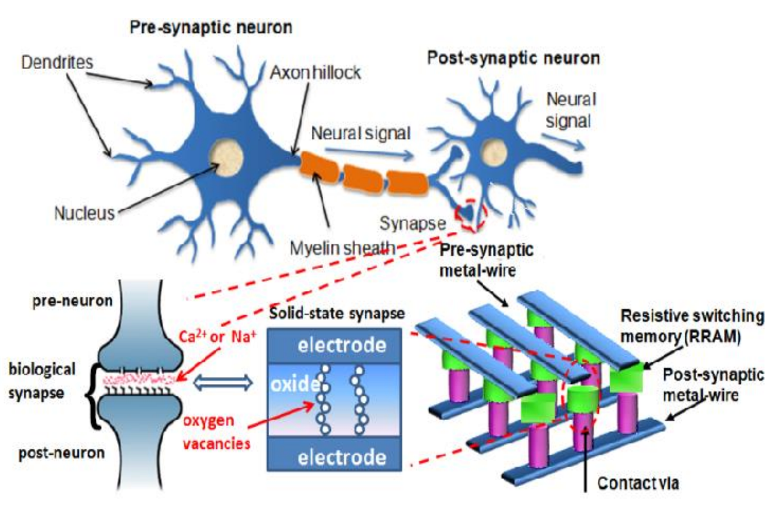


**Figure 1:** Diagram depicting the use of RRAM in Neuromorphic Computing

# Cell-Laden Composite Hydrogel Bioinks with Human Bone Allograft Particles to Enhance Stem Cell Osteogenesis

**Jeongtae Kim**

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Abstract: The demand for bone graft substitutes that closely resemble native bone tissue and enhance stem cell osteogenesis is growing. Composite hydrogels incorporating human bone allograft particles have demonstrated promising bioactivity. In this study, we introduce a novel photocurable composite hydrogel bioink for bone tissue engineering. Our bioink combines human allograft bone particles with methacrylated alginate to improve the osteogenesis of adult human mesenchymal stem cells (hMSCs). Rigorous rheology and printability assessments affirm the suitability of our composite bioinks for extrusion-based 3D bioprinting. Culturing hMSCs within bioprinted composite scaffolds results in significantly enhanced osteogenic differentiation compared to neat scaffolds, as evidenced by heightened alkaline phosphatase activity, calcium deposition, and osteocalcin expression.

The primary focus of this research is to identify the optimal bioink combination for printing human bone substitutes in future investigations. However, using Methacrylate alginate alone provides a limited ink quantity, sufficient for only 8-10 printings. Given the requirement for over 33 printings and a 10-day preparation time, multiple reaction cycles are necessary. We have successfully completed the fifth reaction cycle, providing a sufficient ink supply for experimentation. Our researchers are now prepared to conduct rheology tests and printability assessments. The study will explore combinations of 3%, 5%, and 7% alginate with 10%, 20%, and 30% hydroxyapatite (HA). To assess printability, an initial assessment using alginate alone will be performed to determine the ink combinations suitable for printing. Subsequently, rheology testing will be conducted to gather data, followed by a printing test utilizing a line test and grid pattern test (Figure 1). These experiments will help us identify the bio-ink with optimal printability, stability, and straightness. The findings from this research will contribute to advancements in 3D bio-printing technology and have potential applications in various fields, including healthcare.

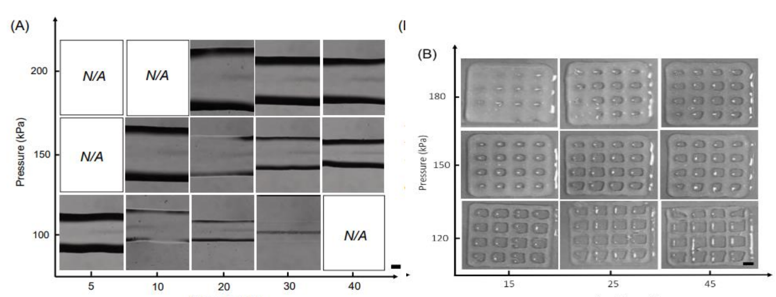



**Figure 1:** Example of printability test showing standard line test(A) and grid pattern test (B) results for a certain composite ink. Microscope images showing the 3D-printed lines

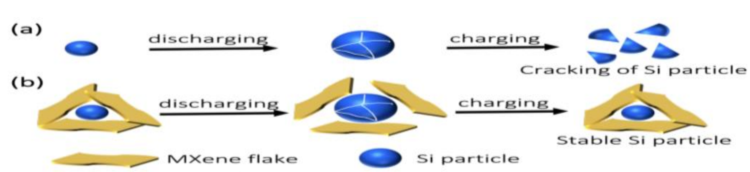
# Reuse of Si as Value-Added Anode Materials in Lithium-Ion Batteries based on MXene Confinement Effect

**Sebastian Mattio-Smith, Advisor: Dr. Mengqiang Zhao, Mentor: Dheeban Govindan**
Department of Chemical and Materials Engineering
New Jersey Institute of Technology, Newark NJ 07102.

Lithium-Ion Batteries (LiBs) have taken over the battery industry thanks to their high energy density, combined with fast charging and discharging times, and their comparably low maintenance requirements. Silicon anodes for Li-ion batteries are attractive because of the very high theoretical capacity of 4,200 mAh $g^{-1}$, which is 10 times more than traditional graphite alternatives [1]. In practice however, during charging and discharging, when Li+ ions move to the Si side of the cell, Si structure volume expands by almost 400%, leading to deformation and loss of stability. Just as a smartphone battery degrades over time - to the point that it can no longer hold a useful fraction of its potential charge - this loss of stability leads to poor maximum capacity even after one cycle of charging. To combat this, researchers at the New Jersey Institute of Technology propose to use 2D MXene flakes, a new family of two-dimensional carbides and nitrides whose favorable electrochemical properties make it ideal to confine Si nanoparticles during this process. Nanoscale Si batteries have shown to be more efficient than bulk Si powder batteries, maximizing surface area [2], and the addition of Si confinement is hypothesized to increase battery life considerably, allowing the second most abundant element in the earth's crust to be put towards energy storage applications at a competitive level.

Conscious of sustainability efforts in the energy industry, this study harvests Si material from end-of-life solar panels to minimize cost and open up more applications for solar panel recycling. Thus far, researchers are in the process of refining the procedure to harvest Si and the ball-milling process to get Si particles of appropriate size from said solar panels. In the future, this study will experiment with MXene sheets to confine particles to extend battery life and maintain maximum theoretical capacity.

**Figure 1.** Schematic showing that the 2D MXene confinement effect improves the cycling stability of Si anodes: (a) without and (b) with MXene confinement.



# Designing Metal Fuels for Custom Thermite Compositions

**Melissa Mello, Mirko Schoenitz, Kerri-lee Chintersingh, Edward Dreizin**

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Thermites are combinations of metal and oxide powders that, when ignited, exothermically react to release tremendous amounts of energy that can be used in welding, pyrotechnic, and military applications. Past work has explored thermites by altering the oxidizer, morphology, microstructure, or fuel to oxidizer ratio and typically used the traditional fuel of choice, aluminum. Recent research on combustion of various metals and the development of machine learning (ML) algorithms enables one to accelerate design of custom thermites. Materials can be customized to increase the rate of energy release, target specific temperature, generate specific gases, or have a gasless reaction. This customization can be achieved by combining thermite and intermetallic reactions, generating tunable mixing scale distributions of fuel and oxidizer, and exploiting distributions of particle sizes, shapes, and porosities. Here, the effect of the combination of metal fuels aluminum and zirconium is explored on the microstructure and reactivity of thermites with CuO and $TiO_2$ oxidizers. Composite thermite powders are formed by arrested reactive milling, a high-energy ball milling technique. Materials were characterized through SEM imaging to explore morphology and microstructure to aid establishing structure-function-performance relationships. Differential scanning calorimetry (DSC) is used to observe the low temperature reaction sequences and product phases that may be relevant to employ in the optimized ignition and combustion scenarios. Preliminary results show that in argon environments up to 1000ºC, samples with greater than 25 at% Zr have low temperature exothermic reactions likely due to the formation of aluminides prior to subsequent oxidation of aluminum. 1.5 mg of the prepared sample powders are ignited by a shockwave and plasma produced by a 25 kV electrostatic discharge. Ignition and combustion of the samples are recorded with a high-speed video camera with a 10x objective lens. Thermites containing $TiO_2$ had no observable ignition. Preliminary videos obtained from the ignition of the CuO samples indicate that the thermites containing Zr ignited faster than the pure 2Al-3CuO sample. Samples will also be ignited using electrically heated wire in air and using lasers. A 440-nm wavelength laser will ignite small pellets of the prepared thermites in a closed 17-mL chamber, operated from 1 to 760 torr. A $CO_2$ laser ignites similar samples in room air. Ignition delays, burn times, and pressure traces will be obtained for the laser-ignited samples. Emission produced by the flame will be explored spectroscopically. Condensed combustion products from ignition testing will be collected for characterization using X-Ray Diffraction. This work will continue to focus on tailoring thermite reactions by tuning metal fuel composition and microstructure. The key experimental data will be used by a ML algorithm to optimize the tunable material parameters and develop novel thermite formulations on demand.

# Complete Rheological Characterization of Concentrated Emulsions in Shear Flows

**Pia Piazzi, Advisor: Dr. David Venerus**
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Abstract: Yield stress materials, classified by their unique ability to transition between *solid-like* and *fluid-like* states, are best characterized by how they flow and deform under stress. The study of this flow behavior is termed rheology, and the rheological properties of yield stress materials play a major role in their functionality within various industries. Defined by the composition of two immiscible liquid phases typically stabilized with an amphiphilic surfactant, emulsions are a subgroup of yield stress fluids that display complex flow behavior. Past studies that have investigated the rheology of emulsions are either outdated, or fail to generate a *complete* characterization, that is, considering the normal stress differences created in shear flows. Since normal stresses are directly related to the function, storage, and transportation of yield stress fluids, measuring them in materials as prominent as emulsions is well justified. The emulsions tested in this study are made using a fractionated crystallization procedure which produces monodisperse droplets of the disperse phase, ensuring a highly controllable system ideal for rheological investigation. Future research will aim to measure the shear stresses and normal stresses of these monodisperse emulsions as a function of constant shear rate, in order to attain a deeper and wholistic understanding of the yielding of emulsions. The results generated may have the ability to impact how concentrated emulsions are utilized in essential products and processes.

# Manufacturing a State-of-the-Art Selector Valve for a Miniature Peptide Synthesizer

**Maryom Rahman**
**Mentor(s): Yu Hsuan Cheng, Alexandra Griffith**
**Advisor(s): Nellone Reid, Vivek Kumar, Sagnik Basuray**
Otto H. York Department of Chemical and Materials Engineering
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Abstract: Recent innovations in cancer research show that using peptide therapeutics can mitigate a variety of ailments. However, peptide synthesis is costly and produces large amounts of hazardous waste. Utilizing the core functions of a peptide synthesizer, a miniature model can be innovated to produce smaller peptides with less cost and waste. Additionally, a miniature peptide synthesizer would have point-of-use capabilities, increasing the efficiency and readiness to treat patients. Synthesis of peptides relies on five main steps: protection, deprotection, coupling, cleaving, and peptide formation. Synthesizers complete the first three steps. The amino acids are selected and attached to a solid polymer (usually a resin). From there, the amino acids are deprotected (unbonded) and then coupled (bonded) with the next amino acid in the sequence. Afterward, the chain is cleaved from the resin and undergoes dialysis, and then lyophilization. In the proposed novel design, the main functions of a peptide synthesizer can be scaled down to a miniature model to create smaller-scale peptides. The miniature peptide synthesizer consists of 4 main parts: the outer shell, two multi-selector valves, the reactor, and an electrical chamber. Innovations in the selector valves were made to improve upon this synthesizer design. Previous designs for the selector valve in the miniature peptide reactor have design issues, leading to leaks and poor flow control. In this iteration, a new state-of-the-art selector valve will be fabricated utilizing Fusion 360 computer-aided design (CAD) software and stereolithography (SLA) 3D printing. This design utilizes a ball piston and a spring to open and close access to the outlet chamber (Figure 1). A simple version of the selector valve has been implemented with one inlet and one outlet and is currently being tested for leaks over various solvents. A 3D model of the multi-selector valve, with 8 inlets and one outlet is currently being designed and implemented.

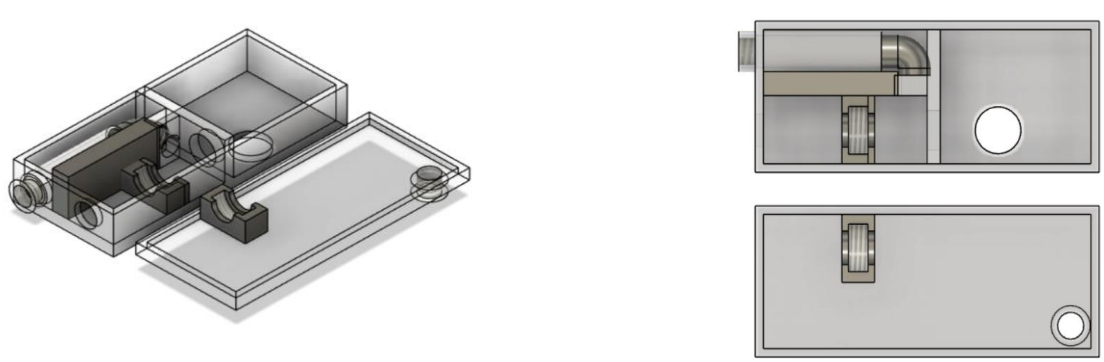

**Figure 1.** Depiction of the Fusion 360 model of a simple one-to-one selector valve.

# Novel MXene-Based Electrified Surface Coatings for Antiviral Air Filtration

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

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**Abstract:** 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.

# Fabrication of 2D TMDs based FET sensors for the detection of Per- and Polyfluoroalkyl Substances

**Ana Sierra-Maldonado[1], James Abraham[1]**
**and Mentors: Md Mohidul Alam Sabuj[2] & Mengqiang Zhao[2]**

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Per- and poly-fluoroalkyl substances (PFAS) significantly adversely affect the environment and human health. PFAS molecules can be found in many places, including water, air, and soil. Although there are ways to detect them, such as High-Performance Liquid Chromatography, Liquid Chromatography-Mass spectroscopy, and Gas Chromatography-Mass Spectroscopy, they are expensive, time-consuming, and inappropriate for continuous monitoring. In this project, we aimed to synthesize a Two-Dimensional Transition Metal Dichalcogenides (TMDs) based Field Effect Transistor (FET) that can detect PFAS molecules in water. Recently, FETs have emerged as a potential candidate for sensing applications due to their fast response, label-free detection, and inexpensive and portable nature. Molybdenum disulfide (MoS2) was used as channel materials in our FET devices, and an additional layer of hexagonal boron nitride (hBN) as an encapsulation layer on the source-drain gold electrodes (Fig.1A). MoS2 like other TMDs have excellent electronic properties, and sulfur is shown to be more reactive than other chalcogenides. The triangle structure of the MoS2 connects to the source and the drain of the device. The chemical vapor deposition (CVD) method synthesized MoS2 and hBN. We focused on synthesizing monolayer MoS2 triangles with high density (Fig.1B) and monolayer hBN. Different parameters such as sulfur to substrate distance, amount of sulfur, cleaning methods of our silicon wafer, and growth time for MoS2 were investigated for the successful synthesis of MoS2. High-resolution optical microscopy, Atomic force microscopy (AFM), and Raman spectroscopy were used to confirm their uniformity and monolayer thickness. Once obtained, the MoS2 and hBN were spin-coated with polymethyl methacrylate (PMMA) solution and transferred onto the device. Upon completion of the FET device, we will analyze its electronic properties. Finally, the device will be functionalized with a pyrene-based linker and different concentrations of PFAS solution will be used for detection (Fig.1C).

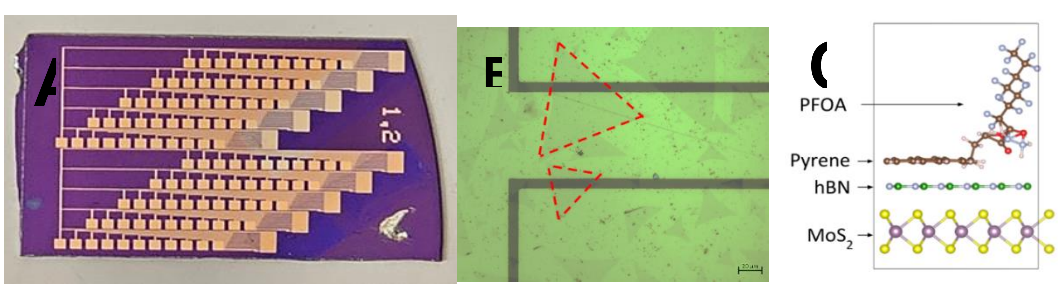


**Figure 1: A)** Completed $MoS_2$ FET device. **B)** Close up of $MoS_2$ FET device with triangular structure **C)** Chemical composition of FET device and interaction with PFOA

# Molecular Dynamics Simulations of Chemical Warfare Agent Surrogate Mixtures

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In order to create barriers against chemical warfare agents (CWAs), it is important to consider their behavior in the presence of water, as moisture is always present in air. Of these behaviors, the vapor-liquid equilibrium (VLE) is of particular importance. Experiments with CWAs are limited due to their extreme toxicity, however, for molecular simulations toxicity is not a concern, and so *in silico* experiments are an alternative to the real ones. In order to create accurate VLE models of CWA mixtures, a non-toxic surrogate resembling a CWA is considered first, so that a computational model can be verified by experimental data. In this study, dimethyl methylphosphonate (DMMP) will be used for this purpose. The aim of this study is to verify the model by reproducing data for DMMP-methanol, and then DMMP-water mixtures, such as density, viscosity, and excess volume. The models for DMMP mixtures will then be verified using pre-existing data from the literature. In the future, information collected in this study has a potential to impact the development of life-saving chemical protection for armed forces.

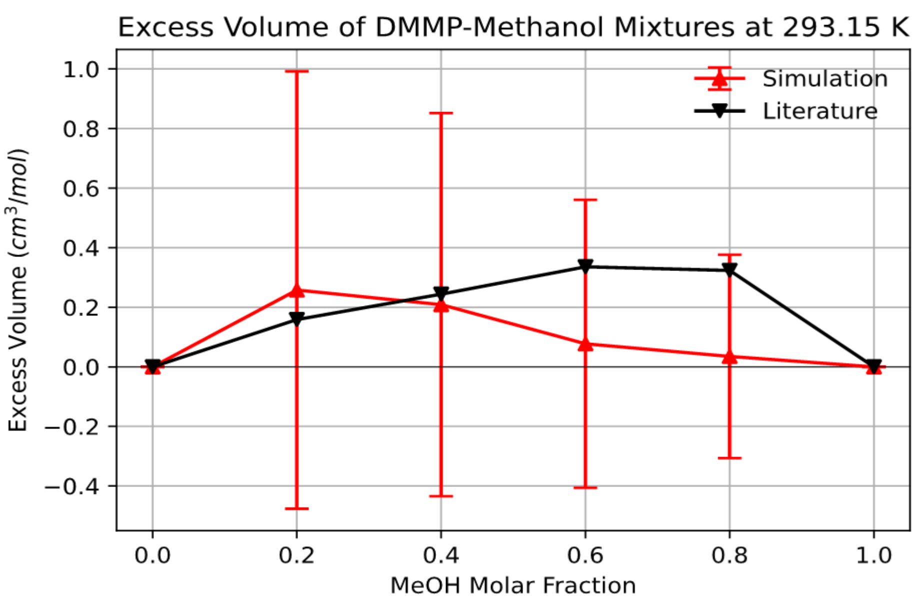


**Figure #:** Simulation prediction of excess volume of DMMP-methanol mixture

# Contact Angle Measurement of Diisopropyl Methyl Phosphonate A Surrogate For Sarin On Various Surfaces

**Manuel Tabares, Advisor: Dr. Dreyzin, and Mentor: Elif Irem Senyurt**
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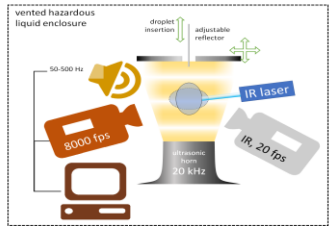
New Jersey Institute of Technology, Newark NJ 07102

Abstract:

Diisopropyl Methyl Phosphonate (DIMP) is a chemical surrogate for Sarin. Sarin is a lethal toxin that can be weaponized and used in chemical warfare. These chemical agents are known to be volatile and reactive substances. A deeper understanding of the chemical properties associated with DIMP is necessary to ensure the proper handling, and disposal, of the material. The surface energy of DIMP on various solid surfaces was examined, by method of contact angle measuring. Based on existing literature, there are many approaches to interpreting surface energetics. Contact angle measurement offers a simple way to obtain the angle formed by a static drop of liquid on a solid substrate. One technique involves goniometry, in which the eyepiece of a goniometer is placed at the three-phase boundary line of the droplet. The droplet itself can be introduced using a pipet or other volumetric device. Precaution must be taken to not disturb the droplet or the surface on which it resides. Researchers at NJIT have found this to be a least preferred method in obtaining contact angle data. An alternative strategy was employed using Axisymmetric Drop Shape Analysis – Profile (ADSA-P). Successive images of the droplet were taken using a high-resolution, high-definition camera: Chronos 2.1. The images are then processed using FIJI: ImageJ with a user developed plug-in. The plug-in is based on a point selection tool that generates a circular, and elliptical, fit that best approximates the profile of the droplet in the picture. From this, the program then processed the image and reported back values from which the observer can calculate the contact angle. The contact angle obtained can be used in future calculations for interfacial surface tension of the experimental liquid. There are many complexities associated with surface energy as it relates to contact angle data. The software used to process the images are developed by users. As it stands, there are no commercial products available that can readily measure the contact angle of a sessile droplet, accurately. While operating this software one may run into technical difficulties when manual selecting points for the theoretical fitting. The images must be clear and focused for the analysis to execute properly. Improvement is needed with respect to photo capture of the sessile drop. The stage on which the substrate rests should be level to ensure that the image can be processed correctly. Strict protocols may be necessary to provide accurate and meaningful contact angle data.

Figure 1: Schematic for levitator experimental setup




# 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**

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Abstract: 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.

# CHARACTERISATION OF RRAM DEVICES FOR NEUROMORPHIC COMPUTATIONS

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

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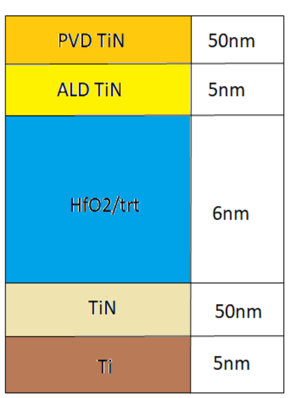
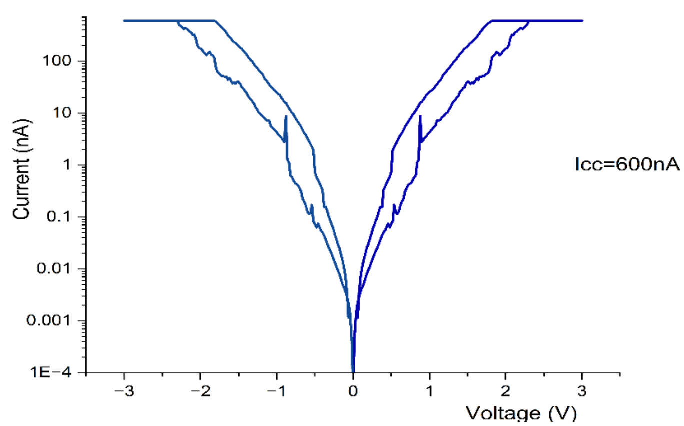
Research activities in the field of brain-inspired computation (also termed Neuromorphic Computation) have received a lot of importance in recent years. Resistive memory devices are considered best to show the biological synaptic characteristics at nanometre scale, because of the fact they offer the 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 analyzing 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.



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

**Sahil Molla[a], Advisor: Prof. Eon Soo Lee[b], Mentor: Yudong Wang[b]**
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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.

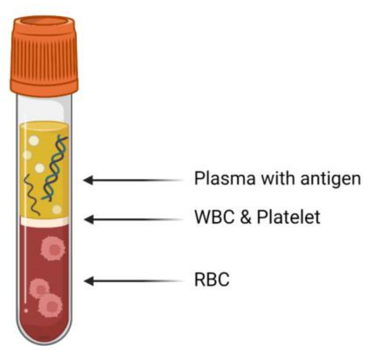


Fig. 1: Schematic drawing of blood components in the whole blood.

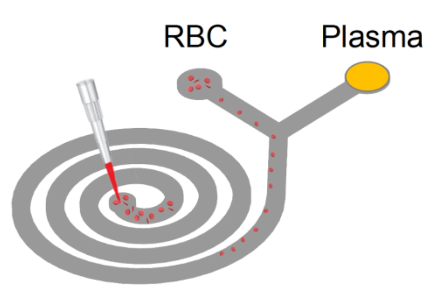


Fig. 2: Schematic drawing of the self-separation mechanisms in the spiral channel.

# 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**
Department of Electrical and Computer Engineering
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**Abstract:** 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

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

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Abstract: 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.

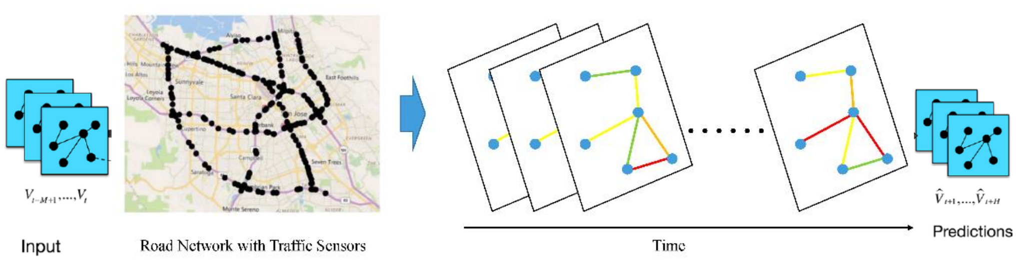


**Figure 1: A block diagram of the proposed framework**

# 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**
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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.

# The Effect of Deepfakes on College Students' Political Opinions

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Deepfakes are pictures, audios, or videos that have been manipulated using machine learning techniques to create realistic synthetic content. Deepfake technology is quickly becoming both very realistic and easily accessible to the average person. At the same time, political polarization, partially caused by radicalization through online content, is at a 50 year high. The past few years have shown the dramatic effects that misinformation spread online can have, specifically with topics such as claims of election fraud in the 2020 American presidential election and anti-vaccination conspiracy theories spread about the COVID-19 vaccination. Research studying the spread of misinformation and disinformation on social media has largely focused on more conventional methods, such as through text posts or traditionally edited images. Deepfakes present a novel vector for the spread of misinformation and as such have been a new focal point for research.

This project is an exploratory study on the impacts that deepfake video and audio can have on the political attitudes of college students. First, pre-existing deepfake content depicting former President Trump and current President Biden were gathered from the Internet, as well as unmanipulated speeches and press conferences. A survey was then created which collected demographic data (age, race, gender, etc) in addition to information about prior political attitudes and party affiliation. This information was collected using both explicit and implicit measures, in order to test if there were any subconscious changes in political attitude. Participants were shown both deepfake and unmanipulated content and asked to determine whether or not they were real. Their attitudes towards the Democratic and Republican parties as well as specific politicians were measured once again, both explicitly and implicitly. Some also participated in semi-structured interviews to discuss in greater detail how they felt they were affected by the content. This is an ongoing project, and it is expected that participants will struggle to distinguish between real and synthetic content. Additionally, they will show mild changes in political opinion.

# Enhancing Graph Features for Improved Roadway Speed Prediction Using GNN and LSTM with Vehicle-Connected Data

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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. These predictions could allow first responders to be prepared for a potential accident if the model suspects a drastic decrease in traffic speeds in a short period of time. We intend to improve the performance of spatio-temporal information through graph neural networks (GNN) and long-short-term memory (LSTM) architectures. Utilizing GNN will allow us to exploit the spatial features such as the road networks, while the LSTM will allow us to exploit the time-based data. 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 short-term traffic speed prediction accuracy.

# Simulating Patient Behavior with Machine Learning Algorithms: The Case of an Ottoman Mental Institution

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**Abstract**: Exploring the historical patient care practices in mental asylums, such as the Toptasi Asylum in the Ottoman Empire (1873-1924), offers valuable insights that can advance modern healthcare and medical practices. By analyzing patients' movements and behavior within a structured daily schedule, this research has the potential to advance knowledge in architecture, medicine, computer science, psychiatry, and other fields. While previous research focused on 3D modeling to study the history, architecture, and modeling daily routines of the asylum, this project seeks to visualize patients' behavior based on the severity of their symptoms. After extensive research and testing of various unique supervised learning algorithms, we chose the Random Forest classifier due to its high accuracy, low overfitting through majority votes, and automation of missing values of data. The model was trained to determine patients' levels of mobility, sociability, and impulsivity based on the severity of their symptoms. Through meticulous data wrangling, parameter tuning, and training, the achieved accuracy rates include mobility (73.91%), impulsivity (82.61%), and sociability (86.96%) with $\Delta=1$, using a 75-25 train-test split. The input data for the machine learning model consists of a JSON file containing various symptoms with corresponding severity indexes. To generate a large dataset of hypothetical patients' symptoms, we utilized generative AI. Through collaboration with psychiatric professionals, appropriate labels (indices) were given to these hypothetical patients. To integrate the existing Agent Based Modeling simulation in the SpatioScholar solution in Unity with the trained Random Forest Machine Learning Model, we developed and deployed an API. This gave the ability to provide appropriate indices after virtual patients were created in Unity through a JSON configuration file. These behavioral indicators were then incorporated into the simulation, resulting in patients with varying behavior. This project not only demonstrates the novel application of supervised learning to enhance a Unity simulation but also in its potential to impact the medical field, historical and contemporary alike. Future work may involve incorporating capabilities for a larger variety of symptoms and output indices for medical usage beyond mental health. These advancements have the potential to revolutionize the way simulations of medical facilities are developed and utilized.

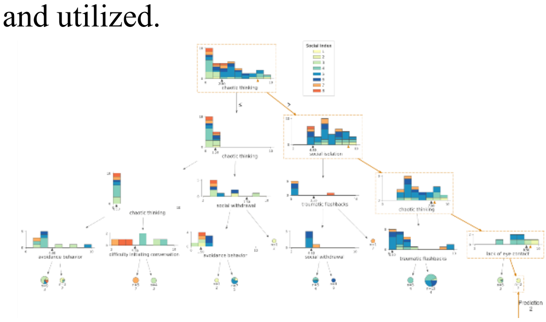

**Figure 1**: Sociability Decision Tree Prediction for Schizophrenia

# Improving Caption Data Diversity via Mood-Amplification for Audio-Language Tasks

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Abstract: Audio-language tasks such as audio-text retrieval and automated audio captioning have recently received significant attention. These technologies can make audio more accessible to d/Deaf and Hard-of-Hearing people and more amenable to text-based search. However, progress has been slower than for vision-language tasks due to the relative scarcity of audio-language data and the high data requirements of modern machine learning methods. To address the scarcity of high-quality audio-language data and thus improve audio-language models' performance, researchers have recently converted large audio-event-tag datasets into "synthetic" audio-caption datasets using large language models. However, there is much more information contained within audio than just audio events, such as the mood and emotion of the audio, or the relationship between audio events. This gap will be addressed by developing a data augmentation pipeline to generate new captions that encode additional information such as emotional, mood, or intensity descriptors into audio captions. Sentiment analysis machine learning models will be used to determine this information from raw audio clips, and following recent research, large language models will incorporate this information into natural language descriptions. The new data will then be used to train automated audio captioning models that will be evaluated across standard audio-language metrics. This research intends to facilitate new research in the audio-language space by using large language models to enhance audio captioning data with untapped audio information.

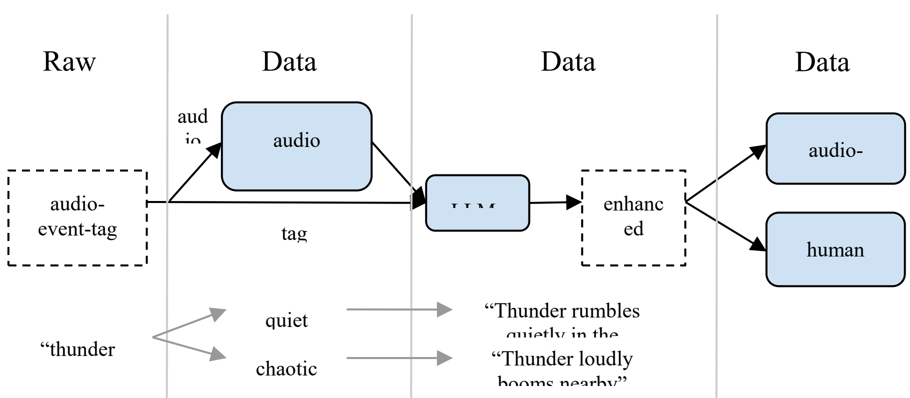


Figure: The proposed data augmentation pipeline. Data Extraction: collecting info about audio clips for use in ML models and using the model to predict emotion. Data Augmentation: using large language models to reformat caption data and include descriptive words to reflect predicted mood. Data Evaluation: training captioning models on new caption data and evaluating on standard metrics, and having humans evaluate captions for accuracy, naturalness, etc.

# Live SMPLX Model control and its applications in the Metaverse

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**Abstract**: 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.

# Real-Time Temperature Profile Forecasting in Metal Additive Manufacturing

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**Advisor: Dr. Bo Shen**

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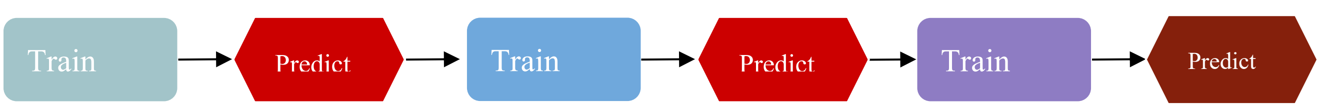
Direct Metal Deposition (DMD) has emerged as a highly popular and widely employed technique in the realm of additive manufacturing, specifically for the creation of intricate 3D printed metal objects. The fundamental principle behind DMD revolves around the focused application of a laser beam onto a substrate, thereby generating a molten pool. This pool then becomes the foundation into which powdered metal is meticulously deposited, layer by layer, to ultimately form the desired metal object. However, the temperature field that arises during the construction process of a DMD object plays a pivotal role in shaping crucial characteristics such as microstructure, porosity, and grain size, all of which significantly impact the quality of the final product.

In the context of this ongoing summer research project, a revolutionary approach has been devised that harnesses the power of machine learning models. The primary objective is to effectively segment and track the temperature profiles of the individual particles involved in the additive manufacturing process. Through a process of extensive training, the machine learning model has been sensitized to discern the intricate characteristics and patterns of the temperature signatures exhibited by the voxels within the molten pool. The innovative approach involves analyzing the heat signature of each voxel and scrutinizing its behavior across multiple timesteps. Additionally, by factoring in the spatial relationships between neighboring points, including their distances, temperatures, and respective timesteps, the iterative model is empowered to make accurate predictions regarding the temperature profiles of voxels that will be formed in future timesteps. This prediction capability is facilitated through the utilization of a decision tree learning algorithm, which leverages the collective knowledge amassed by the deep learning model during the training process.

Remarkably, the proposed model circumvents the need for extensive manual annotations by relying solely on initial manual annotations for training data. Once trained, the model can repeatedly predict the temperature profiles of voxels, thus making the subsequent surface analysis computationally inexpensive. Furthermore, the insights derived from the temperature data are employed to optimize the additive manufacturing process, thereby minimizing porosities and defects in the resulting 3D-printed surface. By merging the power of deep learning and additive manufacturing, this cutting-edge research endeavor not only streamlines the analysis of DMD surfaces but also paves the way for enhanced precision, efficiency, and overall quality in the production of 3D printed metal objects.



# Wall-Climbing Robotic System for Light and Shadow-Based Interaction Towards Human-Swarm Cooperation and Educational Outreach

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Most swarm robotics research focuses on developing autonomous behaviors solely in the context of robot-robot interaction, with few examples of human-swarm interaction. This contrasts with the depth of the research on Human-Robot Interaction (HRI) in the other domains of robotics. This limits the sort of applications for which, and environments within which, swarm robots can operate. Other key challenges in swarm robotics are the cost of hardware for HRI along with researchers managing floor space for physical Robot swarms. Our goal is to develop a wall-mounted robotic swarm that uses standard light projectors to dictate the swarm's behavior. To develop the algorithm that dictates the behavior of the swarm light sensors were used to collect RGB data from standard projectors. This data was then normalized, converted, and transformed to provide an approximation for a range of at least 5 colors. This transformation function would then be coded through Arduino software allowing the light sensors to distinguish what color it's perceiving. Behaviors would then be coded to be associated with what color is read on the light sensor. The robot's physical design will allow it to scale vertical walls that can be magnetized. The entire design consists of a steel chassis, one 30lb magnet, 2 steel O-ring wheels, two N20 motors, a PCB, a 3D print plastic housing, and a light sensor.

# Synthesis and Characterization of Ruthenium Based Photosensitizer Compounds

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Abstract: Climate change is a major issue in modern society. The burning of fossil fuels such as gasoline emits carbon dioxide, a greenhouse gas, into the atmosphere, contributing to the rise in global temperatures. There is a pressing need for alternative, renewable, and clean sources of energy to replace the consumption of fossil fuels. Artificial photosynthesis chemistry seeks to use solar energy in order to drive chemical reactions and generate clean energy sources. We were interested in developing photosensitizer compounds that can more efficiently absorb light in artificial photosynthesis systems. These compounds can ultimately be used in dye-sensitized photoelectrosynthesis cells to split water and reduce H+ to hydrogen fuel, a clean source of energy. Through a series of literature reactions, we synthesized the Ruthenium based compound cis-Ru(4,4'-$(PO_3Et_2)_2$bpy$)_2$Cl. We confirmed the accuracy of our synthesis through NMR spectroscopy. We then attached ligands of interest to this compound, hydrolyzed the product, and attached it to an indium doped tin oxide nanoparticle surface in order to run electrochemical tests on it. We have thus far used the ligand 1,10'-phenanthroline and plan to test other ligands, including 2,2'-bipyridine and 4,4'-difluoro-2,2'-bipyridine to discover their photosensitizing properties. We anticipate that certain ligands will prove to be more efficient than others at absorbing light for use in solar cells. We plan on obtaining further characterization data on these ligands of interest.

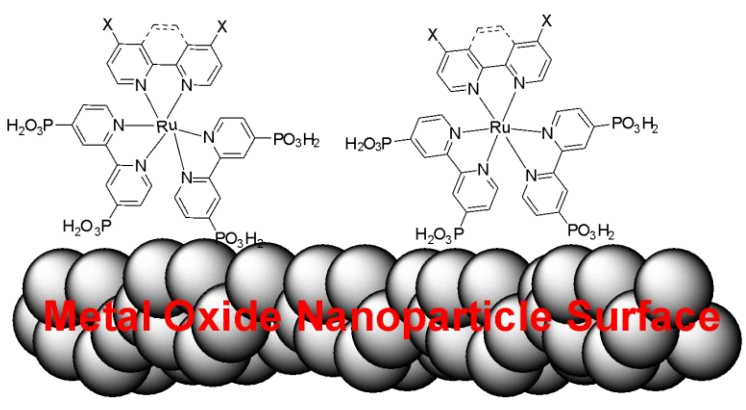


**Figure 1:** Model of binding Ru(4,4'-$(PO_3H_2)_2$bpy$)_2$L to a metal oxide nanoparticle surface in order to test how ligand variation changes reduction potentials, stability in the presence of light and stability towards electron transfer reactions

# Understanding the Impact of Solar, Magnetospheric, and Terrestrial Weather on the Ionosphere

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Abstract: The ionosphere, as the most significant source of plasma in the upper atmosphere, exhibits high daily variability. This variability is driven by solar Extreme UltraViolet (EUV) radiation, the magnetosphere, and Atmospheric Gravity Waves (AGWs). This study aims to understand the relative contributions of these forcing factors to ionospheric variations and their impact on various atmospheric parameters. The baseline variability of the ionosphere is established by solar radiation, with solar variability ranging from hours to years. Geomagnetic forcing from the magnetosphere, influenced by high-speed solar streams and intense geomagnetic storms, can cause day-to-day variability (DTDV) leading to complex processes such as plasma drifts, aurora formation, and the restructuring of the ionosphere. Extreme terrestrial weather generates lower atmospheric waves that extend upward, affecting neutral particles and disturbing ionospheric parameters. These disturbances are associated with events like tornadoes, thunderstorms, and hurricanes/typhoons. This research aims to investigate and compare these forcings with each other. To do so, ground-based observations from the Poker Flat Incoherent Scatter Radar in Alaska are utilized. The data analysis focuses on plasma velocity, density, and temperature (ion and electron) to quantify day-to-day ionospheric variability induced by lower-atmospheric waves, and both solar and geomagnetic conditions. By dividing the data into quiet and disturbed geomagnetic activity periods, the impact of magnetospheric forcing on DTDVs will be determined. Similar approaches will be used to understand solar and atmospheric forcing, and its effects on ionospheric variations. The implications of understanding ionospheric variations are far-reaching, including their impacts on communication systems, spacecraft lifespan, power infrastructure, and the safety of astronauts

# Role Of Granulosa Cells in Phthalates Toxicity

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Phthalates are a group of chemicals commonly used as plasticizers to enhance the flexibility and durability of many products. They were first introduced in the 1920s as additives to plastics and are nowadays widely produced. Their use is widespread in toys, medical tubing and devices, pharmaceuticals, cleaning products, and personal care products. Humans are constantly exposed to different types of phthalates through ingestion, inhalation, intravenous ingestion, and dermal absorption. Phthalates are readily absorbed in the human body and are quickly transformed into their metabolites, which interact with each other and with the body. They have been detected in mixtures in human urine, serum, and milk samples. Phthalates and their metabolites have been proven to be endocrine disrupting chemicals (EDCs), primary toxic agents in the body, and capable of disturbing fertility in males and females. Because the ovary is responsible for the production of sex steroid hormones(steroidogenesis) and fertility in females, it is important to expand our knowledge on the effects of these EDCs on the ovary to be readily able to look for solutions to remediate their consequences on female reproduction. This project focuses on determining the effect of phthalates on steroidogenesis enzymes (the enzymes responsible for converting cholesterol to essential sex steroid hormones). The research tested the hypothesis that phthalates and their metabolites target steroidogenesis enzymes in the ovarian cells. In this research, qPCR (which is a technology used to amplify and quantify specific sections of DNA by reverse transcribing cDNA, using primers) was performed using cDNA samples extracted from harvested granulosa cells from adult female CD-1 ovaries. These cells were previously cultured for four days in the presence of phthalate and metabolite mixtures. The treatments of the samples included DMSO (control), 0.1 µg/mL, 1 µg/mL, 10 µg/mL, and 100 µg/mL of phthalates mixtures and metabolites mixtures. The phthalate mixture consisted of 35% diethyl phthalate, 21% di(2-ethylhexyl) phthalate, 15% dibutyl phthalate, 15% diisononyl phthalate, 8% diisobutyl phthalate, and 5% benzyl butyl phthalate. The phthalate metabolite mixture consisted of 37% monoethyl phthalate, 19% mono(2-ethylhexyl) phthalate, 15% monobutyl phthalate, 10% monoisononyl phthalate, 10% monoisobutyl phthalate, and 8% monobenzyl phthalate. Obtaining and analyzing the gene expression data will enable scientists and researchers to expand their knowledge on the effects of phthalates mixtures and their metabolites mixtures on enzymes in granulosa cells, and the mechanism by which those EDCs disturb female reproduction.

# Computational Analysis of $N_8$ Stabilized Isolated Single Atom Catalysts for Electrochemical Reduction of $CO_2$

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The electrochemical carbon dioxide ($CO_2$) reduction reaction ($CO_2RR$) is an efficient technology that utilizes renewable electrical energy to remove $CO_2$ from the atmosphere and convert it to valuable hydrocarbons, addressing the demanding global challenges of renewable energy and environmental damages caused by $CO_2$ greenhouse gas emissions. However, since $CO_2$ is an extremely stable molecule with a C=O bonding energy of 750 $\frac{kJ}{mol}$, it is necessary to find stable cost-effective catalysts that spontaneously drive the reduction forward and get a high current density that provides high yields of the desired products. In this project, the focus is on a two-dimensional (2D) $N_8$ polynitrogen with various single metal atom catalysts (SMACs) attached to it. 2D materials are attractive due to their high surface area, electronic properties, and high reactivity.[1] SMACS demonstrate a bright future for $CO_2RR$ due to their low cost, unique structure and properties, and their high performance.[2] The objective is to analyze the $CO_2RR$ pathways of $CO_2$ to valuable hydrocarbons such as carbon monoxide (CO), formic acid (HCOOH), methanol ($CH_3OH$), and methane ($CH_4$) on each of these catalysts, aiming to achieve high reactivity and selectivity while lowering the overpotential of the reactions. Over this program, I analyzed the performance of the Pd metal atom catalyst on the reduction pathways by performing computational density functional theory (DFT) calculations on the NJIT supercomputing cluster Lochness, providing significant knowledge on the selectivity and efficiency of the mechanisms. The Avogadro platform was utilized to construct all the possible structures of the reaction intermediates and the atomic coordinates were put into the Orca software to perform full geometry optimizations to determine the most optimal stable arrangement of the atoms leading to the lowest energy intermediates. As the performance of SMACs mainly depends on the nature of the active metals and the coordination environment, computational analysis allows for easy alternation to run numerous tests which is very time consuming and costly to do experimentally. I found that on this catalyst, CO, HCOOH, and $CH_3OH$ can be efficiently produced, while $CH_4$ is highly unfavorable. Furthermore, I found that these reactions proceed better under acidic conditions than basic conditions. Determining the major reaction intermediates provides an understanding of the mechanisms and prediction of excellent catalysts for the $CO_2RR$, which may be used as guidance for experimental design and synthesis to help overcome the challenges of climate change. For future work, I will be investigating the transition states, solvation effects, and applied voltage on the reduction pathways. I will also be testing different SMACs such as Ni, Co, Cr, Fe, and Mn aiming for a high-performance catalyst that is cheaper than Pd

# Space-Time-Studio: Interdisciplinary Collaboration in Studio Between Industrial Designers and Engineers

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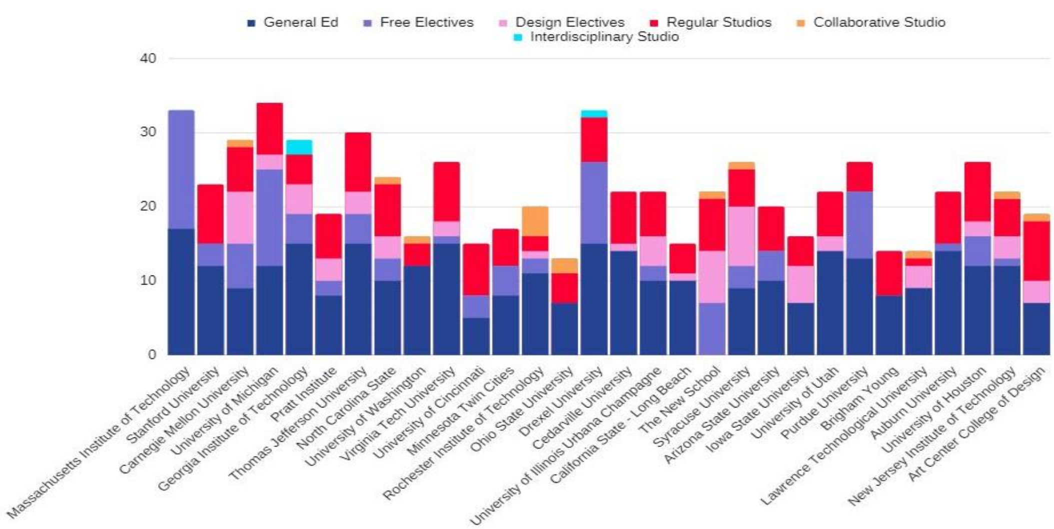
Abstract: The studio is a fundamental aspect of every industrial designer's education, a pedagogical model dating back to the Bauhaus School of the 1920s with only modern adjustments made for technological advances. More recently, some institutes of higher education have explored innovative ways of teaching design, but most of this research focuses on specific case studies such as an interdisciplinary program or an engineering minor created to benefit design majors. This project adds to the growing body of research by examining contemporary industrial design undergraduate programs across the United States and comparing their curricula and design pedagogy. This project gauges interdisciplinarity between industrial designers and engineers in forty of the seventy-five programs by collecting information from program websites and catalogs into a spreadsheet before qualitatively analyzing and coding this data descriptively and virtually. This database of information is part of an ongoing research venture exploring innovation in design education.

Figure 1: Curriculum breakdown of Industrial Design programs



# Sunquakes and Extreme Ultraviolet (EUV) Waves

**Robert Bush, Tufts University**

**Mentors: Dr. Alexander Kosovichev, Dr. John Stefan**

**Department of Physics, New Jersey Institute of Technology, Newark NJ 07102**

Helioseismic events on the solar surface, sunquakes, are triggered by the energy and momentum deposited by particles accelerated during a solar flare. Extreme Ultraviolet (EUV) waves are large-scale disturbances propagating in the corona that are also associated with solar flares and coronal mass ejections (CMEs). Recent models, for example Figure 1, suggest that sunquakes and EUV waves can be excited together by a solar flare. In our study, we attempt to develop a better understanding of how energy is released and re-distributed during a flare using various catalogs of sunquakes, EUV waves, and CMEs. Statistical analyses of this data and its characteristics (i.e., impact area, wave speed) were performed to find trends between sunquakes and EUV waves; events with both an EUV wave and a sunquake were considered "common events."

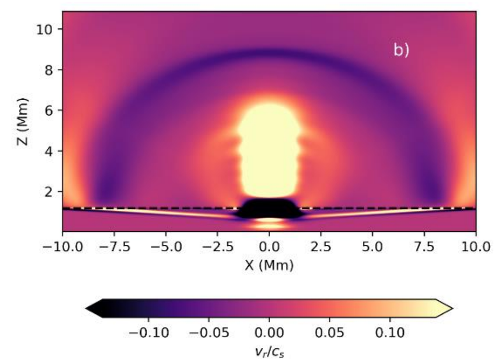



**Figure 1**: The semicircle propagating outwards is an example of a EUV wave, with the bright source being a solar flare and the small ripples close to it a sunquake, strongly supporting a relationship between the two events.

Using this preliminary method to create histograms of the data, it was found that the common events were associated with lower power sunquakes and had smaller impact areas. More recently, we also investigated the relationship of CMEs (coronal mass ejections), which are clouds of ionized particles ejected from the Sun, to the generation of EUV waves. This revealed that EUV waves excited without a CME (which is unexplained by current theories) had slower speeds and likely came from a different source.

We now speculate the smaller impact areas are possibly linked to EUV waves by reducing the amount of energy that reaches the solar surface in a sunquake, meaning lower power sunquakes can be associated with EUV waves since some flare energy is concentrated into these coronal waves. We will be working on finding ways to compare lost flare energy with sunquake power and EUV waves during common events; however, we first need to expand our EUV wave speed catalog from 2013-2022 by creating several time-distance diagrams of each wave event in different solar sectors and calculating their slopes. This will allow us to expand our common events list and test speculated patterns by making histograms with more data.

# Investigation of Electrochemical Degradation of PFOA Using High Surface Area Electrodes

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Per- and poly-fluoroalkyl substances (PFAS) are industrially common chemicals that are persistent in the environment and toxic to humans. Various degradation processes such as chemical, thermal, photochemical, and electrochemical oxidation methods have been used to degrade perfluorooctanoic acid (PFOA) with the electrooxidation process being the most simple and efficient. Anodic materials play a pivotal role in the electrooxidation of PFOA due to their ability to generate $H_2O_2$, a strong oxidant, as well as reactive intermediate species like $Cl^•$, $O_2^{•-}$, $SO_4^{•-}$, $HO^•$ ($E^0$ = 2.5 V), $S_2O_8^{2-}$ ($E^0$ = 2.0 V) and $ClO^-$ ($E^0$ = 1.6 V) in presence of aqueous electrolytes like KCl, $Na_2SO_4$ and $KNO_3$. Commonly used electrodes include boron-doped diamond, Pt, Ti/$SnO_2$, dimensionally stable anode, and graphene for efficient degradation of PFOA. However, several shortcomings like expensive production cost, low conversion yield, and short lifetime prevent their large-scale application. In this study, several commercially available high surface area electrodes (Ti fiber, Ti/Pt fiber, RVC) and electrolytes (KCl, $Na_2SO_4$, $KNO_3$) were screened to investigate the effect of surface area and electrolytes on PFOA degradation. Desalting paper spray mass spectrometry (DPS-MS), a fast PFAS detection method was used to monitor degradation products to better understand the PFOA degradation mechanisms. Our results suggest that RVC electrode with KCl and $KNO_3$ electrolytes are most efficient at degrading PFOA. DPS-MS data showed the highest estimated PFOA degradation yield using KCl while $KNO_3$ resulted in the formation of more carboxylic acid, alcohol products, and radical intermediates. Many of the intermediate compounds detected correspond to a chain-shortening degradation mechanism of PFOA where the carboxylic acid headgroup is oxidized, causing the release of carbon dioxide and the subsequent removal of HF. However, further work needs to be done to improve PFOA degradation yield, PFOA quantification, PFOA intermediate detection. This can include considering other high-surface electrodes like multiwalled carbon nanotube (MWCNT) modified electrodes for better degradation or adding an internal standard into the DPS-MS method for better quantification.

**Table #1:** (A)PFOA degradation yield and (B) products found in RVC-mediated degradation with varying electrolytes.

A)

| Electrode | Electrolyte | PFOA Intensity Pre-Degradation | Average PFOA Intensity Post-Degradation | PFOA Absorption by Electrode | Estimated Degradation Yield (%) |
|---|---|---|---|---|---|
| Ti Fiber | KCl | 1.06E+07 | 3.70E+06 | - | 65.1 |
| Ti/Pt Fiber | KCl | 1.66E+07 | 7.16E+06 | - | 56.8 |
| RVC | KCl | 1.66E+07 | 2.06E+06 | 6.74E+05 | 87.6 |
| RVC | $Na_2SO_4$ | 7.45E+07 | 4.32E+07 | 1.70E+06 | 39.7 |
| RVC | $KNO_2$ | 4.41E+07 | 5.23E+06 | 1.25E+06 | 85.3 |

B)

| Degradation Products (KCl) | Theoretical m/z | Measured m/z | Error (ppm) | Intensity | Mechanism |
|---|---|---|---|---|---|
| $C_6F_{13}$ | 318.97979 | 318.97989 | 0.313499485 | 4.82E+05 | Unknown |
| $C_3F_7COF$ | 215.98269 | 215.98305 | 1.666800242 | 1.06E+04 | Chain-shortening |
| $C_4F_5$ | 142.99256 | 142.99218 | -2.657480921 | 2.41E+05 | Unknown |
| **Degradation Products ($Na_2SO_4$)** | **Theoretical m/z** | **Measured m/z** | **Error (ppm)** | **Intensity** | **Mechanism** |
| $C_4F_5$ | 142.99256 | 142.99223 | -2.307812378 | 2.41E+05 | Unknown |
| **Degradation Products ($KNO_2$)** | **Theoretical m/z** | **Measured m/z** | **Error (ppm)** | **Intensity** | **Mechanism** |
| $C_7F_{15}OH$ | 384.97151 | 384.97083 | -1.766364477 | 1.60E+03 | Chain-shortening |
| $C_6F_{13}OH$ | 334.9747 | 334.97413 | -1.701621048 | 9.90E+02 | Chain-shortening |
| $C_3F_7COOH$ | 212.9792 | 212.97884 | -1.690305908 | 1.37E+03 | Chain-shortening |
| $C_3F_7OH$ | 184.98429 | 184.98484 | 2.973225456 | 9.61E+03 | Chain-shortening |
| $C_2F_5COOH$ | 162.98239 | 162.98175 | -3.926804608 | 4.65E+03 | Chain-shortening |
| $C_7F_{13}COOH$ | 374.96962 | 374.96981 | 0.506707717 | 1.88E+03 | Unknown |
| $C_3F_5O$ | 146.98748 | 146.98199 | -37.35011989 | 2.11E+05 | Unknown |
| $C_3F_5$ | 130.99256 | 130.99191 | -4.962113879 | 1.85E+05 | Unknown |
| $C_4F_7$ | 180.98937 | 180.99001 | 3.536119276 | 1.40E+04 | Unknown |
| $C_4F_5$ | 142.99256 | 142.99195 | -4.265956215 | 5.50E+04 | Unknown |

# Analysis of Environmental Dependance of the HODI Instrument Calibrations

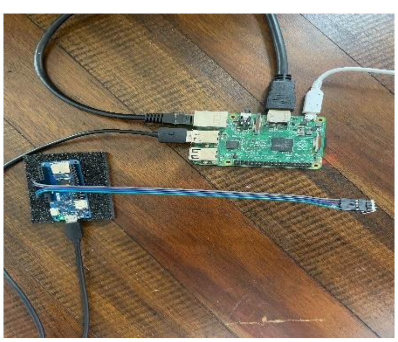
**Austin Dalton, Hyomin Kim, Matthew Cooper**

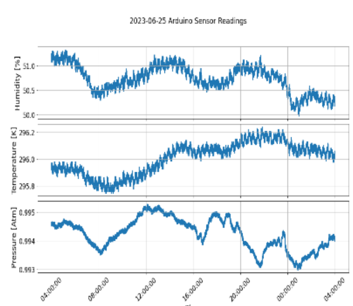
Physics Department, Center for Solar-Terrestrial Research, Institute for Space Weather Science

New Jersey Institute of Technology, Newark NJ 07102

Funding provided by PSEG for NJIT's Undergraduate Research and Innovation Program

The commercialization of the Space Age has led to an economic need for real-time as well a predictive understanding of the upper atmosphere, specifically in the low-Earth orbit (LEO) region where most mega-constellations are planning to be deployed. Satellite monitoring of this region is expensive, thus ground-based instrumentation is used more frequently. This instrumentation is highly sensitive, and precise climate control systems can increase cost significantly. The goal of this project is to avoid this cost increase by the creation of a low-cost (~$250) room environment sensor suite which can track the changes in the observatory environment where the high-sensitivity instrument is housed and in turn reduce the uncertainty of its upper atmospheric measurements. This sensor suite tracks changes in the humidity, temperature, and ambient pressure of the area immediately surrounding the high sensitivity system. Changes in these variables introduce uncertainties in measurements taken of the LEO environment which are not representative of what the satellites experience. This summer's URI has entailed the construction and testing of the low-cost sensor suite which utilizes a Raspberry Pi miniature computer for gathering data and sending it to the control computer so the high-grade instrumentation can incorporate it into the measurement corrections. Arduino microcontrollers are used to run the sensor firmware and send the serial sensor outputs to the Raspberry Pi. This suite has been deployed to test environments to determine if it is producing reasonable results. It will soon be sent to an observatory which has active LEO monitoring equipment to begin incorporation into the control computer's software infrastructure.





# Investigation of the Relationship Between Mini-Filament Eruptions, Small-Scale Magnetic Flux Ropes, and Coronal Ejections, and Their Distribution in Relation to Coronal Holes

**Annalyse Dickinson**
Ursinus College, Collegeville PA 19426
**Mentor: Haimin Wang**
**Co-Mentor: Nengyi Huang**
Department of Physics
New Jersey Institute of Technology, Newark NJ 07102

Abstract: Large solar eruptive events have been extensively studied because their significant impact leads to easier detection. Solar filament eruptions and magnetic flux ropes are a good proxy for one another on this large scale, however, it remains uncertain if and in what way the numerous and ubiquitous small-scale transient events—mini-filament eruptions (MFEs) and coronal ejections (CEs), and the possibly resulting small-scale magnetic flux ropes (SMFRs) detected in the solar wind—correlate, and how they propel solar wind and solar surface processes, leading to their potential impact on Earth. I use datasets of events collected during Parker Solar Probe's (PSP) Encounter 5: full disk Hα blue-wing images from Big Bear Solar Observatory's (BBSO) Goode Solar Telescope (GST), and extreme ultraviolet images from the Atmospheric Imaging Assembly (AIA) to observe MFEs in the upper chromosphere and CEs in the corona, respectively. I examine spatial and temporal correspondence between these MFEs and CEs and define conditional thresholds in which correlated events can be identified. I also aim to discover the spatial distribution of events in relation to coronal holes; their open magnetic field facilitates internal events to escape the atmosphere and impact the solar wind in heliospace.

# Blockchain Technology and its Applications in Plastic Recycling Industry Supply Chain

Nikita Dubinin, **Junmin (Jim) Shi**
Martin Tuchman School of Management
New Jersey Institute of Technology, Newark NJ 07102

Plastic waste management has been costly and inefficient, with plastic recycling rates dropping to around 5-6% in 2022, plastic production is only increasing and is expected to triple by 2050. Blockchain technology is providing leverage and improvements in many sectors such as financial institutions, government services and an ever-emerging digital currency market, while its application in plastic recycling hasn't been fully utilized. The objective of this research was to address some of the current problems in the plastic recycling industry that could be solved with the use of blockchain technology that would allow for a secure, easily traceable, and greener solution than dumping. This research was based on data analysis, reports and recent findings on plastic recycling as well as current applications of blockchain technology improvements. Some of the recurring problems is that plastic is hard to identify and sort accordingly. Plastic recycling companies could implement blockchain and build around it as a foundation. This could solve the identification problems since blockchain would provide traceability of material. As of recently, BASF, a company in Canada has been implementing blockchain technology to extend life cycles of plastics by using a physical tracer for identification. If implemented in plastic recycling companies in the USA, it would allow for a transparent supply chain in which less product will need to be replaced and instead reused. Thus, increasing the revenue while still making a greener choice. At the moment, plastic recycling still has been a problem to tackle as well as finding a way to reach more of the general public to recycle. Some other benefits found of implementing a blockchain system is that a company would be able to exchange plastic for digital currency, thus providing an incentive for recycling. Further work can be done on how blockchain technologies will improve the plastic recycling industry supply chain within the financials as well as sourcing from consumers.

# Reversible Adsorption of Oxidized Atmospheric Mercury for Its Quantitative Chemically-Resolved Analysis

**Joel Duzha, Advisor: Dr. Alexei Khalizov**

Department of Chemistry and Environmental Science

New Jersey Institute of Technology, Newark NJ 07102

After its release into the atmosphere from coal combustion and waste incineration, atmospheric elemental mercury Hg(0) homogeneously mixes within the atmosphere due to its long atmospheric lifetime, making the emissions not only a regional but a global problem. Through photochemical reactions with atomic bromine, Hg(0) is oxidized to Hg(II), allowing it to be deposited on land and oceans through wet and dry deposition, where bacteria convert it into methylmercury. This highly potent neurotoxin can enter the food chain and bioaccumulate, causing harm to all organisms in these environments, including humans. Understanding the chemical identity of Hg(II) is crucial because it determines how quickly Hg(II) is transported in the environment and the impact it will have on the organisms. Current methods of preconcentrating and analyzing atmospheric Hg(II) result in a loss of information about its chemical identity. Membranes are used for Hg(II) pre-concentration, but when different mercury species are collected on the membrane, they may react with one another or with other atmospheric constituents such as chloride ions, thus losing their original chemical speciation. The goal of this project is to develop a procedure to quantify the effectiveness of different membranes and membrane treatments for reversible mercury adsorption using ion drift−chemical ionization mass spectrometry (ID-CIMS). We will identify a membrane that allows Hg(II) to be adsorbed and released without altering its chemical identity. In doing so, we will improve analytical detection methods helping to advance field measurements and predictions of Hg(II) transport, deposition, and bioaccumulation.

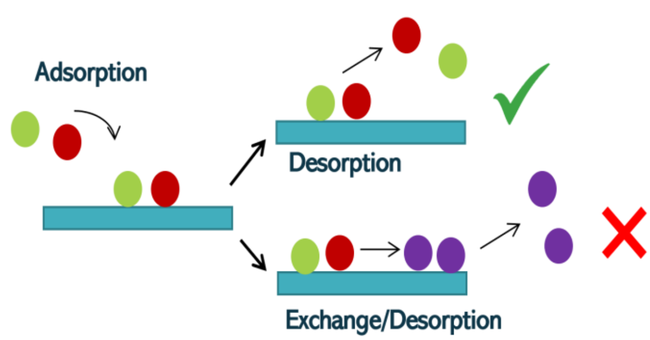
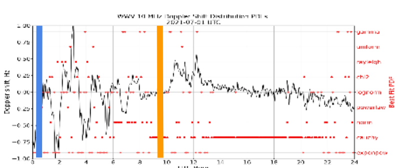



**Figure 1:** The optimal membrane should be able to not only adsorb gaseous oxidized mercury, but also release it upon gentle heating

# An analysis of doppler residuals on a high frequency radio link between Colorado and New Jersey

**Sabastian Fernandes, Mentor: Dr. Gareth Perry**
Department of Physics
Center for Solar-Terrestrial Research
New Jersey Institute of Technology, Newark NJ 07102

**Abstract:** High frequency (HF; 3-30 MHz) skywave signals are used for long-range aviation, military, government, and weather station communications across the globe. The HF spectrum also spans the frequencies used for remote sensing of the near-Earth plasma environment. Fluctuations in the ionosphere's total electron content and electron density have been studied by means of measuring the Doppler shift of HF signals, caused by their interactions with the ionosphere, as exemplified in Figure 1. Monitoring these Doppler residuals provides insight into the level of geomagnetic activity caused by the coupled Sun-Earth plasma environment. This study analyzes the long-term trends of one such continuously sampled HF signal: a tower beacon (callsign WWV) broadcasting at 10 MHz, located in Fort Collins, CO. The signal is received by an antenna (callsign K2MFF) at the New Jersey Institute of Technology in Newark, NJ. The received signal is processed by the connected Grape V1 SDR (Software Defined Receiver). The Grape SDR samples the collected frequency once per second, and then organizes the data into a tabulated format. The difference between the received signal and the expected 10 MHz transmitted frequency can then be plotted as a function of time, as shown by the black line in Figure 2. One can identify that HF Doppler variations received during the daytime are more stable than those received during the nighttime. This night-day contrast is consistent across almost all 24-hour cycles, barring dates of antenna maintenance or severe solar storms. In order to identify the proper statistics regime to use when further characterizing this data, samples taken over the course of each day were subdivided into 5-minute intervals, and then individually fit to common probability distribution functions. Results indicate a strong correlation between daytime measurements and Cauchy statistics, and between nighttime measurements and a mixture of exponential power / lognormal statistics. Further analysis of this data will include a correlative study on the physical mechanisms which govern these periodically differing distributions.



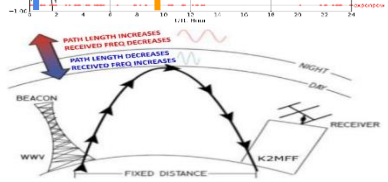



**Figure 1:** A diagram representing the path which the 10 MHz signal travels from the WWV beacon in Fort Collins, CO to the K2MFF receiver at the New Jersey Institute of Technology in Newark, NJ. The ionosphere's exposure to sunlight during sunrise is associated with a blueshift for HF signals, and vice versa (redshift) for sunset.

**Figure 2:** A graph which overlays the collected Dop with a red marker identifying the statistical probabili function that best fits the data within the local 5-minute frequency samples). The blue vertical line marks the sunset in Newark, NJ, and the orange vertical line marks for sunrise.

# Monitoring Water Conductivity from Vehicle Splash and Spray to Optimize Road Salt Use

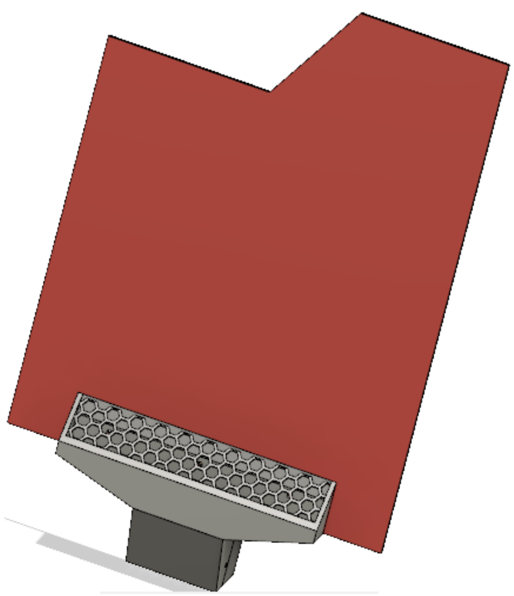
**Joel Florim, Advisor: William Pennock**

Department of Civil and Environmental Engineering

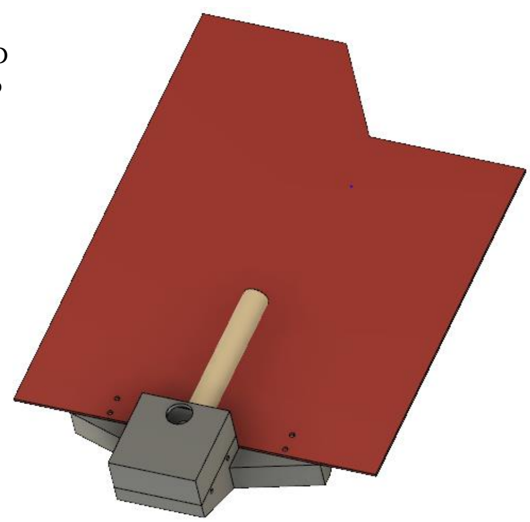
New Jersey Institute of Technology, Newark NJ 07102

Abstract: Every year during the winter season, the north eastern part of the United States resorts to applying road salts on roadways to melt snow and ice. Road salt is damaging to vehicles and transportation infrastructure by causing corrosion to exposed metals. The salt also affects the environment by contaminating drinking water and polluting crops. The amount of salt used on roadways must be optimized so that these negative effects can be minimized. One solution is to monitor the amount of salt that is already on the road in real time by constructing a vehicle-mounted conductivity sensor. As the truck drives over a wet surface, the tires pick up some of that liquid and ejects it into the air, in an effect known as "vehicle splash and spray". Mudflaps are used to suppress this effect by baffling the water and directing it to flow to the ground. By modifying the mudflap to instead capture this liquid, one can then direct the fluid to a conductivity sensor to monitor the quantity of salt in that liquid and hence the amount of salt on the road. This measurement can be used for salt truck operators to make decisions on the correct amount of salt to apply on roads. This summer, the project's aim is to create the design of a container to be attached with a sensor and mounted on the mudflap of a truck. The container is 3D printed using PETG filament to provide a rigid system for the sensor to be enclosed.

Figure 1 Image of Collection with



and 2: 3D Mudflap Design Sensor



**Algae Separation Using Recoverable Magnetic Particles**

Oluwanifemi Fuwa: Dr Wen Zhang, and Mentor: Lili Li, Ph.D. Student

Department Of Civil and Environmental Engineering
New Jersey Institute of Technology, Newark NJ 07102

A large outbreak of harmful algal blooms (HABs) has led to a detrimental effect on the environment, ecosystems, aquatic creatures, and human health. Harmful algal blooms (HABs) are photosynthetic eukaryotic organisms. These harmful algal blooms tend to occupy a lot of nutrient-enriched waters. The nutrient in these waters creates an outstanding proliferation of algae. When algae stay in the water for a longer period, they start to decompose and become detrimental to the health of humans and animals. To address this issue, this project proposes a sustainable and environmental technique for algae removal through magnetophoretic separation of recoverable magnetic particles. To overcome the poor quality of water, the separation of algae in water will be impactful. Some other traditional techniques such as centrifugation, sedimentation, flotation, membrane filtration, and coagulation-flotation can be used to separate algae. Methods such as synthesizing magnetic nanoparticles while using co-precipitation, conducting magnetic particle encapsulation, measuring the zeta potential of each magnetic particle, and cultivation of the microalgae were conducted in the laboratory. The project also involves the removal performance of different surface-coated magnetic particles, the reaction mechanism between magnetic particles and algal cells, and the recovery of particles using alternating strong and weak magnetic fields. The results of this project may help us to have a more comprehensive understanding of magnetophoretic separation and pave the way for the sustainable prevention and control of harmful algal blooms

# Studying the Effects of Cholera on the Mentally Ill in the Ottoman Empire

**Saketh Golla, Advisor: Dr. Ozludil**

Department of Computer Science, Albert Dorman Honors College

New Jersey Institute of Technology, Newark, NJ 07102 USA

**Abstract:** The effects of cholera outbreaks on the functioning of Ottoman medical facilities, specifically mental institutions, are not well-defined. However, they had dramatic effects on the lives of mental patients in Ottoman mental institutions. Therefore, a major goal of this project is to incorporate these effects into an agent-based model (ABM) already available in Unity through previous work. ABM is a computational model of autonomous individuals or groups, called agents, that simulates their interactions with other agents and with their environment. Agents that represent different classes (patient, caretaker, etc.) of inhabitants in the Toptaşi Asylum (1873-1924), a key mental institution in the Ottoman Empire, each were provided a set of rules through natural language files that allowed them to act autonomously in their environment. Using Unity, a game development platform, the research aims to replicate the spatial changes made to the asylum due to cholera outbreaks, including disinfection stations, isolation rooms, and a *gasilhane* (room to wash the deceased) using the 3D modeling software Blender. The objective is to gain an understanding of how the treatment of cholera in the asylum influenced the functioning of the institution. We also simulated patients that had cholera symptoms in our model by using existing data about the number of cases throughout the outbreaks from August 29, 1893, to October 5, 1893, to accurately capture the number of patients affected. These will be divided into a new class of agents that will exhibit behaviors like being more isolated, entailing occupying less populated spaces of the asylum, and having a different routine than other patients. This is achieved by modifying the files that set the rules for the patient routines and assigning a distinct color to the agent models to easily indicate they are infected. These modifications will make the model more historically accurate by depicting the effects of cholera in the asylum. This work can be used to analyze and simulate the effects of contagious diseases in historic medical facilities.

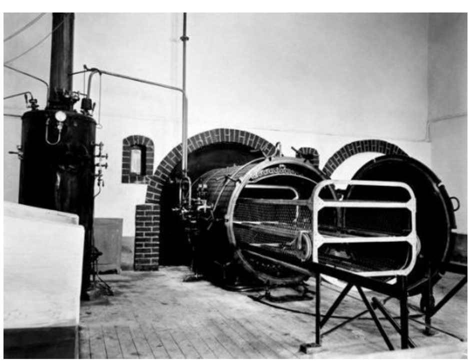


**Figure # 1:** Disinfection station.

Source: Ottoman Imperial Archive.

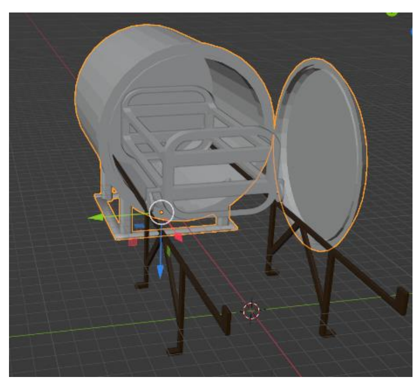


**Figure # 2:** Model of disinfection station

in Blender.

**The Effect of Perfluorooctanesulfonic Acid (PFOS) on Ovarian Follicles**

Steven Habeb

Department of Biological Sciences Advisor: Dr. Genoa Warner Department of Chemistry and Environmental Science

New Jersey Institute of Technology, Newark, NJ 07102

This study examines the impact of perfluorooctanesulfonic acid (PFOS) on ovarian function. PFOS, commonly used as a water and stain repellent in products like firefighting foam, surface coatings, electrical components, and metal plating, is resistant to degradation and accumulates in the environment and living organisms. Exposure to PFOS is associated with adverse health effects, including cancer, liver damage, reproductive development issues, and immunological suppression. Our hypothesis is that PFOS exposure affects ovarian function, potentially harming female reproductive system development and health. To investigate this, follicles will be extracted from the ovaries of adult female CD-1 mice and cultured with vehicle control (DMSO) or various PFOS concentrations (0.1, 1, 10, and 100 µg/mL) for 96 hours. Follicle growth will be assessed at 24-hour intervals. Hormone levels in the media will be measured using enzyme-linked immunosorbent assay (ELISA), and follicle gene expression will be analyzed through quantitative polymerase chain reaction (qPCR). We anticipate that PFOS exposure will disrupt steroid hormone production, gene expression, and follicle growth in the female mice's ovaries. This research has implications for reducing PFOS exposure in workplaces, homes, and communities, as well as identifying strategies to prevent or mitigate the harmful effects of toxicants on ovarian health and reproductive function.

# Effects of Nanoplastics on Gene Expression in the Placenta

**Michelle Jojy**

**Advisor: Dr. Genoa Warner**

Plastics are an integral part of modern life, but their degradation leads to the release of microplastics and nanoplastics that contaminate the environment and enter our organs and bloodstream. These tiny plastic particles can have endocrine-disrupting properties that may negatively impact prenatal development. The placenta, which plays a crucial role in fetal development through its role in hormone production and blood circulation, is particularly vulnerable to these particles. We expect that environmentally relevant doses of nanoplastics will disrupt gene expression, indicating that nanoplastic exposure is harmful to the placenta. To investigate this, we exposed pregnant mice to environmentally relevant doses of either control or particles measuring 50 nm or 200 nm, administered at a rate of 5 mg/kg/day. Subsequently, we extracted RNA from placenta samples and synthesized complementary DNA strands. Reverse transcription quantitative polymerase chain reaction (RT-qPCR) was then employed to analyze changes in placental gene expression. This research will fill a critical gap in knowledge about the impact of nanoplastics on the placenta and provide valuable information on their effects on fetal growth and development.

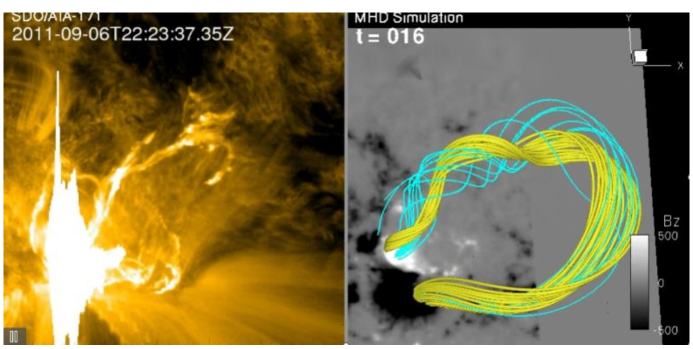
# Magnetohydrodynamic Simulation of Coronal Magnetic Field Evolution and Eruption

**Nathaniel Kapleau, Advisor: Dr. Satoshi Inoue**

Department of Physics

New Jersey Institute of Technology, Newark NJ 07102

Solar flares are known to have a wide range of effects on everyday human life. Strong solar flares can permanently damage satellites (which includes GPS), disrupt long range communication, stop online financial transactions (such as those done on Wall Street or at any bank), and destroy all electronics as we know it (in extreme cases). As such, learning all about solar flares is imperative. What causes them to become so powerful in magnitude? What can we do to better predict when large solar flares will occur? These questions, among many others, are extremely important to fully understand due to the threat of solar flares and eruptive phenomena impacting our everyday life. It is generally believed that solar flares are primarily carried by the coronal magnetic field, allowing certain solar flares to reach great magnitudes. However, due to observational issues, very little is known about the 3D structures and dynamics of the magnetic fields that carry such eruptive phenomena. The solution? Magnetohydrodynamic (MHD) simulation. Through MHD simulation, combined with observed magnetic field data, we are able to better understand and visualize the magnetic field lines within the coronal magnetic field that carries the solar eruptions, thus understanding more about what causes these eruptive phenomena to propagate and become as powerful as they do. Given future results from the simulations once compared to real life data, I expect to be able to better understand how the magnetic field of the corona shifts and changes when in contact with solar flares. Below is an example of MHD simulation:




Credit: Jiang, C. W., Feng, X. S., Wu, S. T., and Hu, Q. (2013), Magnetohydrodynamic Simulation of a Sigmoid Eruption of Active Region 11283, ApJL, 771, L30. http://iopscience.iop.org/2041-8205/771/2/L30

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

**Rahul Laha, Advisor: Dr. Philip Pong, Mentor: Dr. Abdellatif El Mouatamid**
Department of Electrical and Computer Engineering
New Jersey Institute of Technology, Newark NJ 07102

Abstract: 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.

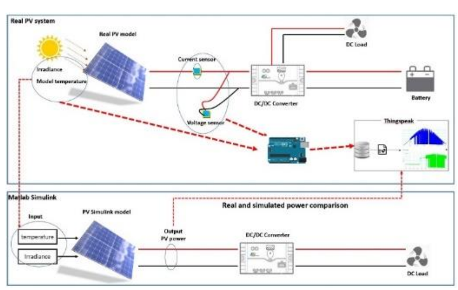



**Figure 1:** Entire system deployment with sensors and solar panel

# Adsorption Behavior of PFAS to Microplastics

Adam Leszczynski, Mentor: Sumbel Yaqoob, Advisor: Dr. Mengyan Li

Department of Chemistry and Environmental Science

New Jersey Institute of Technology, Newark NJ 07102

An important group of persistent organic pollutants that are receiving widespread attention are per- and polyfluoroalkyl acid substances (PFAS). Alongside PFAS, another type of pollutant that has been under a lot of observation is microplastics, which are also capable of persisting within the environment and bioaccumulating in organisms. Previous research on the synergy between PFAS and microplastics revealed that certain types of PFAS are capable of adsorbing to microplastics in aquatic environments, allowing microplastics to act as a means of entry for PFAS into biota at higher concentrations. In this experiment, the adsorption behavior of a specific class of PFAS, fluorotelomer carboxylic acids (FTCA), is observed on polyethylene (PE). In parallel, containers made of glass and polypropylene were observed without PE to determine the degree of sorption of 6:2 FTCA to reaction vessels. Time points were taken at time 0, 1, 4, 7, and 24 hours and analyzed for decrease in 6:2 FTCA concentration via liquid chromatography-tandem mass spectrometry. It was found that 6:2 FTCA does not exhibit significant adsorption to polyethylene microplastics. The concentration of 6:2 FTCA did not decrease significantly within glass containers, whereas the concentration of 6:2 FTCA in the polypropylene container showed a decrease of about 26%, but the amount of adsorption was similar to that of the analytical control (without PE). The lack of sorption of 6:2 FTCA may be attributed to lack of contact to PE due to the microplastic floating near the air-water interface and was not distributed evenly throughout the reaction vessel. Additionally, the hydrophobic interactions between 6:2 FTCA and PE may not have been strong enough. Further work can be done on the interactions of other kinds of FTCA, such as 5:3 FTCA, and other kinds of plastics, such as polystyrene (PS), as there are many combinations of PFAS and microplastics found throughout polluted environments that can exhibit their own unique adsorption behaviors

# Predicting Solar Flare Indices from SHARP Parameter Dynamics using Convolutional Neural Networks

**Emily Luo, Princeton University**
Mentors: Dr. Bo Shen, Department of Mechanical and Industrial Engineering
Dr. Qin Li, Institute for Space Weather Sciences
New Jersey Institute of Technology, Newark NJ 07102

Abstract: The impacts of solar flares, eruptions of electromagnetic radiation from the sun's surface, range from minor side effects to severe space weather phenomena. High class M and X flares can cause radio blackouts on Earth, and if accompanied by a Coronal Mass Ejection (CME), can result in power outages and damaged satellite communication. Understanding and predicting solar flare activity is important for Earth's everyday operations, and machine learning models have been employed to do so. Classification ML models predict a flare's class (B, C, M, X) while regression ML models predict a more detailed metric: Flare Index (FI), the weighted sum of the flares that have occurred on a given day for solar Active Regions. Our research focuses on creating a ML model that uses Spaceweather HMI Active Region Patch (SHARP) parameters, space weather properties correlated with solar activity, to predict the 24 hr Flare Index for a given day while addressing two key challenges:

1. Class imbalance in the dataset. Due to the lower frequency of high-class flares, there is less training data for the model to use to recognize these more critical events.
2. Impact of SHARP parameter dynamics. Prior research looks at just one timestamp of parameter data, but we study how changes in over time can affect solar activity.

For our study, a Convolutional Neural Network (CNN) is applied. The training dataset consists of 25 SHARP parameters, collected in a one-hour cadence, for days in 2010 to 2016. The data is grouped into different time intervals to be used as input, and is tested with data from 2017 (Figure 1). Preliminary results show less variance in the predicted values when trained with longer time intervals of SHARP parameters (Figure 2), suggesting that using parameter dynamics is more reflective of solar behavior. In the future, our goal is to include both image data from line-of-sight solar magnetograms as well as SHARP parameters as training input to increase the model's robustness.

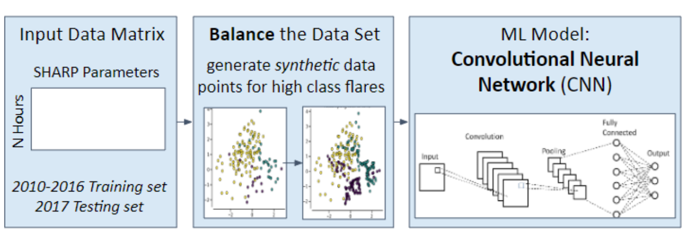



**Figure 1:** ML Model Training Approach

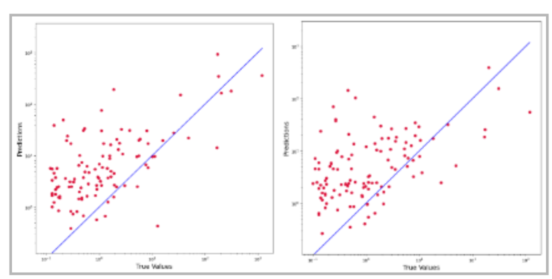


**Figure 2:** Predicted FI vs. True FI for 1 hr (left) and 4 hr Intervals (right)

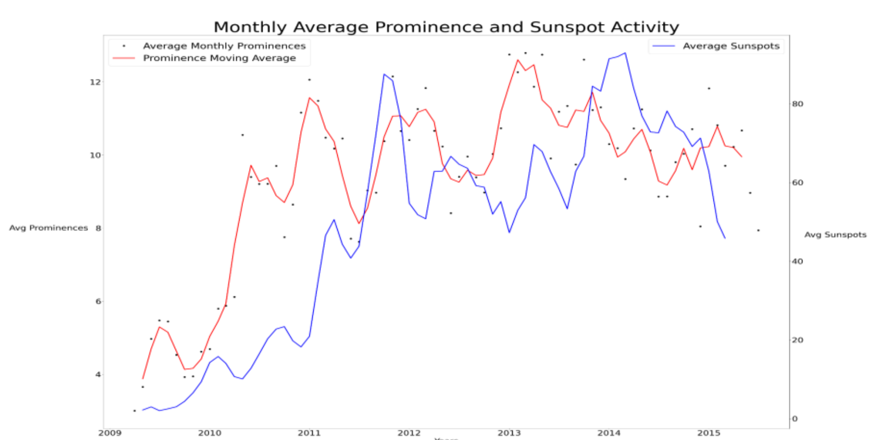
# Solar Prominences

**Arman Manookian, Advisor: Vasyl Yurchyshyn**

Pepperdine University

Malibu, CA

Solar filaments are 3D structures that reach high into the solar corona. When observed near the solar limb they are considered solar prominences. The goal of this project is to gain some insight into how prominences are correlated with the solar cycle and magnetic minimum and maximum. Using fits image data from a four-inch full disk H-alpha telescope, an IDL program was able to draw out the solar limb and detect prominences from March 2009 until August 2015. The time, number of prominences per time, and coordinates in pixels were then saved into one csv file per day. These files were then put through a Python program to extract the average number of prominences per month. This data was compared to outsourced data of the monthly average number of sunspots. Since sunspots occur more frequently during magnetic maxima and sunspot data is readily available, it was determined that the sunspot data would be the best comparison to the prominence data. To gain a visual understanding of the data, the monthly average prominences, a rolling average of prominences, and rolling average of sunspots were plotted. In order to find out how correlated these two phenomena are, a new plot with the prominences versus the sunspot data was made and the Pearson correlation was calculated. With a correlation of 0.66 out of 1, the data seems to support the leading theory regarding prominences—while some prominences are in the active region (AR) of the sun, there are also prominences in the quiescent region, meaning they are present regardless of solar activity. Using the same prominence data from 2009-15, a python program is being created to track every prominence that occurs to see the long-term trends, such as how long a prominence lasts. Typically, prominences in ARs last for a few hours while those in the quiescent regions can go on for days at a time. The program is currently being written and when it's complete, there should be a noticeable increase in hours-long prominences as the years go on since 2015 is a magnetic maximum for solar activity. noticeable increase in hours-long prominences as the years go on since 2015 is a magnetic maximum for solar activity.



# Reactivity Of Gaseous Mercuric Bromide With Solid And Liquid Interfaces

**Laila Nashir and Alexei Khalizov**

Department of Chemistry and Environmental Science

New Jersey Institute of Technology, Newark NJ 07103

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.

# Magnetohydrodynamic Simulation of Solar Magnetic Field Eruptions Triggered by Small Emerging Flux

**Huu Minh Triet Nguyen, Advisor: Satoshi Inoue**
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Abstract: Solar flares and coronal mass ejections (CMEs) have a profound impact on our geomagnetic environment and infrastructure. Consequently, comprehending the initiation of these phenomena is crucial for space weather forecasting. It is widely acknowledged that solar flares and CMEs arise from the release of free magnetic energy through the formation of a magnetic flux rope—a collection of helically twisted magnetic field lines that stores this energy. However, the specific physical mechanisms responsible for the formation of the magnetic flux rope remain incompletely understood. Recently, Bamba et al. (2013) and Wang et al. (2017) reported the observation of small emerging flux (EMF) occurring just prior to a flare, suggesting it as a strong triggering mechanism for solar eruptions. Numerical studies, such as those conducted by Chen & Shibata (2000) and Kusano et al. (2012) using magnetohydrodynamic (MHD) simulations, have successfully reproduced eruptions with small EMF, albeit in 2D or simplified 3D models that do not fully capture the realistic magnetic environment of the solar corona. In this study, we aim to address this limitation by conducting an MHD simulation within a more realistic magnetic environment.

Initially, we prepared a potential field based on a simple dipole field and introduced sheared magnetic field lines by applying a twisting motion to the bipole field. We placed the small EMF in a localized area along the sheared field lines. While a continuously applied twisting motion on the photosphere could induce magnetic field eruptions, the kinetic energy gradually increased. Conversely, when the small EMF was introduced during the evolution, we observed a significant rise in kinetic energy after the formation of the magnetic flux rope. These findings align with observational studies, highlighting the crucial role of small EMF in explaining explosive eruptions.

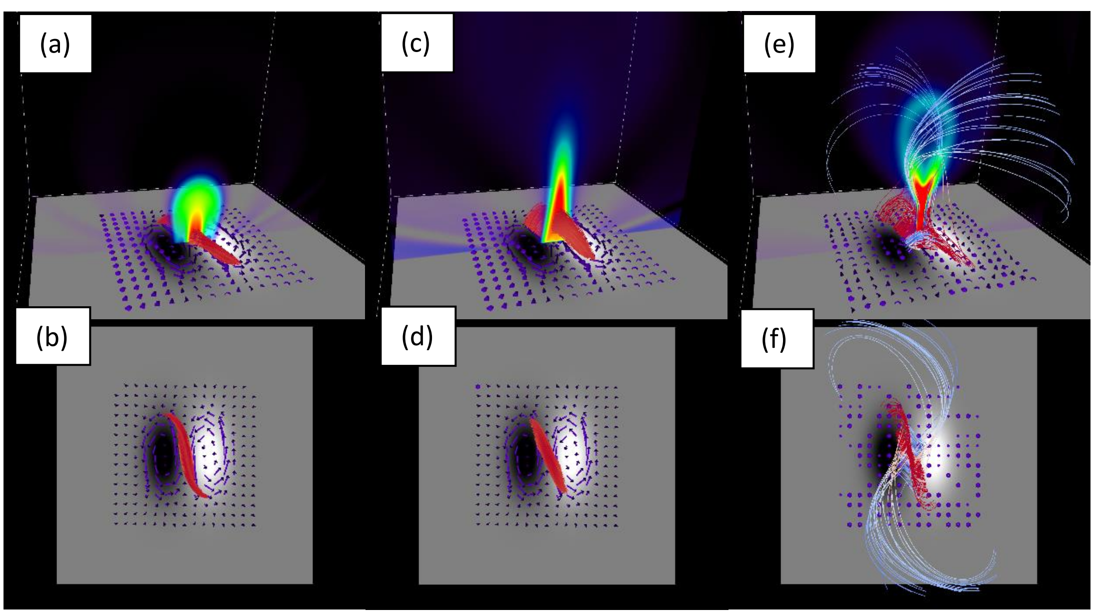


*Figure: Magnetic field lines at various timesteps and conditions. The arrows indicate bottom boundary velocity vectors. The cross-section slice represent current charge density.*
*(a) & (b) Chosen initial condition in motion from side and top view*
*(c) & (d) Final configuration for continuous twisting motion but no inserted EMF (no eruption) from side and top view*
*(e) & (f) Final configuration for stopped twisting motion and inserted EMF (eruption observed) from side and top view*

# Trigger Mechanisms for Solar Flares

**Naya J. Pared, Mentor: Jeongwoo Lee, Co-Mentor: Qin Li**
Department of Applied Physics
New Jersey Institute of Technology, Newark NJ 07102

Solar flares occur when magnetic energy is released via magnetic reconnection. Scientists have found that magnetic flux emergence and shearing motion of magnetic fields may contribute to the buildup of energy needed for the solar flare. However, it is still unclear as to what triggers the solar flare. This project is intended to address possible trigger mechanisms for solar flares by studying solar flare EUV and magnetic data obtained from the Atmospheric Imaging Assembly (AIA) and Helioseismic and Magnetic Imager (HMI) onboard Solar Dynamic Observatory (SDO).

The first target quantity is the reconnected magnetic flux during flares. We first analyzed the AIA images to find the best intensity threshold for adequate definition of flare ribbons, which was then used to map out the area of the flare ribbons over time. We then overlay the AIA images over HMI data to readout reconnected magnetic flux. The third step is to take a time derivative of the reconnected magnetic flux. The second target quantity is a convergence motion of bipolar magnetic elements toward the magnetic neutral line. The converging motion is determined by directly tracing the magnetic elements in both polarities during the solar flare. From these two quantities, the research can look at what is the trigger for the solar flare.

The goal of the project is to experiment with this data then extend the procedure to look at other solar flare events over longer periods of time to try and determine the triggers. Thus Far we have studied the AIA and HMI data chosen for a specific solar flare event on June 21, 2015. Once this is completed, then the process can be extended to other data.

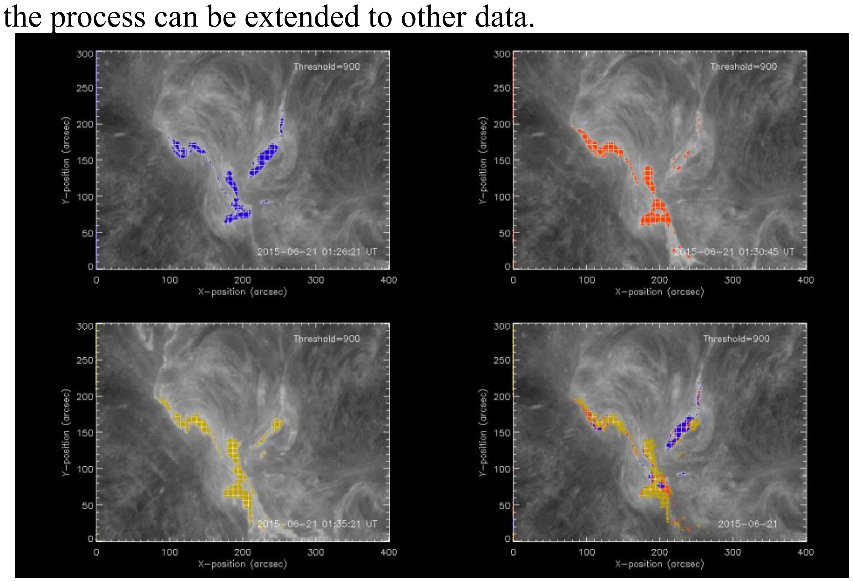


**Figure 1:** Analysis of the AIA data for the solar flare on June 21, 2015. This depicts the flare at three different times, 01:26 UT (blue), 01:30 UT (red), and 01:35 UT (yellow) at an intensity threshold of 900 counts in the AIA 304 A images. The last image shows results at all three times mapped together to show how the area changes over time during the solar flare.

# Nonlinear Water Waves: Theory and Experiment

Jaiman Parekh, Advisor: Dr. Wooyoung Choi

Department of Mathematical Sciences
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Fluids are a fascinating area of research due to their unpredictable behavior; on a large scale, a body of water does not seem to change much, but upon closer examination, ripples and waves of various sizes characterize the surface due to an inherent property known as nonlinearity. This property is important when there are multiple equations that are being simultaneously solved, each highly sensitive to the initial conditions chosen. In models for a fluid, this is exactly what is found: many equations with chaotic characteristics. Constraints such as surface tension and viscosity, which are often neglected in models, add an increasing layer of difficulty. This research examines how vertically shaking a tank with a fluid can generate specific types of waves. For certain frequencies of oscillation, waves will collide in such a way that they isolate and strengthen each other, as opposed to creating weak ripples. This makes the waves distinct and observable. Statements about the evolution of entire classes of nonlinear systems can be verified through the comparison of theoretical predictions and experimental measurements of these waves. The most direct application of these findings is understanding the sizes of waves generated by winds as well as how ocean currents share energy, but the results extend to the many fields of math and physics in which nonlinearity is involved.

# Nanobubbles-Enabled Foam Fractionation For Efficient Algal Removal

**Varsha Rayasam**

**Mentor: Yihan Zhang**

**Advisor: Dr. Wen Zhang**

Department of Civil and Environmental Engineering

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Coastal and estuarine hypoxia, when oxygen-depleted conditions (hypoxia and anoxia) occur from phytoplankton development and decomposition, is a significant and expanding global environmental hazard. The excessive intake of nitrogen, phosphorous, and sediment pollution from watersheds causes eutrophication, which has detrimental effects on fish and other living resources. Harmful algal blooms (HABs) are becoming more frequent in inland freshwater (lakes, ponds, reservoirs, and rivers) in all 50 US states as well as around the world. These blooms are brought on by the rapid development and accumulation of microalgae like cyanobacteria, dinoflagellates, and diatoms in the surface waters. Algal blooms pose significant challenges to water quality and ecosystem health, requiring effective and sustainable strategies for their mitigation. The small size of algal cells (usually 2–20 m in diameter) and very low densities make them exceedingly energy-intensive even though there are a number of strategies for effectively separating wild algal biomass from water. Many separation technologies now in use have problems with scalability or financial feasibility. Centrifugation, coagulation/flocculation, membrane filtration, and air flotation are popular separation techniques. Centrifugation is the method used to separate the algae, and while it has a high efficiency, it has the potential to consume more energy than it produces. The use of low-pressure air sparging and foam production to aid in algal cell collection in contrast showed that scattered air flotation combined with foam fractionation greatly reduced the energy requirements (0.003-0.015 kWh/m3). Due to its distinctive characteristics, such as excellent stability, small size, and vast interfacial area, nanobubbles have attracted interest lately. In comparison to standard microbubbles, nanobubbles, which have diameters between a few tens and hundreds of nanometers, have improved buoyancy and surface interaction. These features make them especially appropriate for foam fractionation, a separation process based on the selective adsorption of target chemicals at the gas-liquid interface. Our main assumption is that the utilization of air nanobubbles could reduce the amount of sparged or purged air that is necessary for foam bubble production, particularly when surfactants are present. Smaller bubble clusters may be more resilient to collapsing and offer higher surface areas to absorb the algal cells in the foam made with nanobubbles as compared to microbubbles. Foam fractionation offers a promising method for separating hydrophobic molecules and algae from liquid solutions. This project explores the technical and economic feasibility of foam fractionation, with a focus on using air nanobubbles for algal removal, which has not been extensively investigated before.

**Studying the Impact of Xylemic Parameters on Drought Resistance**

Isaiah Rejouis, Faculty Mentor: Dr. Xiaonan Tai
Department of Biological Sciences
New Jersey Institute of Technology. Newark, NJ 07102

Due to climate change, droughts across the globe have triggered an elevation in mass tree die-off. And although scientists have increased the complexity of modern hydrological models to create more accurate simulations, there still remains limited data on the specific impact of each factor on accuracy. Every forest's ability to resist drought relies heavily on that site's dominant species, collecting this data involves financial and logistical costs. Furthermore, site-specific simulations require the extensive measurement and analysis of various characteristics, in addition to requiring a large number of laboratory resources. In this experiment, I will test the parameters conventionally attributed to influencing simulated drought resistance, measured in evapotranspiration. The goal of this study is to isolate and identify the most cost-efficient parameter to be studied when assessing tree resistance to drought.

# Mercury Sorption in Propanotrophs

**Hannah Shahinian, Advisor: Dr. Lijie Zhang, and Mentor: Lai Wei, PhD Student**

Department of Chemistry and Environmental Science

New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: Mercury (Hg) is a pervasive pollutant, and its organic form methylmercury (MeHg) is a potent neurotoxin that is known to bioaccumulate and biomagnify through food webs. This leads humans to face high MeHg exposure when consuming seafood. As a result, understanding and controlling how MeHg cycles in the environment is essential to protecting human populations. The net accumulation of MeHg is governed by methylation of inorganic mercury [Hg(II)] to MeHg as well as degradation of MeHg to Hg(II). In recent years, many types of bacteria, including methanotrophs, have been found to sorb MeHg and Hg(II), potentially reducing their bioavailability. This research project aims to determine if two propanotrophs, *Mycobacterium dioxanotrophicus* PH-06 and *Azoarcus* sp. DD4, that are already prominent in 1,4-dioxane bioremediation are able to effectively sorb both MeHg and Hg(II). To test this, we analyzed the changes in aqueous Hg concentrations and sorption after mixing bacterial cells with Hg(II) and MeHg. Our results show high levels of Hg(II) and MeHg sorption in both bacteria, hinting that these bacteria may be able to decrease the bioavailability of both of these toxic Hg species by immobilizing them. Future research should explore the biochemical pathways leading to this sorption and assess its use for bioremediation in realistic settings with varying water chemistries or where there is co-contamination of 1,4-dioxane.

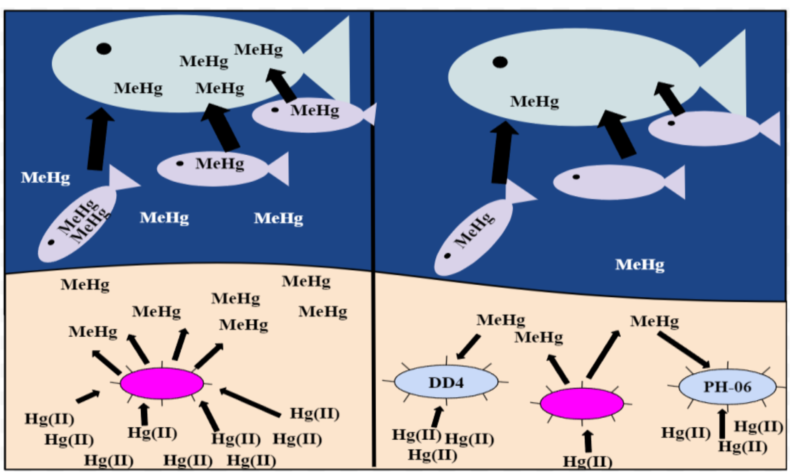


**Figure 1: Diagram of potential bioremediation of Hg with PH-06 and DD4. The purple bacteria are a representation of anaerobic Hg(II) methylating bacteria.**

# Exploring Solar Flares using the SolarDB Cyberinfrastructure

**Simona Sotiri, Mentors Dr. Jason Wang, Dr. Yao Ma, and, Dr. Nian Liu**

Department of Computer Science

Department of Physics

New Jersey Institute of Technology, Newark, NJ 07102

Abstract: Solar eruptions often occur through solar flares and coronal mass ejections. These are events that have very significant effects on space weather and Earth's processes. We track these phenomena because they interfere with our technology and pose risks to Earth's atmospheric system. Using data from powerful observatories across the globe, we store this information in databases. The one we focused on being the flare database which is a part of the SolarDB cyberinfrastructure that contains several databases for very important space weather areas and multiple machine learning tools for analyzing space weather data. However, this Flare Database had some severe flaws. Many of the movies for certain solar active regions (ARs) and specific events have missing files and thus, cannot generate a completed movie of a solar flare. The first step we took was to investigate the problems with this Flare Database and to observe what files were missing from the original Flare Database. Then after knowing this, we used python coding techniques and modules to find the missing data out of the larger data set and downloading the missing files. Next, we wanted to analyze the results of what was missing by making statistical comparisons to the data that was already being stored in the Flare Database to detect and understand where the original problems lied. We found that many AIA and HMI data image files were missing between ARs, although there was no overall correlation between how many or what types of files were missing. Then we wanted to complete this project by compiling completed movies for each AR in the Flare Database. In total, I have helped compile movies that were missing for 75 ARs out of 189 that are being stored in the Flare Database. While this work is still in progress, future work will be done based on the work we've done here to complete the data set and will be progressed to aid in machine learning techniques for early detection of those solar flares in the Flare Database.

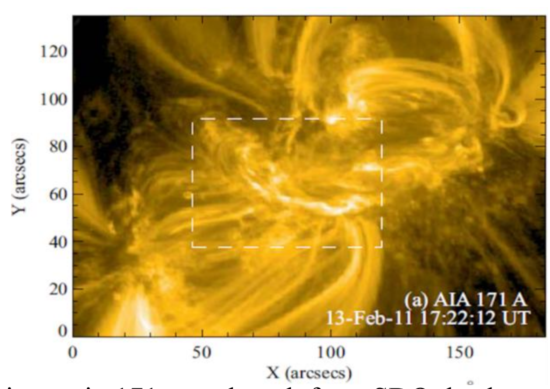


**Figure 1**: AIA image in 171 wavelength from SDO database of radio bursts.

# Tracing Energetic Electrons in the Solar Corona using Solar Radio Bursts

**Luke Thomas, Mentor: Sijie Yu, Co-mentor: Surajit Mondal**

Institute for Space Weather Sciences

New Jersey Institute of Technology, Newark NJ 07102

Abstract: Solar Radio bursts are emissions that propagate from the Sun and are classified into multiple types. Type 2 and type 3 radio bursts are associated with coronal mass ejections (CMEs) and Solar flares, respectively. Type 1 radio bursts, however, are not currently associated with any specific Solar phenomenon, despite being the most common type of radio burst and being the first discovered. Using radio dynamic spectra data of Type 1 "noise storms" from the Very Large Array Radio Telescope, this study aims to gather the radio emission frequency, intensity, frequency drifting rate, and time duration data from these bursts, which will allow for the tracing of energetic electrons traveling through the Solar corona into the interplanetary medium and vice versa. This tracing can be done by examining the frequency drifting rate, the rate at which the emission frequency changes over time, as the emission frequency decreases as the energetic electron moves further radially from the Sun due to decreasing plasma density at further distances from the Sun, and the reverse is true for energetic electrons moving into the corona from the interplanetary medium, where an increase in emission frequency is expected. The relationship between the emission frequency and plasma density provides a useful diagnostic tool for studying the density structure of the plasma through which the energetic electrons propagate, and allow us to use imaging to trace these energetic electrons back to their source region on the Sun. This information can be further used to study other Solar processes, such as the acceleration of the Solar wind and the heating of the Solar corona, and study of these bursts can be used to increase our space weather prediction capabilities, which will help to protect Earth's satellite and communication systems. In this study, an algorithm was developed to detect Type 1 radio bursts and extract their statistics from VLA dynamic spectra images using image processing and machine learning techniques, as well as use those statistics to trace energetic electrons back to their source regions on the Sun.

# Developing An Interactive VR/AR Museum Experience to Contextualize Van Gogh's Artwork

**Carolyn Toledo, Advisor: Dr. Hyejin Hannah Kum-Biocca**

School of Art and Design

New Jersey Institute of Technology, Newark NJ 07102

## Abstract

Modern advancements in the technology of virtual reality (VR) and augmented reality (AR) have enabled hands-on exploration of concepts, ideas, and experiences in ways that had not been feasible up until recent years. These developments have opened up countless opportunities for how this technology could be used for learning and simulating experiences. As such technologies and applications become more and more well-known and accessible, more possibilities arise for the extent of their impact on how we view and interact with the real world.. By combining the real with the intangible, or simulated surroundings with real human input, further exploration can be achieved by enhancing the senses. Employing this in a museum illustrates this greatly – while a painting often can say enough by itself, the addition of context seen side by side adds to the viewer's interpretation significantly.

The project I have cultivated uses AR and VR technology and design to simulate a direct experience with an artist (Van Gogh) that draws the viewer into his world to develop a deeper understanding of his work. More specifically, a series of 3D environments will be created in which a user can virtually navigate through the use of a VR headset and interact with certain parts of their surroundings to learn visually. The experience consists of two locations: a museum gallery housing some of Van Gogh's works and the asylum he stayed at during part of his career. The development of this project is primarily governed by the direction of the user experience as well as the connection between the visuals and their educational context. Using software such as Maya and Unreal Engine and on-site images taken of both locations, the experience will be designed to provide a unique tour and show information in ways that could not be possible in person, accessible from anywhere in the world.

# "Jets" On The Sun: Joint Radio And Extreme Ultraviolet Observations

**Mallory Wickline, The Pennsylvania State University**

Primary Mentors: Prof. Bin Chen (Department of Physics), Prof. Pankaj Kumar (NASA Goddard Space Flight Center); Co-Mentor: Meiqi Wang (Department of Physics)

New Jersey Institute of Technology, Newark NJ 07102

Abstract: Solar jets are one of multiple types of mass- and energy-moving phenomena that occur in the solar atmosphere. They are beam-like, collimated plasma eruptions that are brief in occurrence and assist in particle transport for electrons escaping the sun. Through the magnetic reconnection process, it is postulated that jets are capable of high-speed particle acceleration and plasma heating, which result in highly potent radio emission and extreme ultraviolet (EUV) emission, respectively. The goal of this study is to understand particle acceleration associated with these jet events and their transport. This research is being conducted through a collaborative partnership with NASA's Goddard Space Flight Center (GSFC). Initial research methods began with developing an extensive catalog of jet events that cross reference both in-situ spacecraft data with remote sensing radio and EUV data. The catalog includes over two years of recorded events until May 2023. Catalog coverage includes Parker Solar Probe (PSP) and Solar Orbiter (SolO) connection data, Extended Owens Valley Solar Array (EOVSA) dynamic spectrograms, type III radio bursts, and impulsive solar energetic particle (SEP) event association. Based on criteria defined by the NASA research team, a small selection of events was taken out of the catalog to carry out a comprehensive study on. These observed events will eventually serve as a comparison to predictions from jet modeling and simulations from NASA GSFC. Current research methods include using microwave imaging spectroscopy to gain an understanding of the position and acceleration of escaping electrons. We will discuss the implications of these observations in understanding particle transport during future research through the analysis of multi-wavelength data.

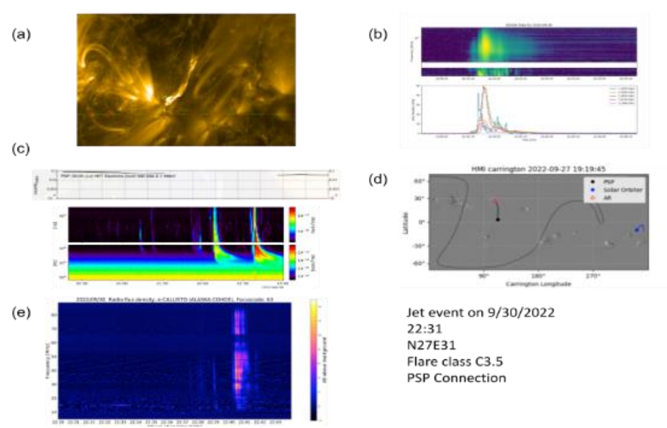


**Figure #1:** Example selected jet event featuring (a) AIA image in 171 Å channel (b) EOVSA dynamic spectrogram (c) Parker Solar Probe ISOIS electrons count rate plot and FIELDS high and low radio frequency spectrograms (d) Parker Solar Probe connection to the local active region shown via solar Carrington map (e) CALLISTO Alaska Cohoe solar radio spectrogram displaying type III radio burst.

# Uncovering the Function of Group-6 Propane Monooxygenases in *Mycobacterium* sp. DT1

**Kathryn J. Wulf, Jose Antunes, Dr. Mengyan Li**
Department of Chemistry and Environmental Science
New Jersey Institute of Technology, Newark NJ 07102

1,4-dioxane (dioxane) is a probable human carcinogen listed by the Environmental Protection Agency (EPA). This chemical has historically been used in industry to stabilize chlorinated solvents. Once in the environment, this contaminant is extremely difficult to remove due to its high mobility, solubility, and its high chemical stability owed to strong ether bonds. These physical and chemical properties cause this contaminant to resist typical water treatment technologies such as filtration, coagulation, and air stripping. Chemical remediation methods, such as advanced oxidation processes (AOP) have been utilized, but these methods are unselective and compete with oxidation byproducts or inorganic ions that would be present in typical groundwater environments and produce harmful byproducts through incomplete oxidation reactions. Physical remediation methods such as granulated activated carbon (GAC) are not sustainable or efficient in removing dioxane. Synthetic adsorbents incur high costs and energy, and the media utilized requires constant regeneration. Establishing an effective and cost-efficient degradation technique has become a priority due to the dangers of this contaminant to human health, its persistence in the environment, and increasingly more stringent local and state drinking water regulations to accommodate the $10^6$ lifetime cancer risk of 0.35 ug $L^{-1}$ set by the EPA. Bioremediation methods are a comparably low cost and low energy means to degrade dioxane and avoid the risk of producing toxic byproducts. In this work we have found by heterologous expression of the Group-6 propane monooxygenase into *Mycobacterium smegmatis* $mc^2$-155 that this enzyme is largely responsible for the removal of dioxane, as evidenced by the insignificant difference between the dioxane removal capacity of wild-type DT1 and the transformant. This work aids in further usage of bioremediation techniques to be used to tackle dioxane removal as we better understand the mechanisms of biological remediation.

**Electrochemical Degradation of 1,4-dioxane by RuPd bimetallic Nanoparticle Catalyst**

**Quentin Young, Advisor: Dr. Omowunmi Sadik, Mentor: Dr. Francis Osonga, Dr. Milad Torabfam**
Department of Chemistry and Environmental Science

New Jersey Institute of Technology, Newark NJ 07102

Used in the chemical manufacturing of paints, detergents, cosmetics, etc., 1,4-dioxane is a wastewater pollutant classified as a potential human carcinogen by the Environmental Protection Agency (EPA) and as a Group 2B carcinogen by the International Agency for Research on Cancer (IARC). Due to the heterocyclic structure of 1,4-dioxane and its two ether bonds, it is a difficult contaminant to degrade effectively. Therefore, developing an effective treatment for degrading 1,4-dioxane in wastewater and groundwater is of environmental and human health importance. The goal of this research is to design RuPd bimetallic nanoparticles catalysts supported on a glassy carbon electrode and study the electrocatalytic degradation of 1,4-Dioxane on the designed electrode in a three-electrode system. To determine the effectiveness of our designed catalyst on 1,4-dioxane degradation, the electrochemical techniques of cyclic voltammetry (CV) and chronoamperometry (CA) were conducted. The following analyses are currently or will be performed: 1. Gas chromatography mass spectrometry (GC-MS) to determine the degradation products of 1,4-dioxane and its remaining concentration after treatment. 2, The groundwater sample measurement and bulk electrolysis to evaluate the applicability and scalability of our designed system. 3. The measurement of chemical oxygen demand (COD) to define oxygen consumption requirements in the degradation of 1,4-dioxane.

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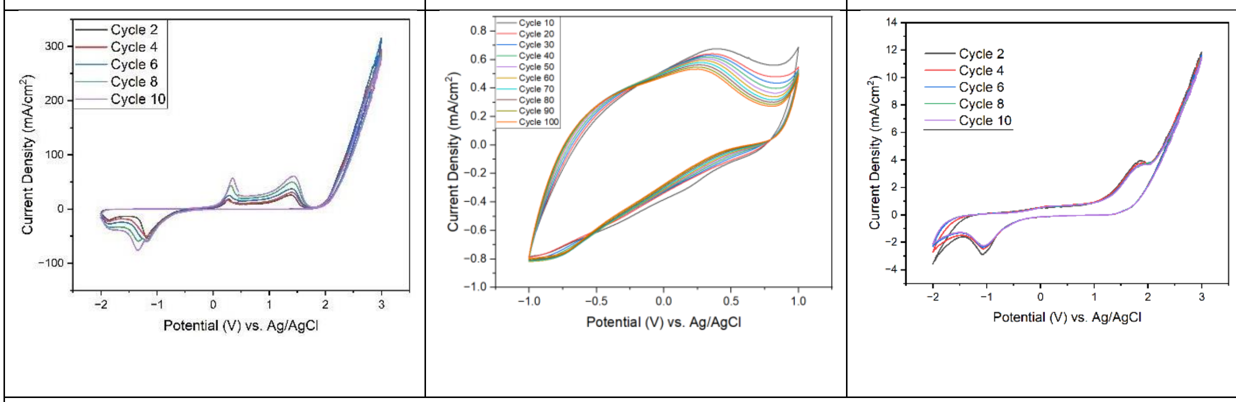


Figure 1: A) Cyclic Voltammetry test with RuPd coated glassy carbon working electrode, Pt counter Electrode, Ag/AgCl reference electrode for a solution of 25 mg 1,4-Dioxane in 1 liter of (1M) NaNO3 for 10 cycles. B) Cyclic Voltammetry test with RuPd coated glassy carbon working electrode, Pt counter Electrode, Ag/AgCl reference electrode for a solution of 25 mg 1,4-Dioxane in 1 liter of KCl (500mg in 1litre dH2O) for 100 cycles. C) Cyclic Voltammetry test with RuPd coated glassy carbon working electrode, Pt counter Electrode, Ag/AgCl reference electrode for a solution of 25 mg 1,4-Dioxane in 1 liter of KCl (500mg in 1litre dH2O) for 10 cycles.

# Tensile Failure in Enhanced Geothermal Systems due to Heat Energy Extraction

Larissa Cavalcante

Advisor: Dr. Oladoyin Kolawole

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**Abstract**: The existence of geothermal resources in low-permeability and low-to-medium temperature geothermal reservoirs make it critical for hydraulic stimulation to produce heat from such enhanced geothermal systems (EGS). Since tensile failure in rocks occurs when the effective tensile stress across some plane in the tested sample exceeds its critical limit (tensile strength), and the fractures developed therein replicate the fracture behavior in hydraulically-stimulated rocks, such as in EGS. Further, geothermal fluid migration for extraction of heat in enhanced geothermal systems is dependent on the in-situ fracture network created by the induced hydraulic fractures due to tensile failure. However, there is still a lack of knowledge on the impact of these enhanced geothermal systems on the tensile failure and behavior, and its influence on heat extraction in low-temperature geothermal reservoirs. This study investigated the effects of brine-rock interaction on the tensile strength of low-temperature EGS using limestone and shale rocks, and we further assessed the implications for long-term geothermal extraction in low-to-medium temperature geothermal reservoirs. First, an injection to yield heat extraction experiment through a brine-rock treatment system was conducted on subsurface shale and limestone rocks at an elevated temperature of 100°C to study fluid-rock interaction in low-temperature EGS. Secondly, a series of rock mechanical tests (i.e., indirect tensile strength tests) were conducted to assess tensile strength and the fracture network developed in the treated samples. The results were analyzed and presented. This ongoing novel work will advance the state of knowledge and technological advancements required to mitigate climate change and achieve sustainable geo-resources through geothermal energy production.

**A Scheme for 3-D Energy and Collision Aware Drone Off-line Path Planning**

**Tendai Chimuka,** Computer Engineering
Jorge Medina, Mentor
Roberto Rojas-Cessa, Advisor

Helen and John C. Hartmann Department of Electrical and Computer Engineering
New Jersey Institute of Technology
Newark, NJ 07102

**Abstract**
We proposed a 3-D energy and collision-aware scheme for drone off-line path planning. The scheme aims to optimize the number of waypoints visited while ensuring path collision avoidance and accounting for drone energy capacity. The strategy implemented by the scheme to prevent path collisions involve considering various flight altitudes for drones in the event of collision detection. We approach 3-D path planning as an optimization problem, incorporating constraints such as drone capacity capabilities, waypoint locations, the number of waypoints, and the inclusion of different flight altitudes. The objective is to maximize the number of visited waypoints while minimizing the number of required drones and the energy expended during the waypoint visits.

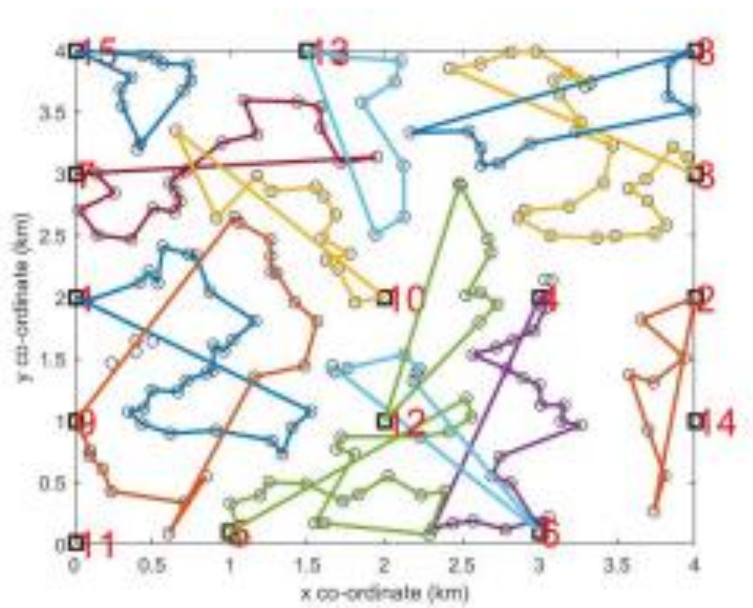


*Figure 1 Example of flight paths with intersections that show possible air collisions.*

# Preparation and Characterization of Composite Hydrogel Inks Loaded with Ceramics For Bone Tissue Engineering

Justin Diaz (presenter) & Jeongtae Kim
Department of Chemical and Materials Engineering
New Jersey Institute of Technology, Newark NJ 07102

**Abstract**: Methacrylated alginate hydrogel loaded with hydroxyapatite or tricalcium phosphate ceramic particles were prepared as potential feedstocks for printing of novel bone scaffolds. 3D printing of bone tissue could eventually replace traditional treatments for bone injuries such as auto and allograft bone substitutions due to its availability, ability to manufacture complex shapes for variable defect sites, and biocompatibility. This study explores 3 w/v % methacrylated alginate with 15 w/v% hydroxyapatite or tricalcium phosphate loading. Rheology and printability tests were used to assess the effect of ceramic type on flow properties of ink.

# A Computational Modeling Approach Using Temporal Difference Learning on Dopaminergic Reward Systems

**Mina Eskandar, Advisors: Farzan Nadim, and Horacio G. Rotstein**
Department of Biological Sciences
New Jersey Institute of Technology, Newark, NJ 07102

Abstract:
The mechanisms by which dopamine, a critical neuromodulator in the brain, drives reward-based learning and influences neuronal plasticity are not fully understood. One proposed mechanism in the field is the reward prediction error theory of dopamine, in which dopamine signals are involved in integrating received and predicted rewards for learning. A simple model of this process is the Temporal Difference (TD = time to reward) learning, to model this process. TD learning utilizes a computational framework that updates value estimates based on predictions of future rewards and observed reward outcomes. A recent study has shown that the cerebellum (Cb) modulates dopaminergic activity originating from the substantia nigra pars compacta (SNc), and demonstrated reward associations not only in SNc dopaminergic activity but also in the Cb to SNc pathway in mice performing a Pavlovian task. Here, we aim to develop a computational neuronal firing rate model utilizing a temporal difference learning approach to simulate reward associations and learning observed in those experimental data. Our proposed model incorporates a critic (evaluator) component that predicts future rewards in real time. The critic's predictions, combined with actual rewards, modulate the delivery of a neuromodulatory TD signal to the critic, shaping decision-making for action selection. Through this computational modeling approach, we aim to gain a deeper understanding of the dynamics of reward association and neuronal coding of prediction errors, which may not be readily apparent in a laboratory setting. Additionally, we seek to investigate the interplay of reward prediction errors within the brain, consistent with empirical evidence, and how the Cb regulates dopaminergic activity originating from the SNc. An improved understanding of the neuronal circuitry underlying movement propagation from the cerebellum to the basal ganglia ultimately holds promise for advancing the treatment of dopamine neuron impairments observed in neurological disorders such as Parkinson's disease.

**Design and Development of a Lab-Scale Hardware-in-the-Loop Simulation Platform**

**Aaron Fan**
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Abstract: This study introduces the design and realization of a lab-scale, hardware-in-the-loop (HIL) simulation platform for power systems, employing a Raspberry Pi and Arduino UNOs. HIL simulations, vital in system design and prototyping, offer a safe and efficient method to test hardware and software systems within a simulated operational context. The proposed platform leverages a Raspberry Pi to emulate the dynamic model of a three-area power system, with Arduino UNOs performing as local controllers. This cost-effective approach minimizes the need for physical prototypes, leading to substantial cost savings and enhanced scalability. The platform functions as an educational tool for understanding closed-loop control systems, eliminating the necessity for costly industrial hardware. The implemented three-area power generation system includes synchronous generators, renewable energy sources, and energy storage systems. Initially, the system was modeled and tested using MATLAB, then implemented on budget-friendly, readily available hardware, with the Arduino UNOs acting as area-specific controllers and the Raspberry Pi running the control system model. The results exhibited negligible deviations from the anticipated MATLAB outcomes, suggesting the potential for this platform's use in other industrial applications like aerospace, automotive, and machinery systems in future investigations.

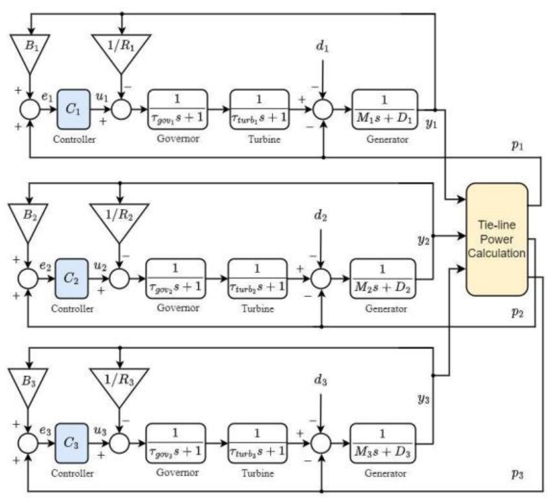


**Figure 1:** Figure 1: Block Diagram of the Three-Area Generation System. Each controller equation was run on an Arduino UNO, while tie-line power calculations were executed on a Raspberry Pi.

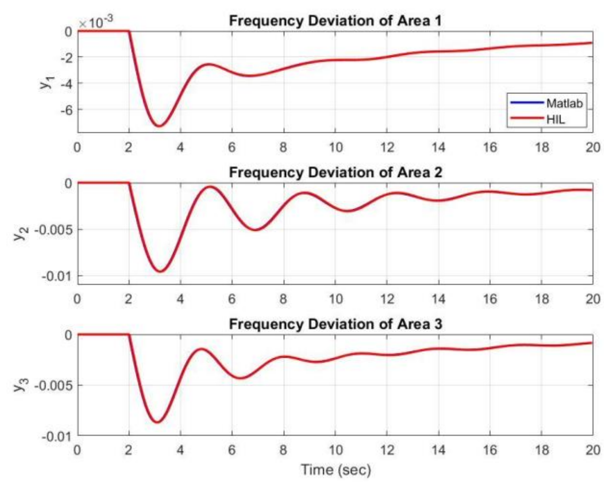


**Figure 2:** Frequency deviations of the three-area power system between MATLAB model and our simulation platform.

# Improving The Reactivity Of Ball-Milled Aluminum Powders Using Liquid Metal Embrittlement

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Liquid Metal Embrittlement (LME) is a process of modifying normally ductile/malleable solid metals, such as aluminum, with the help of liquid metals, such as gallium, in order to limit their elongation to failure. Recent studies have shown improvements in reactivity of aluminum-based thermites by mixing aluminum powder with a gallium alloy, Galinstan, liquid at room temperature. Here, the LME approach serves to change not only the reactivity but also the morphology of aluminum powders used as fuels. Aluminum powders with tunable particle sizes and shapes are prepared by ball-milling. A Retsch PM 400 planetary mill is used. Emulsion-assisted milling is used to prepare porous spherical aluminum powders with narrow particle size distributions. Thin foils of gallium serve as additives mixed with the starting Al powder in a milling vial. Less than 5 % of gallium are added and milling is performed in agate vials with agate milling balls to minimize interaction of gallium with the milling media and vials. Powders prepared with and without addition of gallium are recovered and characterized using scanning electron microscopy and thermal analysis. Effect of gallium additives and milling conditions on the structure, morphology, and reactivity of the prepared powders will be discussed.

# The Effect of Background Complexity on Ensemble Perception in Video Conferencing

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Ensemble perception, or the ability to judge the summary statistics of groups of items, has been studied extensively in simple displays without background clutter. However, it is unknown whether these findings apply to complex real-world stimuli such as video conferencing displays. This study aims to investigate the effect of background complexity on ensemble perception in video conferencing (vcon) displays. Using an eye tracker to limit the participants' field of vision, participants will be asked to judge the mean emotion of a distribution of facial expressions presented against a plain gray background or against their own natural or typical green-screened backgrounds. These facial expressions are morphed images taken from the Chicago Face Database. The expected outcome is that ensemble perception may be worse with a cluttered background, but not worse than expected based on performance judging a single face. The findings of this study will be presented in vision science conferences for undergraduate researchers.


# Neuromodulatory Contribution to Temperature Robustness of Locomotion

**Ayman Mohammad, Advisor: Dr Gal Haspel, and Mentors: Maria Belen Harreguy PhD Student, Smita More-Potdar PhD Student**
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**Abstract**: Neural circuits are widely diverse and capable of generating numerous behaviors. A specific type of neural circuit known as Central Pattern Generator (CPG) is responsible for generating essential rhythmic behaviors such as locomotion or swimming. These behaviors are susceptible to perturbations and demonstrate flexibility in adapting to internal and external changes, making them a viable model to study robustness. One of the most important environmental perturbations of neural circuits is temperature because it affects the dynamics of cellular and physiological processes. The nervous system and its output are very susceptible to temperature because it is composed of multiple cells and relies on their function and interaction. Because neuromodulation regulates neural connectivity and can confer homeostasis, an essential question is whether and how it contributes to the temperature robustness of neural activity.

The aim of this project is to determine whether serotonin play a role in maintaining the robustness of locomotion to changes in temperature. We predict that in the absence of serotonergic input, *C. elegans* nematodes will display an increase in variability of locomotive behavior that will uncover a sensitivity to elevated temperatures. To test this prediction, we have used a precise temperature control system (Figure 1) that maintains a constant temperature while we track the movement of the nematodes. Currently, we are focusing on monitoring the behavior of the nematodes with specific temperature sequences, such as initially decreasing the temperatures and then increasing it and vice versa. For future experiments, we plan to test these temperature changes in mutant strains, and in the presence of a serotonin antagonist to test the effect that an acute or chronic absence of serotonin has on temperature sensitivity. The response of the locomotor circuit to these perturbations will provide insight into the role of neuromodulators in the maintenance of robustness.

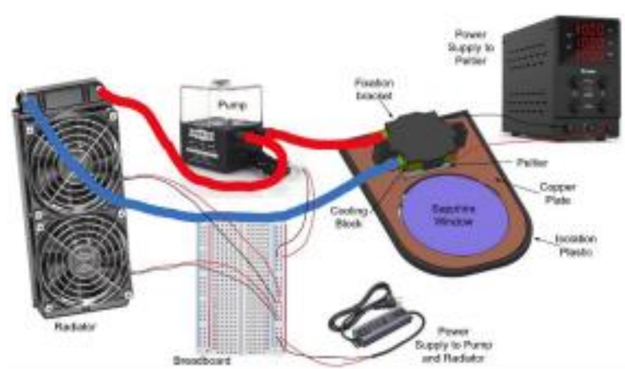


Figure 1: **Temperature Controller Assembly.** This device is used to precisely control the temperature of the nematodes through the desired temperature changes. The nematodes will be held at the following temperatures: 30°C, 20°C, 10°C, and 5°C. Adapted from Wang et al. 2023)

# Characterization of Helium and Nitrogen Blast Over Pressure (BOP) Profiles

**Isha Rai**
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Repeated Low Level Blast (rLLB) injuries are implemented on small animal models in a lab setting using helium gas, which is one of the industry standards to replicate the specific injury mechanism. Due to recent conflicts between Russia and Ukraine, sourcing lab grade helium has become difficult, forcing researchers to switch to nitrogen gas. Nitrogen blasts have been previously idealized to have the same effect as helium blasts, however, results have recently shown minor inconsistencies that may be indicative of a more significant difference in the underlying injury mechanism. Using MATLAB, OrginPro, and LabView, the pressure data obtained from historical blast trials can be analyzed and compared to one another in terms of the peak overpressure reading, the impulse of the wave, the rise time, and the speed of the wave. The purpose of this experiment is to show that there is a difference between the nitrogen BLAST wave forms and the helium BLAST waveforms, and that minimizing the differences between the two will lead to decreased biochemical differences in the injury mechanism.

# Prediction of Process-Property Relationship in Metal Additive Manufacturing

**Dharam Shah: Undergraduate Student and Dr. Bo Shen: Mentor**
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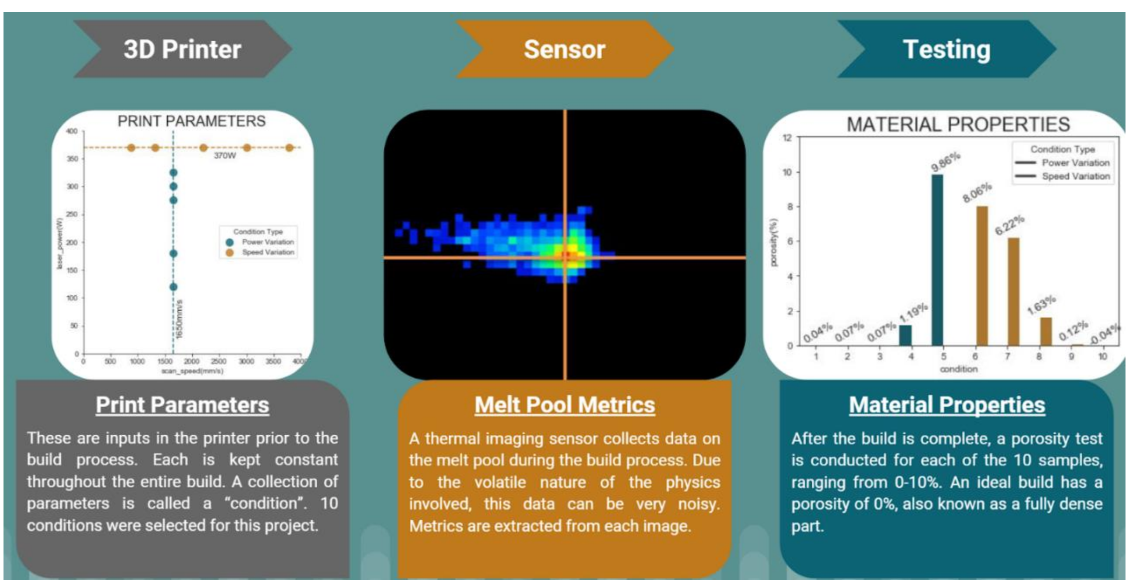
Abstract: Additive manufacturing (AM), or more commonly known as 3D printing, is a promising technology that enables the production of complex metal products and devices. Compared to traditional manufacturing methods, AM offers benefits such as design freedom for complex shapes, faster prototyping, cost-effectiveness for small production runs, customization, supply chain flexibility, and innovation opportunities, making it a valuable method for producing. However, current technology for AM processes currently produces a part yield of approximately 30%, meaning that approximately 3 out of 10 parts pass quality control checks. As a result, businesses are required to produce roughly 3 times the number of parts to fulfill an order. Making AM methods more efficient would allow businesses to efficiently use AM processes and would lead to improved profit margins. The primary data objective of this research project is to determine which print parameters, or what settings for the printer, correlate best with the porosity, amount of empty volume, of the object. The ideal porosity is 0%, which means that an object is fully dense. In order to do this, we used a data set that collected information about a 3D printed metal product before, during and after its production process. We then created and compared various machine learning models that predict which print parameters are the most correlated to the porosity of the object. By viewing the results of multiple models, we are able to verify and validate which print parameters are the most consistent in impacting the porosity of the 3D printed metal part.

**Figure 1:** (Left) Describes how the print parameters were collected. (Middle) Describes what melt pool metrics are. (Right) Provides a visual of the porosity values per each condition. (Image from Miles Craig.)



# How is Locomotion Affected in Semaphorin Deficient C. elegans Worms?

**Naomi Shah, Mentors: Dr. Gal Haspel and Maria Belen Harreguy**
Department of Biological Sciences
New Jersey Institute of Technology, Newark NJ 07102

Locomotion, the act of self-propulsion, is a fundamental animal behavior and a building block to other behaviors, like searching for food, migrating, escaping predation, and catching prey. Visible phenotypes based on locomotion have provided insightful access to the molecular basis of behavior and neurodevelopment. The development of the nervous system is orchestrated by molecular signaling that directs neurons toward their appropriate targets. The goal of this project is to understand how locomotion is affected by the absence of different components of a neurite-guidance system, namely semaphorin signaling.

Semaphorins have been shown to serve as axon guidance molecules, allowing axons to find their targets and thus contributing to nervous system development. This is a fundamental biological process and nematodes with semaphorin deficiency are thus unable to perform many important functions in relation to nervous system development. Understanding how locomotion is affected in mutant organisms that are semaphorin-deficient will shed light on the extent that semaphorin signaling mediates neural system development. Furthermore, semaphorin signaling is highly conserved through animal species. There are only three semaphorins and two plexins in *C. elegans* allowing comprehensive experiments *in vivo*. Identifying the involvement of the conserved semaphorin signaling in *C. elegans* neurodevelopment and locomotion behavior may then be applied to other organisms.

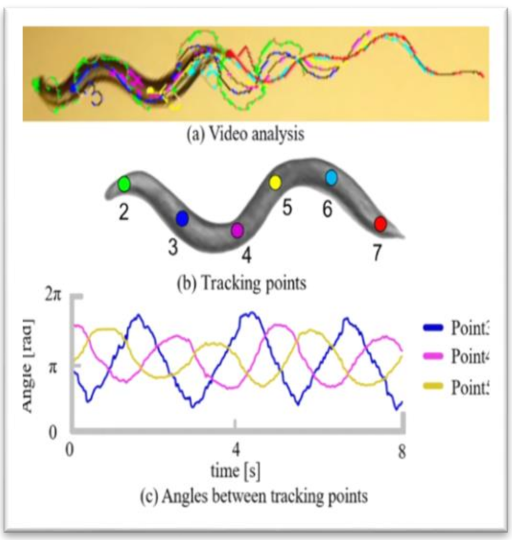



***Figure 1: Data Points from Various Tracking Points Yields Visual Data. Behavioral tracking is useful to capture motion analysis of C. elegans (a and b). When graphed, the data points form curves that represent temporal changes in the locomotion of C. elegans. Adapted from Sakamoto et al., (2021).***

To track the movement of five different semaphorin strains, mutant strains of *C. elegans* I am using a multi-worm behavior tracker and picking thirty young adult hermaphrodite animals onto three agar plates. I am taking five videos of one minute each per plate. Using Tierpsy Tracker, I will then be able to get a breakdown of the discrete postures of the worms at various time points. I will focus on the variable's frequency and speed for the head, tail, and midbody data sets and the raw data will be converted to graphs (Fig. 1). I will then store the video files for future analysis, eliminating and rerecording any videos that do not provide comprehensible data.

By continuing with this research, I will be able to provide comprehensive data that will be useful in identifying how locomotion is affected by the absence of semaphorin signaling components in *C. elegans*. As semaphorins play a significant role in the development of the nervous system, the results of my experiments will help to establish the role of semaphorin signaling in neuronal development.

**Understanding the Pathophysiology of Persistent Post Concussion Symptoms with Convergence Insufficiency: an Analysis of Cerebral Blood Flow in Concussed Patients**

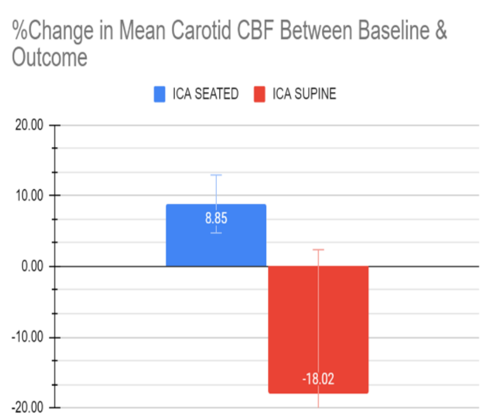
**Soham Shashikumar**

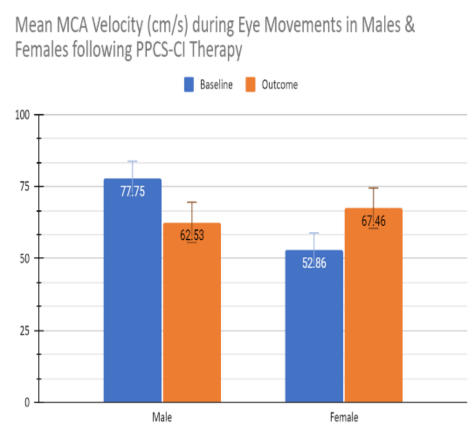
Advisors: Dr. Stephanie Iring-Sanchez & Dr. Tara Alvarez

Biomedical Engineering Department

New Jersey Institute of Technology, Newark NJ 07102

Abstract: Physicians primarily diagnose concussions based on clinical observation, but using quantitative physiological measurements could lead to more accurate diagnoses. The aim of this project is to investigate the pathophysiology of persistent post-concussion symptoms and convergence insufficiency (PPCS-CI) by analyzing existing physiological data. This data will consist of objective eye movements conducted using an Oculus virtual reality headset, as well as beat-by-beat blood pressure, heart rate, internal carotid blood flow, end-tidal $CO_2$, and middle cerebral artery velocity taken in controls and PPCS-CI patients. All physiological measurements will be collected through LabChart, which will be spliced based on comments indicating each portion of the eye movement protocol using MATLAB. The sectioned data will be further filtered and analyzed using MATLAB to determine if there is a significant difference in physiological measurements between control and PPCS-CI subjects. We hope the findings of this study will help improve prognoses for PPCS-CI patients, both locally within athletic teams at NJIT, as well as for the more general adolescent population.



# Book of Abstracts

## 2023 Undergraduate Summer Research and Innovation Symposium

## July 26-27, 2023