NJIT
New Jersey Institute of Technology

BOOK OF ABSTRACTS
Twelfth International Undergraduate Summer Research Symposium

Thursday, August 1, 2019

Book of Abstracts
Twelfth NJIT International Undergraduate Summer Research Symposium

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Symposium Coordinator: Ms. Angela Retino
McNair Coordinator: Ms. Zara Williams

Sponsors

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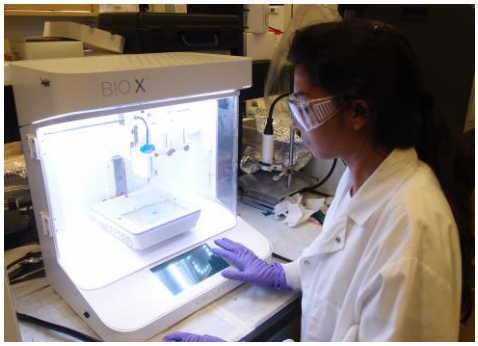

New Jersey Institute of Technology
University Heights
Newark, NJ 07102-1982

Joel S. Bloom
President

August 1, 2019

Welcome all – students, faculty, industry mentors, sponsors and friends of the university – to NJIT's Twelfth International Undergraduate Summer Research Symposium. It is exciting to see so many ingenious inventions, and the bright, enterprising minds behind them, gathered in one place. That some of you have joined our innovation hub from as far away as India is a testament to the power of collaboration in the service of progress – not just in our own state or country, but across the globe.

I want to especially thank the Provost's office for making undergraduate research a high priority on our campus, the students' advisers for their ideas and precious time over the summer, and our many sponsors for their generosity and commitment to helping forge the problem-solvers of tomorrow - today.

And to the more than 130 of you exhibiting your work at the symposium, congratulations! By thinking creatively, following through with diligence and tenacity – and even retooling when the evidence requires it – you have embraced the rigors of professional science. You make us proud, and we look forward to following your successes in the years to come.

Sincerely,

Joel S. Bloom
President

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Fadi P. Deek
Provost and Senior Executive Vice President

August 1, 2019

A message from the Provost:

Welcome to NJIT's Twelfth International Undergraduate Summer Research Symposium. I would like to congratulate all undergraduate summer research students, their faculty advisers, and program directors for the impressive research work exhibited here. The symposium demonstrates excellent interdisciplinary research and innovation by undergraduates who are honing their expertise as they prepare for leadership roles in science and technology. As it is critically important for all of our students to develop such skills, undergraduate research and innovation has been identified to be an integral part of NJIT's *2020 Vision* Strategic Plan.

I thank all staff members, faculty advisers, and program directors for organizing this impressive international symposium. Through the Undergraduate Research and Innovation (URI) initiative established by Dr. Atam Dhawan, senior vice provost for research, this year's summer research program has been significantly expanded and includes more than 130 students from NJIT and partner institutions.

The online publication of the Book of Abstracts of NJIT's Twelfth International Undergraduate Summer Research Symposium is excellent, as it showcases the wonderful research work done by our students and faculty, and will be archived through the URI website.

NJIT is committed to excellence in undergraduate education and research to provide our students exceptional learning experiences that enable them to become leaders in our global society.

I look forward to meeting summer research teams at the symposium and learning more about their exciting work.

Sincerely,

Fadi Piere Deek

Fadi P. Deek
Provost and Senior Executive Vice President

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Undergraduate Research and Innovation

August 1, 2019

I would like to extend warm welcome to all students and faculty advisors participating in the 2019 Twelfth International Summer Research Symposium. Congratulations to all NJIT undergraduate students, international students, high school students, faculty advisors and mentors for their impressive research work that spans over core and interdisciplinary areas including science, technology engineering and mathematics (STEM) as well as arts and architecture.

The spectrum of research projects pursued this summer clearly focuses on discovery of new knowledge along with application research addressing the needs and challenges of our global society for high potential impact. Opportunities to work during the summer on research projects bring a special focus as students are not stressed out with heavy course work. Through such opportunities, students get hands on working closely with fellow students and faculty advisors to gain valuable research experience that enhances their future career prospects whether they go to graduate or professional school, or join industry. The posters presented in the Symposium emphasize the fact that when our students concentrate on scientific and application research, they produce outstanding results with leading edge of innovation.

I am very pleased to present the "Book of Abstracts of Twelfth NJIT International Summer Research Symposium" that contains 100 abstracts submitted by symposium participants. We expect that the Book of Abstract will be used as a resource long after the symposium as an online publication. You can find it at the Undergraduate Research and Innovation website http://centers.njit.edu/uri/programs/index.php.

Organizing such a symposium requires tremendous efforts and time. I am very grateful to President Dr. Joel Bloom, and Provost and Executive Vice President Dr. Fadi Deek for their synergistic vision and kind support to undergraduate research and innovation. Special thanks to Symposium Coordinators, Angela Retino, from the Undergraduate Research and Innovation (URI) program, and Ms. Zara Williams, from the McNair program, and staff members from the Office of Communication and Web Services who helped in web publication of the Book of Abstracts.

Again, my heartfelt congratulations to all students, faculty advisors and mentors. I look forward to next year's symposium for more exciting and innovative research.

With best regards,

Atam P. Dhawan, Ph.D.
Senior Vice Provost for Research and Development and Distinguished Professor
Executive Director, Undergraduate Research and Innovation

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Ronald E. McNair
Postbaccalaureate Achievement Program

August 1, 2019

Welcome to New Jersey Institute of Technology's Twelfth International Summer Research Symposium. It is indeed an honor and a privilege to be part of this exciting event and to join with all the other individuals and groups that make up the event.

In particular, I would single out Zara Williams of the Ronald E. McNair Achievement Program and Angela Retino of the Office of Research for their efforts in coordinating the numerous summer activities culminating in the Symposium. Without them, we could not achieve the success this special showcase enjoys.

The 2019 Research Symposium is the 19th summer symposium presenting the research efforts of undergraduate students from NJIT's Ronald E. McNair Program. From its modest beginnings, it has grown into today's event, which includes more than 130 presentations by the students from the United States and India presenting over 100 research posters. This undergraduate research symposium is the largest such event held at NJIT. We are extremely proud of the research efforts of all these students, the quality of the research presentations, and the support of the NJIT administration, in particular President Joel Bloom, Provost Fadi Deek, and the Vice President for Research Dr. Atam Dhawan, as well as the faculty and staff in contributing to the success of today's event.

Angelo J. Perna,
Professor of Chemical
Engineering & Environmental
Engineering McNair Program
Director

Book of Abstracts
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PROVOST UNDERGRADUATE SUMMER RESEARCH PROGRAM

Creation of a PLGA encapsulated platinum nanoparticles drug delivery system for treatment of triple negative breast cancer using electrohydrodynamic co-jetting

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The aim of this study is to develop a targeted drug delivery system for treatment of Triple Negative Breast Cancer (TNBC). With no hormonal receptors to target, TNBC, accounting for almost 20% of all breast cancers, only has invasive and painful forms of therapies for treatments, such as chemotherapy, radiotherapy, and surgery. Chemotherapy drugs often make use of the anti-cancer properties exhibited by platinum (such as cis-diamminedichloroplatinum(II), commonly known as cisplatin). However, cisplatin is highly toxic and due to its systemic delivery kills healthy cells indiscriminately from cancer. In this study, platinum nanoparticles (PtNps) are suggested as a less toxic alternative to other platinum based chemotherapy drugs. A targeted drug delivery method is also proposed as an alternative to its current systemic delivery in order to make treatments less painful and more effective.

In this project, Electrohydrodynamic (EHD) co-jetting is used as the fabrication technique for drug delivery devices. EHD co-jetting is a method where dissolved polymer in organic solvent is pumped through a capillary needle with a high voltage applied to it in order to create solidified polymer structures. This method of fabrication is desirable due to the high level of control of size and shape of particles it allows for. Size and shape are two properties that are highly determinant of how and where a drug is delivered in the body. The platinum nanoparticles (PtNPs) were fabricated using a sonochemical technique. These PtNPs were then included in the jetting solution to create a polymer encapsulated PtNP delivery device. The main goals of this study were to determine how process parameters such as concentration of PtNP in solution, collection distance, pump speed, and solution composition had on the size and shape of the particles. We also aimed to create recipes of particles of approximately 50nm-200nm in size. Also in the scope of the project was to create a new fully sealed acrylic box for EHD co-jetting particle fabrication to occur in. The boxes used for earlier jets in our lab were not completely sealed as we were not jetting toxic chemotherapy drugs. In order to jet the particles for this study, it was necessary to create a new fully sealed box as an extra layer of protection.

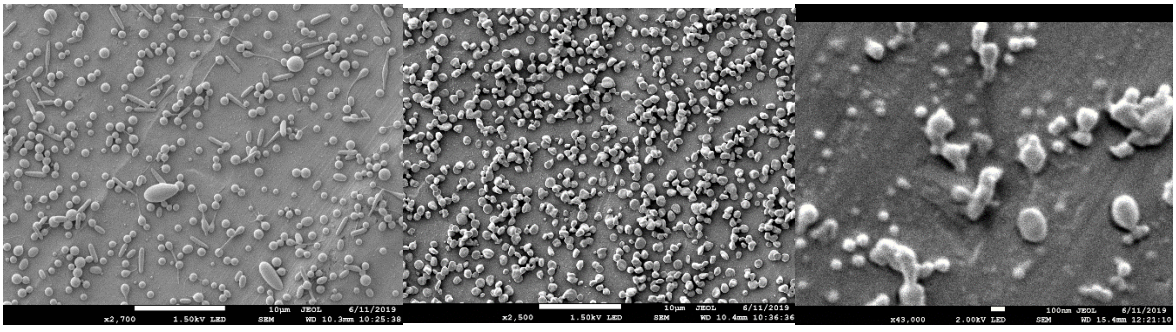

Figure 1: SEM images of EHD jetted particles resulting in different morphologies

Characterization of Cytokines Released for Post-Myocardial Infarction Therapy

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Cardiovascular diseases, including myocardial infarction (MI), are one of the leading causes of death and disability worldwide. The inflammatory response following MI is critical to the cardiac remodeling process. In this signaling cascade, cytokines are released by numerous cell types including macrophages and cardiomyocytes that contribute to both the pro-inflammatory and anti-inflammatory response post-MI. In this project, a novel *in vitro* myocardial infarction model is used to understand key cytokine interactions present between macrophages and cardiomyocytes in the post-MI microenvironment. Tissue inhibitor metalloproteinase-1 (TIMP-1), an inhibitor of matrix metalloproteinases, is a known anti-apoptotic and anti-fibrotic cytokine that is an interesting target for cardiac regeneration therapy. Several studies have shown TIMP-1 promotes cellular differentiation in numerous cell types. In our interest, overexpression of TIMP-1 in embryonic stem cell transplanted hearts post-MI have shown to contain significantly more differentiated cardiomyocytes compared to embryonic stem cell transplanted hearts [1]. Based on the results present in Figure 1, our *in vitro* co-culture model that mimics the post-MI pro-inflammatory response has shown an increase in fractional release, which is a measure of calcium handling efficiency. This data was collected prior to this project and suggests cardiomyocytes in the pro-inflammatory environment are more mature than other culture conditions. The specific goal for this summer is to directly quantify the presence of cytokine TIMP-1 in the *in vitro* model in order to look at how cytokine TIMP-1 can possibly have an effect on cardiomyocyte function in the presence of macrophage subsets. An ELISA is to be conducted in order to quantify the amount of TIMP-1 present in these conditions. This can lead to a greater understanding of TIMP-1 and its importance during and after the cardiac remodeling process.

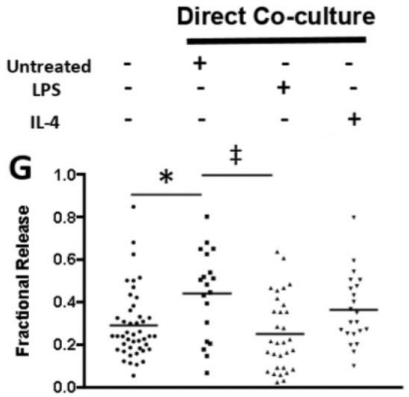

Figure 1: Ca^{2+} fractional release (N=6 independent trials, mES-CM Monoculture n=45, Untreated Co-culture n=19, LPS Treated Co-culture n=31, IL-4 Treated Co-culture n=22, Kruskal-Wallis and Games-Howell, *,‡$p<0.05$) [2]

[1] Glass, C., & Singla, D. K. (2012). Overexpression of TIMP-1 in Embryonic Stem Cells Attenuates Adverse Cardiac Remodeling following Myocardial Infarction. Cell Transplantation, 21(9), 1931-1944. doi:10.3727/096368911X627561

[2] Hitscherich, P., Xie, L., Del Re, D., Lee, E. (2019) The effects of macrophages on cardiomyocyte calcium-handling function using in vitro culture models, Macrophages affect cardiomyocyte calcium handling. Manuscript in preparation.

Determination of Mechanical Properties of a Rat Brain Using Simulated Indentations

Ilham Chahla, Advisor: Xianlian Zhou

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The key motivation is to understand mechanisms of Traumatic Brain Injury (TBI) with accurate material models of living brain tissues and high fidelity physical simulations. TBI simulations are challenging to conduct experimentally, causing researchers to veer toward the development of computer models to study the biomechanics of TBI. We will correlate the material properties of rat brain tissue material properties to indentation forces and displacements measurable by a laser equipped probe through parametric computational simulations. The proposed simulations will provide us the information needed to quantify the relation between materials, boundary conditions, and measured force and displacement, resolving the difficulty of traditional indentation methods with analytical deformation models on living tissues with irregular geometry and inhomogeneity. We will extract useful data correlations from regression, curve fitting, and implementation of machine learning models from simulation-generated data. The discovered correlations will later be used in a laser indenter developed by Dr. Liu of ECE to predict *in vivo* rat brain properties. This will ultimately enable us to study the homogeneity/inhomogeneity, isotropy/anisotropy, and linearity/nonlinearity of brain properties using both computation and physical measurements. These properties may be vital for developing hypotheses about disease mechanisms and potential preventive measures against TBI.

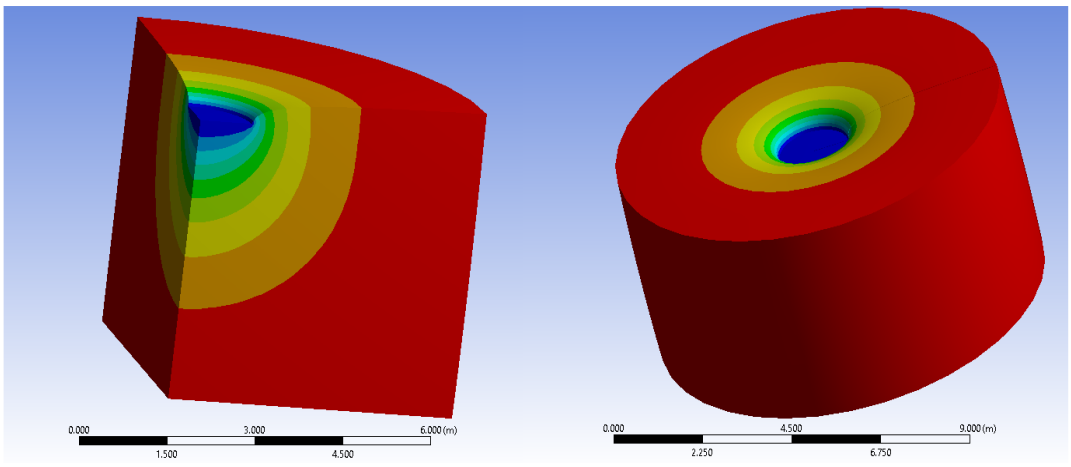

Figure 1: 2-D axisymmetric model simulated using Ansys Workbench to represent the total deformation in the indented specimen.

Subject-Specific Finite Element Models of the Foot Joint of Veterans with Spinal Cord Injury

Matthew DaSilva, Advisor: Dr. Saikat Pal
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New Jersey Institute of Technology, Newark, NJ, 07102 USA

Abstract: The goal of this project is to develop and utilize subject-specific finite element models to determine the risk of fractures of the calcaneus and other bones of the foot in Veterans with chronic SCI. People with spinal cord injury (SCI) have increased forces applied on their feet with upright standing and ambulatory maneuvers compared to their daily routine in a wheelchair. This sedentary lifestyle has shown that a loss of bone below the level of lesion after SCI in combination with weight-bearing activity may greatly increase the risk of fracture. The calcanei and, by extrapolation, the other bones of the foot appear to be at an increased risk of sustaining a fragility fracture while ambulating a powered exoskeleton. This becomes an interest as the VA's Spinal Cord Injury Services are prescribing exoskeletal devices for ambulation and require assistance regarding issues of safety. Because of the emergence of exoskeletal devices, the field of SCI Rehabilitation needs knowledge regarding the prevalence and extent of severe bone mineral density (BMD) loss in the foot. BMD is a value used to understand bone health, with specific regards to identifying the risk of fracture as seen in cases of severe loss.

By utilizing CT scan data, subject-specific models were created using the segmentation program Simpleware (Exeter, UK). These models were then assigned density values which correspond to greyscale intensity provided by the CT data. To ensure the accuracy of the greyscale values from the scans, known density lennite and hydroxyapatite rods were placed in the scanner as calibration points for the assignment of material properties. These models will then undergo Finite Element Analysis to determine the compressive and torsional strength of the bone and predict the likelihood of bone fracture while being loaded.

Figure 1

Fig. 1 shows raw CT image data. The Hydroxyapatite rod, used for calibration, is also visible.

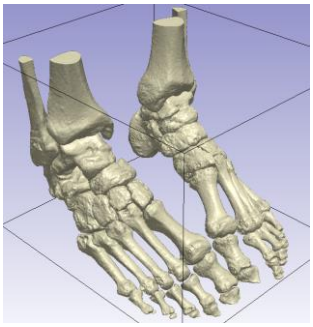


Figure 2

Fig. 2 shows a Subject-Specific Model created using CT image data.

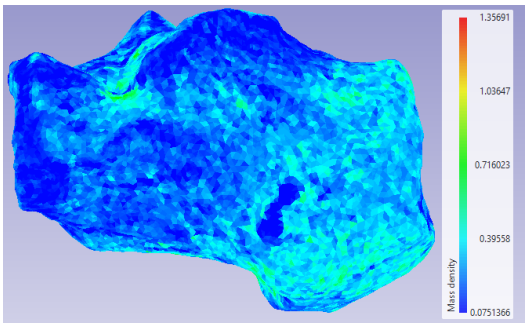


Figure 3

Fig. 3 shows the mass density of the calcaneus model based on the greyscale intensity of the CT data.

The Effect of Traumatic Injury on Glial Subtypes

Kelly DiCristina
Advisors: Bryan J. Pfister, Ph.D.
Department of Biomedical Engineering
Center for Injury Biomechanics, Materials, and Medicine

Traumatic Brain Injury (TBI) is an injury to the brain that can produce diminished or altered cognitive abilities or physical functioning, and despite its prevalence has unsuccessful clinical trails. To model the mechanical and clinical phenomenon of these injuries, an *in vitro* system has been used and shows changes in glial activation, proliferation and secretion of inflammatory mediators. Many studies focus extensively on how neurons are affected during these injuries; however, there is limited work that focuses solely on the effect on glial subtypes—astrocytes, microglia, and oligodendrocytes—acutely after injury. Glial cells support neurons through numerous avenues including metabolic, structural and immune support in the healthy brain. Because glia outnumber neurons in the brain, their exact role in injury is not fully understood as they have been shown to have dual roles being neuroprotective and detrimental. To determine the effect of injury on glial viability and reactivity, threshold of injury must be investigated.

To simulate an injury, strains e.g. 30% or 50% were tested to determine which would produce changes in cell viability immediately after injury. After determining a threshold for injury, a mild, moderate and serve injury standard will be set based off the current system design. Glial cells were stretched biaxially at strains known to cause neuronal injury and simulate injuries in the brains. Mixed glia and pure glial cultures were prepared and injured at the controlled strains. Functional changes were tested using Fluo-4 to indirectly measure the electrical activity of glia. To test for cell viability Acridine Orange (AO) was used to label living cells, and Propidium Iodide (PI) was used to label dead cells. In a mixed glial culture immediately after injury, increase in calcium response was observed at those strains as compared to before injury that gradually diminished over time (Figure 2). Injury in pure glial cultures also caused an increase in cell death and proliferation.

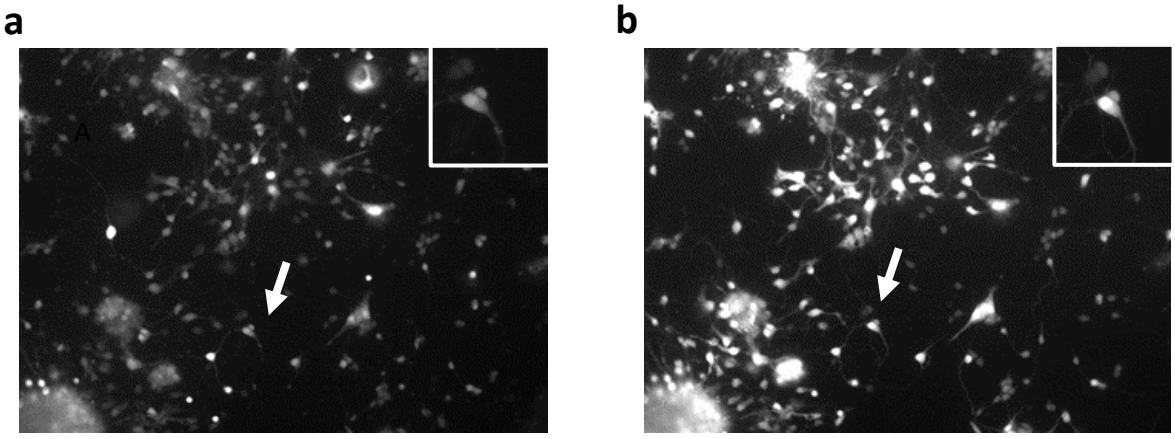
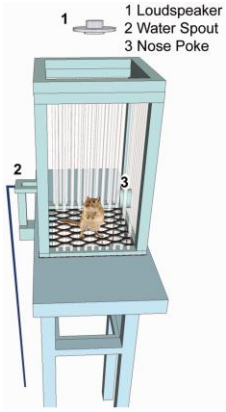


Fig. 1 Mixed glial cultures stained with Fluo-4 (a) before and (b) immediately after a 30% injury. The inset shows a representative cell calcium response before and after injury.

Effect of Tone Duration on Masked Thresholds in Gerbils

Madhusudan Duwadi, Mentor: Nima Alamatsaz (PhD student) , Advisor: Antje Ihlefeld
Department of Biomedical Engineering
New Jersey Institute of Technology

For a long period, scientists and engineers have been working to improve hearing ability in cochlear implant and hearing aid users. In quiet surroundings, hearing aid and cochlear implant devices can restore speech intelligibility. However, in noisy places like a restaurant or an airport, the majority of people with hearing loss still struggle to understand spoken words. Attempts at improving these hearing devices alone seem to have been unsuccessful in the restoration of hearing abilities. Several studies show that hearing loss changes not only the peripheral auditory apparatus but also the central auditory system. Changes in physiology should affect the central processing of auditory features in the brain. In particular, prior work shows that experience with hearing loss adversely affects the ability to hear out targets in situations with background sound. This may be due to widened neural filters or a reduced ability to combine information across neural filters or both. This project measures how the duration of target sound affects the ability of a normal-hearing animals to hear out the target when background sound is present. To establish the experimental paradigm, Mongolian Gerbils, *Meriones unguiculatus*, were trained and behavioral data were collected on normal hearing Gerbils.

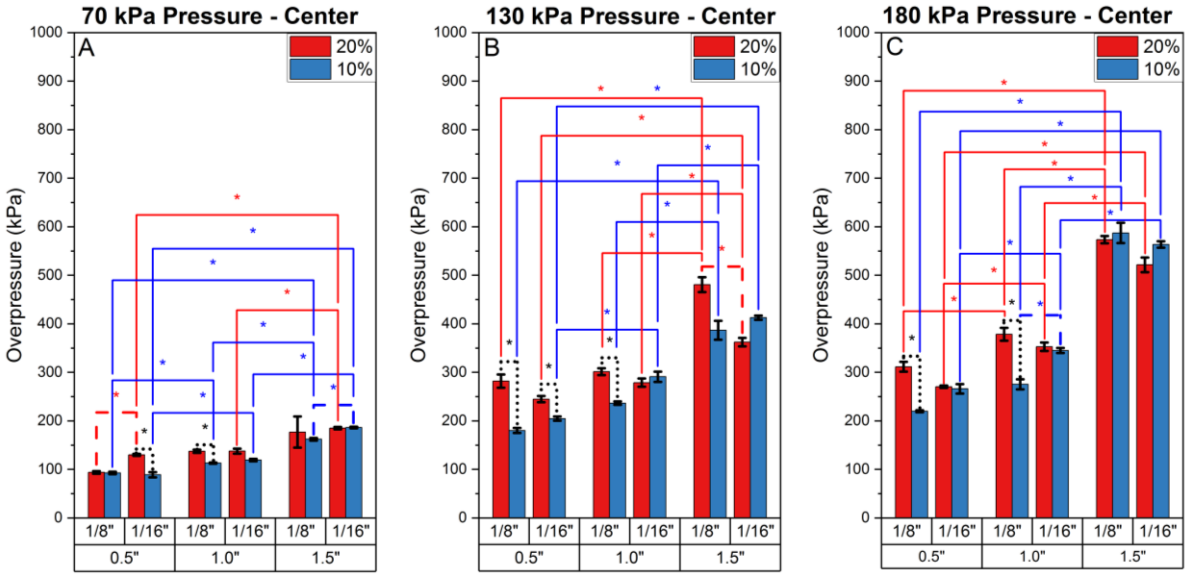


Firstly, Gerbils were put on water restriction and trained to associate a target sound to the water as a reward, motivated by a thirst for water. The adjacent figure shows the experimental setup of the cage inside a soundproof booth inside the lab. Gerbils were trained to perform a nose poke and wait for a target sound (1 kHz pure tone at 50 dB SPL for duration of 1 second) to get their water reward at the lick spout. The trials in which a target tone is played are referred to as GO TRIAL, whereas, the trials in which no sound is played are referred to as NOGO TRIALS. A FALSE ALARM was recorded every time the gerbil tried to approach the Lick Spout in the absence of Target tone (NOGO TRIAL). A background sound, also known as a masker, was played for the entire trial period with an equally spaced rise and fall in the amplitude of the sound with constant frequency over time (modulated at 10 Hz). Eventually, the duration of the target sound was reduced, starting from 1 second and gradually becoming shorter down to about 50 ms. Unlike before, in a shorter duration of target sound, there were less number of dips (gaps/silences) in the masker for the duration that the target was played. This made it harder for the Gerbils to know if there was any target tone as there was lesser amount of auditory information in this case to decide whether the target tone was present or not. This project tries to analyze the interval of time the Gerbil needs in between the two rises (or the time interval of dip/silence) to detect the presence of sound which in turn gives the amount of information required for the brain to detect the presence of sound. In the near future, the trained Gerbils will be subjected to craniotomy to insert the electrodes inside the auditory cortex to obtain the neurophysiological data which can be compared with the behavioral data obtained from this project. Going further, the data obtained from these Gerbils will be used to compare the data obtained from the hearing impaired Gerbils, as well as humans.

The relationship between the reflected and transmitted pressure in a simplified geometry model: a parametric experimental study

Thinuri Fernando & Supriya Iyer
Advisors: Dr. Maciej Skotak & Dr. Namas Chandra Mentor: Jose J Rodriguez
Department of Biomedical Engineering, New Jersey Institute of Technology, Newark NJ 07102

Soldiers in combat zones exposed to shock waves from explosions are susceptible to traumatic brain injuries. While the injury is caused by the transmission of the shock wave through the brain, the mechanisms of the shock wave propagation through the brain are not well-understood. The complicated geometries of the human head and variability in brain material properties for computational models make studying the problem difficult. Our project design obtains accurate pressure data using a simplified model of the brain. The model is composed of a 3" x 3" x 3" plastic box with a polycarbonate window (skull) and homogenous gel (brain). The front face of the box where the main transfer of shock wave occurs through is closed by either a thick (1/8 in) or thin (1/16 in) polycarbonate window. The box is filled with either 10% or 20% VYSE Professional Grade Ballistic Gelatin, a material used as a standard for ballistic tests. Two Millar SPR-524 miniature pressure sensors are used to measure the transmitted pressure inside the gel. The two sensors are located in the center and diagonal .85 inches towards the corner and are inserted into the back of the box through stainless-steel cannulas. The sensors are moved 0.5, 1.0 and 1.5 inches from the back wall. The box, filled with gel and instrumented with pressure sensors, is exposed to shock waves with three intensities: 70, 130 and 180 kPa. We gathered experimental pressure waveforms by the in-gel mounted sensor and strain. Statistical analysis in SPSS suggests that the effect of changes in depth (0.5, 1.0,1.5 in), gel concentration (10%, 20%), and window thickness (1/8 in, 1/16 in) on internal pressure is significant. Further analysis will be conducted to test for significance in relation to impulse (energy transmitted by the shock wave) and strain between the different depths, gel concentrations, window thicknesses and sensor locations.



I overpressure recorded by center sensor at shock wave intensity of A) 70 kPa, B) 130 kPa, and C) 180 kPa. Error bars represent standard error. Lines indicate significance ($p < 0.05$): 1) black dotted line: between gels, 2) blue and red dashed lines: between window thicknesses for 10% and 20% gel, respectively, 3) blue and red solid lines: between depths for 10% and 20% gel respectively.

Therapeutic Efficacy of Human Bone marrow Derived Mesenchymal Stem Cells in Blast-Induced Traumatic Brain Injury (TBI)

Swata Gade
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Blast-induced traumatic brain injury (bTBI) is the most common head injury in service members (SMs) and leads to severe physical, cognitive, and emotional impairments that impact the quality of life in many SMs. While the pathophysiological events contributing to bTBI are not completely known, studies have identified that blood brain barrier breakdown, oxidative stress and neuroinflammation synergistically contribute to the bTBI pathology. Treatment strategies aimed at bTBI are unsuccessful largely due to lack of understanding of how blast waves interact with the brain and cause injury. Recently, cell-based therapies using stromal stem cells have shown neuroprotective properties in various neurological disorders including stroke. Our present study investigates whether human bone-marrow derived mesenchymal stem cells (MSCs) mitigate neuropathology in rats exposed to moderate blast TBI. Accordingly rats weighing 320–360 g were subjected to 180 kPa blasts in a shock tube and 30 min after blast, MSCs (1x 10^6 fluorescently tagged with CellTracker Orange) were administered to rats subjected to blast by two routes, intranasal and intravenous, in order to examine the abundance of MSCs in the brain. 24 hours post blast, transcardial perfusions were performed in animals with 4% paraformaldehyde, and different brain regions (frontal cortex, hippocampus and thalamus) were sectioned (20 µm) and mounted. The Abundance of MSCs was analyzed in frontal cortex, hippocampus, and thalamus by immunostaining with anti-NUMA antibody that specifically reacts with human antigens (in this instance human MSC). Studies investigating neuroinflammation and reactive astrocytosis were performed by immune-fluorescence analysis using specific markers of microglia (Iba1) and astrocytes (GFAP). Results indicate that the abundance of MSC accumulation in brain was similar in both routes of (intranasal and intravenous) administration, although qualitatively intranasal administration lead to higher accumulation. Blast TBI resulted in microglial activation as indicated by a strong tendency of increase in number of Iba+ microglia in frontal cortex, hippocampus and thalamus. Likewise, Blast injury caused a robust increase in protein levels of GFAP, a marker of astrocytes. These results together show that blast TBI causes microglial activation and induces reactive astrocytosis. Interestingly both neuroinflammation and astrocytosis were significantly mitigated by the administration of MSCs. Studies investigating the efficacy of MSCs in pathological factors such as oxidative stress and other neuroinflammatory paradigms are being carried out. The overall results of this study strongly indicate that MSCs have a therapeutic potential to mitigate neuropathology (neuroinflammation and astrocytosis) associated with bTBI and offer neuroprotection. We believe these studies will open new avenues for the cell-based treatment strategies aimed to mitigate neuropathological and behavioral abnormalities in bTBI.

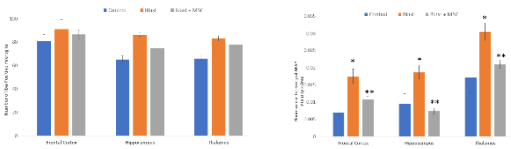

Figure: MSC administration mitigates microglial activation (left panel) and reactive astrocytosis (right panel) in different brain regions of rats exposed to moderate blast TBI.

Advanced Manufacturing of Tissue Engineering Materials: Relating Material Properties and Cutting Mechanics

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A number of Tissue Engineered Medical Device products are fabricated from animal derived starting materials. This includes porcine dermis which can be found in products used for breast reconstruction and hernia repair. Although porcine dermis is an established starting material, there is a lack of information on not only its material properties, but also its manufacturability. The purpose of this Advanced Manufacturing study was to evaluate the cutting mechanics of the tissue and how it relates to its location dependent material properties. Porcine dermis was obtained from Midwest Research Swine (MRS) who are a known provider of starting material to medical device companies. A custom steel-rule die press was used to cut samples for both material property measures and cutting mechanics data. This required the development of an *NJIT Makerspace* process to prepare Backing Material. The hardness and tensile properties of the porcine tissue samples were measured with a *Rex Gauge Hardness Tester* and *MTS load frame/ DIC camera System* respectively. Tensile testing was conducted on the speckled tissue (**Figure 1A**) until tissue failure. Sample location was determined by traditional methods. A *Cognex Vision System* process was also developed to automate the measurement of test sample location in the future. The cutting mechanics was evaluated with a custom built 1.2 ton *Instrumented Die Press* (**Figure 1B**). This unit provided preliminary results relating the cutting force and blade displacement in porcine materials from different locations. The material properties and cutting mechanics of the tissue samples were related to their location on the pig's body. The results were compiled to test the hypothesis that the properties are location dependent.

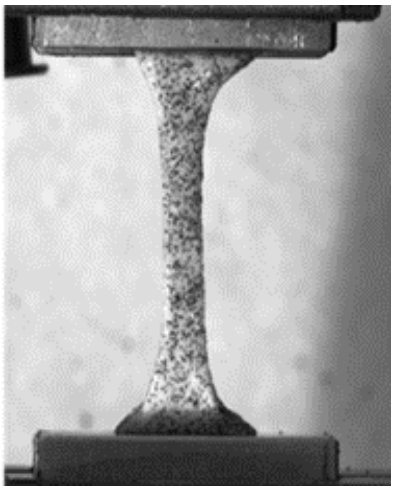
A	**B**
	

Figure 1. (A) Representative speckled tensile sample for DIC Tensile testing (B) Custom designed instrumented die press.

Directed evolution of KaiC, A circadian clock protein for Green Biofuel Production

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Abstract: The goal is to optimize cyanobacteria for sustainable fuel production, while mitigating the harmful effects of greenhouse gases (CO_2). We have become addicted to fossil fuels, which is not sustainable or renewable. We use nature to address economic and societal concerns. Photosynthetic organisms can provide a reliable fuel source. Cyanobacteria is an excellent candidate for biofuel production. Cyanobacteria are also the simplest know organism to have circadian activities. The production of glycogen biofuel depends on natural circadian rhythms, which follow the night/day cycle. Round the clock glycogen production is limited by this night and day cycle and as a result, this limits biofuel yield. In order to relieve this restraint, a new metabolic pathway will be designed into cyanobacteria to allow glycogen production. A switch will be engineered to allow day functions at night. To achieve this goal, the primary protein, KaiC, responsible in regulation of the circadian clock will be engineered to be active at night. KaiC function is associated with binding to its partner SasA. This binding results in protein regulation. A directed evolution strategy will be used to engineer KaiC. A KaiC library (~10^8 members) will be created and screened to discover an active variant(s) for gene regulation. A high throughput assay has been developed KaiC binding to SasA (Figure 1).

The directed evolution of proteins also produces novel protein sequences that can provide insight to the function of the wild type protein. The exact mechanism of the KaiC active site is not entire known, nor is the mechanism by which it binds with SasA. Thereby changing the residues around the active site and measuring the response, the importance of unsuspecting amino acids can determine for other lines of inquiry

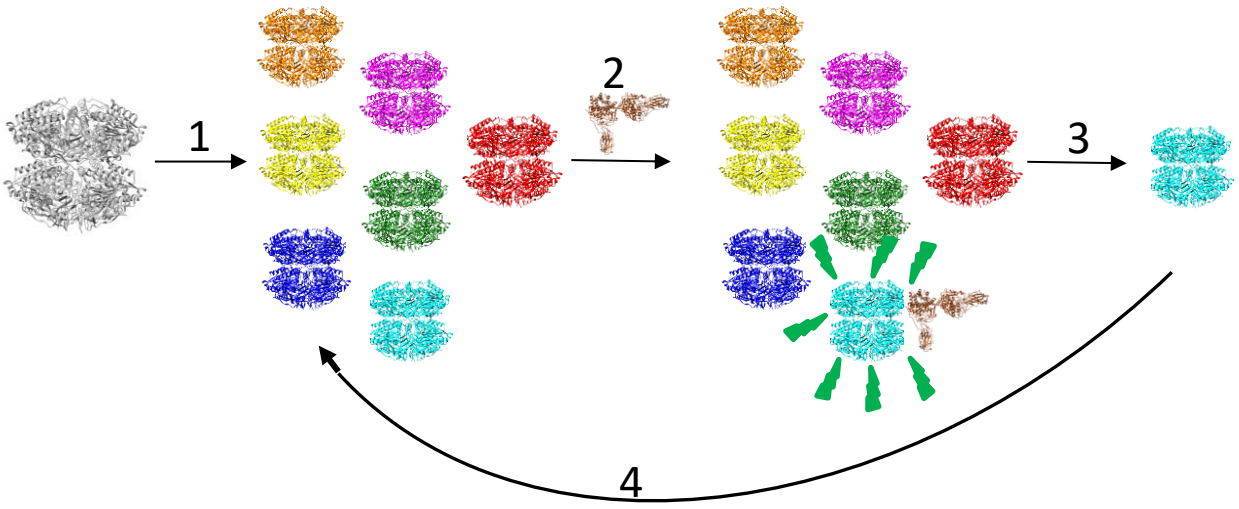

Figure 1. 2-hybrid bacterial screen for mut-KiaC binding to SasA. Step 1: A library will be constructed of wt-KaiC. Step 2: The library will be assayed for a member of mut-KaiC library that binds to Sas. Step 3: The winner will be isolated from the library. Step 4: The gene will be isolated and used as parent for the next generation.

Rehabilitating Stroke Patients through Adaptive Digital Environments

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Clinicians often instruct patients afflicted with strokes to perform in-home exercises such as marching in place, balancing on one foot, and sidestepping. The clinician supervises these exercises and makes adjustments based on the patients' needs and individual performance. However, because clinicians' face-to-face time is limited, it can be difficult to keep a patient performing said exercises consistently and correctly at home. Patients may become tired too quickly or may develop a habit that reduces the effectiveness of the exercise. VSTEP is designed to assist patients in performing their exercises and staying motivated.

The goal of VSTEP is to engage patients previously afflicted with strokes to perform their fitness, balance, and mobility exercises optimally through the use of a video game! In-game feedback and adjustment motivate patients to improve their exercise consistency, heart rate, recovery and overall physical health. With a Kinect sensor and a heart rate monitor, VSTEP simulates the patient's movement and heart rate within the game, guides the patient to performing correct exercises, and pushes the patient to achieve their ideal exercising heart rate. All of this, while done with the assistance of a supervisor, can be done without the need for constant readjustment from a clinician. Manual adjustments can be done as well, although the program is intended for automatic motivation and adjustment.

To properly guide the patient in their exercises, the displays two targets whose positions are affected by patient movement and patient heart rate. These targets indicate to the patient how high and wide to raise their knees for the marching and balance exercise. If the patient is successfully hitting these targets repeatedly, the targets raise slightly to encourage the patient to push further. If, however, the patient is struggling to reach the new target positions over the course of a few steps, the targets lower until the patient can reach them again. The targets also lower and raise in response to the patient's heart rate. If their heart rate is too high, and the targets will lower slowly, and too low of a heart rate will raise them slowly. This is done to ensure that the patient is within their ideal exercising heart rate ± 5 BPM according to either the Karvonan or Tanaka Heart Rate Formula and performing the marching and/or balancing exercise correctly. While the patient is exercising, all of their heart rate and performance data is being exported to a CSV file to be viewable to clinicians for future records.

Visual Analytics for Data-Driven Social Science

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Abstract: Governments worldwide have started to implement open data initiatives and also launch open data portals to enable the release of their large amounts of data in open and reusable formats. The design of most open data sites follows a strategy, where opening more data, instead of opening data better, has been the driving force.

We will develop a visual analytics tool for helping social scientists discover interesting data sets that help them ask and answer new questions about cities and societies. Our proposed visual analytics tool will transform the daily use of open urban data by social scientists and policy-makers for formulating their research questions and decisions. We will address the challenge of scale and complexity that analysts face while working with open data portals. These portals comprise too many datasets and various categories that could be of interest, yet, there is little guidance on how datasets could be potentially associated with answering specific analysis questions.

Interfaces like the NYC and Boston open data portals serve as collections with immense value for advancing social science research or evaluating alternative urban policies.
However, to tap into the value of these collections, currently, analysts spend a lot of manual effort for reconciling information from many datasets. This process is not only time-consuming and cumbersome but could also be counter-productive with many explorations leading to analytical dead ends. We will solve this problem by building novel visualization techniques that help social scientists connect the dots and understand how many disparate data sets can be semantically integrated for answering analysis questions.

$^{10}B/\ ^{11}B$ Kinetic Isotope Effect in Boronic Acid Oxidation

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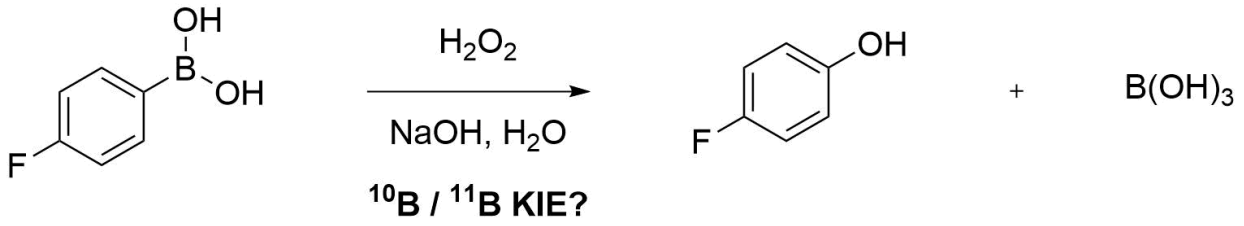
Organoboron reactions play an important role in the synthesis of many pharmaceuticals. Despite their widespread use in the industry, the reaction mechanisms of several well-known organoboron reactions are still incomplete. While Kinetic Isotope Effects (KIEs) have long been used in the determination of reaction mechanisms for other organic elements, there are no such protocol for boron. The development of such a protocol would allow for the investigation of many complicated organic reactions, such as the Suzuki-Miyaura cross-coupling reaction.

We have studied the utility of High-Resolution Mass Spectrometry (HRMS) in the quantification of boron KIEs. The simple oxidation reaction of 4-fluorophenylboronic acid to 4-fluorophenol by hydrogen peroxide in basic water was chosen due to its ease of preparation and its well-known reaction mechanism. Our objective was to determine the change in $^{10}B/^{11}B$ ratio in the reactant as the reaction progressed, and to use calibration curves to quantify the conversion. Using HRMS, we were able to measure both of these quantities in a single injection, and the experimental KIE of boron was calculated. We observe a significant change in the $^{10}B/^{11}B$ ratio throughout the course of the reaction, indicating a normal KIE. Density Functional Theory (DFT) calculations were used to validate our experimental protocol. Our presentation will demonstrate the feasibility of using HRMS in the quantification of boron KIEs and address the issues of reproducibility and precision of this technique.



Engineering Nanoparticles for Drug Brain Delivery

Nicole Loehle
Advisor: Dr. Xiaoyang Xu, Mentor: William Ho, PhD Student
Otto H. York Department of Chemical and Materials Engineering
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The Blood Brain Barrier (BBB) is the interface between the Central Nervous System (CNS) and the blood. The BBB is extremely selective of what can pass through to the brain, only allowing small molecules and specific proteins necessary for brain function. Unfortunately, this means life-saving treatment of neurological diseases, including Parkinson's, Alzheimer's, stroke, and brain cancer, are blocked from entering into the brain. Nanoparticles have the potential to overcome the BBB to deliver drugs and therapeutics to the brain. This research is focused on creating PLGA-PEG nanoparticles and attaching BBB- specific ligands to their surface to deliver therapeutics through the BBB into the brain.

To create our nanoparticles, we use Poly(lactic-co-glycolic acid) (PLGA) because it is a copolymer known for its biodegradable and biocompatible nature, as well as its ability to easily functionalize ligands through simple chemistry. We also use Polyethylene Glycol (PEG) because it is a polymer that allows for 'stealth' modification of the nanoparticle. This is important because nanoparticles can circulate in the blood long enough to reach their targeted area and deliver their therapeutics. We plan to have our nanoparticles undergo receptor-mediated transcytosis, where receptors must bind to their specific ligands in order for cells to take up the therapeutic payload. If the receptor binds to the matching ligand, a vesicle, or cellular sac used for transport, will encapsulate the ligand and carry it through the cell. We will conjugate a peptide (ligand) that is recognized by BBB endothelial cells to the surface of the nanoparticle so our nanoparticle can pass through the BBB endothelium using receptor-mediated transcytosis.

We used Transwell plates to create an in vitro model of the BBB by co- culturing endothelial cells and astrocytes to accurately mimic the human BBB environment. Transwell plates have a microporous membrane that will separate our endothelial cells (modeling the blood vessel) and our astrocytes (which models the brain portion). We have optimized the resistance of the cell monolayer by testing different ratios of the cell media. I have performed Transendothelial Electrical Resistance (TEER) readings to measure the resistance of the cell monolayer in Ohms. When resistance reaches its peak, the cells are confluent and tight junctions are fully formed, blocking passage into the lower compartment of the Transwell. In order to reach the lower compartment, the nanoparticles must undergo receptor-mediated transcytosis and bind to the receptors on the surface of the endothelial cells, so the nanoparticle can pass through the endothelial cell layer and carry the therapeutics to the astrocytes below.

Figure 1:

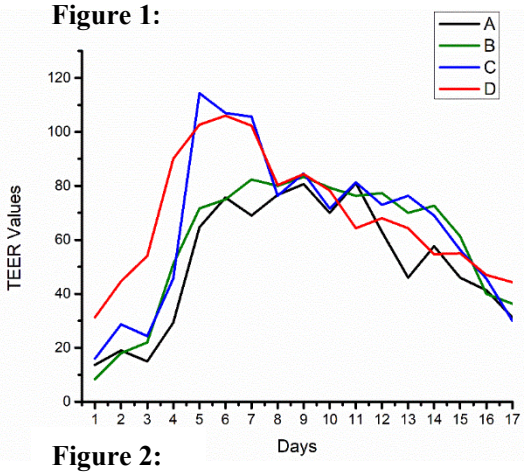

Figure 1: TEER values of four different conditions to investigate optimal seeding condition.
A: Endothelial cells with EndoGRO media, **B:** Endothelial cells with both EndoGRO and Astrocyte media, **C:** Endothelial and Astrocyte coculture with EndoGRO media only, **D:** Endothelial and Astrocyte coculture with both EndoGRO and Astrocyte media. Condition D will be used for future experiments because it shows the quickest rise in TEER resistance.

Figure 2:

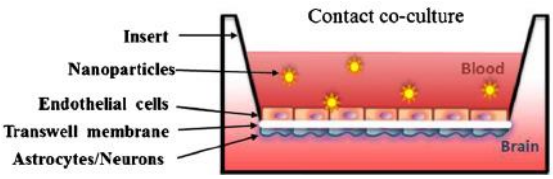

Figure 2: Visual schematic of a Transwell plate.
(McCarthy, Malhotra, O'Mahony, Cryan, & O'Driscoll, 2014)

Destruction of PFAS Using High-Frequency Power Ultrasound

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Abstract: Per- and Polyfluoroalkyl substances, known as PFAS, are a group of synthetic chemicals containing an aliphatic carbon chain in which the hydrogen atoms have either been completely or partially replaced by fluorine. Previously known as PFCs, these compounds have been manufactured since the 1940s and were used in several consumer products including non-stick cookware, paints, carpets, floor polishes, masking tape, and stain repellants. The unique properties of PFAS, including the strength of the C-F bond, hydrophobicity, lipophobicity, and surface tension lowering capabilities, have contributed to its widespread use in industrial and commercial areas. Due to these properties, most PFAS are extremely resistant to degradation. The use of these compounds in numerous applications coupled with their resistance to traditional environment remediation methods has led to the detection of a broad range of PFAS in the environment and the human body.

This research uses ultrasound to induce the sonochemical degradation of two common PFAS, perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA). The mechanisms causing sonochemical reactions in liquids are the phenomenon of acoustic cavitation, which concentrates and releases a tremendous amount of energy in localized areas, and pyrolysis, the splitting of molecules caused by high temperatures. The concentrated energy in minute-scale cavitation bubbles produces various radicals by the pyrolysis of water and dissolved gas molecules. Radicals are capable of initiating or promoting many fast oxidation reactions. The sonochemical reactions caused by the hydroxyl radical will lead to the destruction of PFAS within the reactor. For this study, the degradation of PFOS and PFOA was performed using two different configurations to produce an ultrasonic field, a horn transducer operating at 20 kHz and a plate transducer operating between 200 – 800 kHz. The 20 kHz transducer provides agitation, breaks up clusters of molecules, and increases the number of bubbles in solution. The high-frequency ultrasound plate produces the hydroxyl radicals, which oxidize and degrade organic compounds in suspension.

Variables such as sonication time, frequency, and PFAS concentration were examined to determine the optimal conditions within the reactor to generate the most significant removal efficiency. Results were analyzed using liquid chromatography/mass spectrometry to detect the presence of any organic pollutants remaining. KI dosimetry and sonoluminescence were used to evaluate the presence of hydroxyl radicals within the reactor.

Novel Drug Delivery System using Anti-Angiogenic Peptides for Glioblastoma Multiforme

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Glioblastoma, also known as glioblastoma multiforme (GBM), is an extremely aggressive type of nervous system tumor that forms on the tissue of the brain. Nourished by a large and complex network of blood vessels, the tumor cells reproduce quickly, making GBM one of the deadliest cancers. Glioblastoma accounts for roughly half of all brain and central nervous system cancers, with a one-year survival rate of less than forty percent and a five-year survival rate of less than five percent. Current standard of care for patients with newly diagnosed glioblastoma includes surgery, radiation therapy, and chemotherapy. One such treatment involves an in-situ drug delivery system. Following surgery, carmustine wafers are implanted in the tumor cavity. The wafers then slowly dissolve while releasing medication that will kill the remaining cancerous cells. These wafers, however, lack the ability to homogeneously coat and conform to the tissue voids of the resected tumor cavities, amongst other issues. To address this lack of proper fit, space-conforming peptides modified with an anti-angiogenic mimic will be developed as an injectable hydrogel. As indicated in previous literature, GBM is marked by aberrant vascular proliferation. These blood vessels support the tumor through nutrient delivery and cancer cell migration. It has been hypothesized that the peptides will be able to conform to the unique shape of the cavity and exhibit anti-angiogenic properties to address this abundant vascularization, thus minimizing chances of cancer recurrence.

Within this project, there are three main objectives to be accomplished. First, peptides of choice will be synthesized and purified into hydrogels. The first is termed SL-Kr5, with its mimic based on domain 5 of the extracellular protein Kringle. The second peptide, known as SL-LAM, is based on the laminin-1 protein. Lastly, the final peptide, known as SL-HP is based on the histidine-rich-glycoprotein. Once the gels are formed, their *in vitro* properties will be assessed through a tube formation assay. The assay will be run on several different types of endothelial cells (involved in blood vessel formation) to obtain a thorough understanding of the antiangiogenic capabilities. The effects of the peptide on the cells will be understood by measuring the extent of tube formation in terms of total length of tubules formed, as well as the number of segments, branches, junctions, nodes, and segments of vessels. The assay will be run using rat brain microvascular endothelial cells, rat retinal microvascular endothelial cells, and primary human retinal microvascular endothelial cells. It is expected that the peptide will allow for a dose-dependent destruction of the aforementioned capillary networks in each of the cell types, such that at higher concentrations of the peptide there is a stronger anti-angiogenic response observed. This will give us a clear picture of the anti-angiogenic effect of the peptides on these cell types, giving a strong indicator of how they will perform *in vivo* in future experiments. The successful completion of the objectives of this project will provide a clear and reliable understanding of the potential of each peptide hydrogel as an effective drug delivery system for the treatment of GBM.

Encouraging the Use of Built-in Language Features for Learning Control Flow

Student researcher:
Michael Mobilio (IT)

Faculty mentor:
Michael J. Lee, PhD (Informatics)

Abstract: This research attempts to develop a learning curriculum that encourages the use of specific control flow patterns in the JavaScript and Python programming languages. This is a technical approach that benefits the user by letting them construct, visualize, and follow specific control flow patterns through the use of the built-in features from their choice of programming language. This research aims to improve students' understanding and recognition of better control flows.

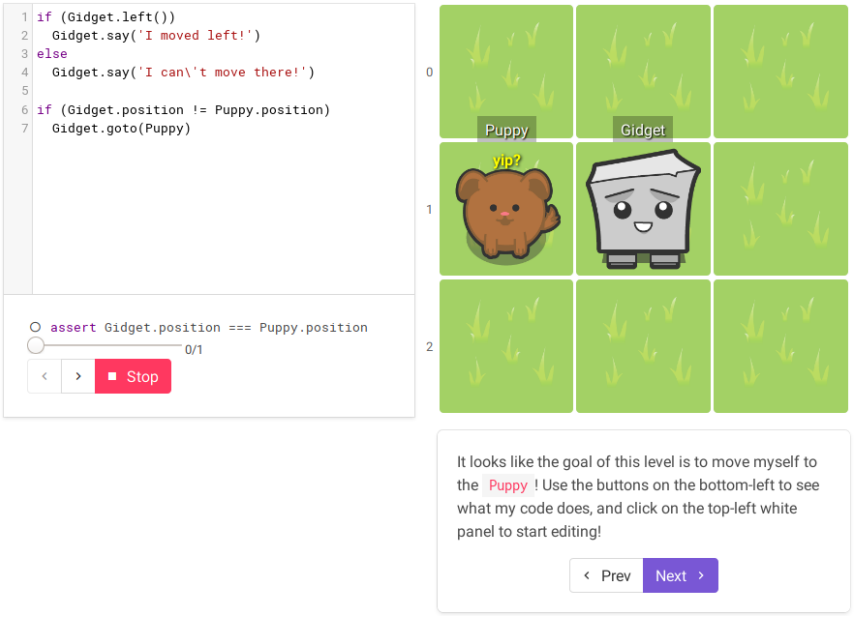

Figure 1: Sample challenge inside the Gidget 4 interface

Investigating the role of a genetically-conserved spinal neuronal class, *Dmrt3*, in the functional control of locomotion in zebrafish

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Understanding the neural circuits that underlie locomotion is key in furthering knowledge about the causes of motor behaviors and disorders. This project explores the role of spinal interneurons, linked to the gene *Dmrt3a*, in larval zebrafish. The interneurons have been observed in horses and mice, and these past studies suggest that they are linked to speed-shifting and locomotor coordination[1]. Our hypothesis is that the activity of *Dmrt3a* neurons is necessary for coordinating locomotion at different speeds. Although there is evidence for this hypothesis in other models, the function of these neurons has never been tested in a moving animal which can be manipulated experimentally. We will test the locomotive abilities of larval zebrafish lacking active *Dmrt3a* interneurons, as well as the effects of stimulation of the interneurons while larvae are at rest or swimming.

The aims of this experiment are accomplished through the use of a behavior rig and FishTracker software[2] that allows for the tracking of larval swimming behaviors like the following: tail-angle, tail-beat frequency, bout duration, interbout duration, bout distance, and average swimming speed versus grating speed. With these parameters it will be possible ascertain in a statistically significant way if the *Dmrt3a* interneurons are involved in speed-shifting or locomotor coordination. Furthermore, in order to accomplish the aforementioned, the experiment was split into two portions.

In the first part of experimentation we will use an OMR grating (optomotor response grating that facilitates swimming) at three different speeds and test it with two different groups of fish. The first group of fish is the wild type larvae which will act as the control, and the second group will be the experimental group or the *Dmrt3a*:Gal4;UAS:Botox-GFP transgenic line. The transgenic line of larvae have their *Dmrt3a* interneurons silenced using botox[3], which allows for us to conclude that differences in locomotion between the experimental and control group come about as a result of the lack of *Dmrt3a* interneurons. The second portion of experimentation uses the same control group of larvae, while the experimental group will be the transgenic line of *Dmrt3a*:Gal4;UAS:ChR2-YFP larvae. The transgenic larvae have channelrhodopsin2 on the *Dmrt3a* interneurons, which activates the neurons when they have light shined on to them[4] (this experiment uses a laser and an optic fiber as the means of light). Furthermore, the larvae will also be tested with an OMR grating, except this time the larvae will have their head embedded in agarose (free swim is not possible when activation of neurons requires concentrated source of light). This experiment will help to see if stimulation of the neurons leads to changes in locomotive behavior of the larvae.

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2. Marques, J. C., Lackner, S., Félix, R. & Orger, M. B. Structure of the Zebrafish Locomotor Repertoire Revealed with Unsupervised Behavioral Clustering. *Curr. Biol.* (2018). doi:10.1016/j.cub.2017.12.002
3. Satou, C. *et al.* Transgenic tools to characterize neuronal properties of discrete populations of zebrafish neurons. *Development* **140,** 3927–3931 (2013).
4. Kateriya, S. *et al.* Channelrhodopsin-2, a directly light-gated cation-selective membrane channel. *Proc. Natl. Acad. Sci.* **100,** 13940–13945 (2003).

Integrated Solid-Fluid Interaction Potential for Modeling Gas Adsorption in Templated Mesoporous Carbons

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Due to their high surface area, nanoporous materials have numerous applications in chemical engineering, such as separation processes, catalysis, and energy storage. We focus here on three-dimensional ordered mesoporous (3DOm) carbons, which are specifically promising as frameworks for zeolite crystal synthesis and for solid natural gas storage.[1] Because of the interconnection 3DOm carbons are also suitable for electrochemical applications as the narrow necks allow for efficient charge and discharge rate because of the improved diffusion of ions.[2]

Nitrogen adsorption is a standard technique used for the characterization of these materials with respect to surface area and pore size distribution. The relation between the experimental adsorption isotherms and the theoretical adsorption isotherm is commonly used to find the pore size distribution. The theoretical adsorption isotherm is often calculated using Monte Carlo molecular simulations using the fluid-solid interaction potential in a certain simplified geometry (e.g. sphere). However, the calculation of the potential in 3DOm carbons fails to account for the decrease in surface area due to the overlapping spherical pores.

The classical model for interconnection treats each pore as being connected by narrow necks, commonly referred to as the "Ink Bottle Pore". In this project a different model is used in which the overlap of the pores creates an interconnection between them, a window, thus altering the potential (Fig. 1). In complex materials, such as 3DOm carbons, the interconnection affects the desorption path, which can occur through pore blocking or cavitation.[3] This change in the mechanism of desorption is well documented for the "Ink Bottle Pore", but is not described in detail for other models. The potential (Fig. 1) generated by the overlapping pore model can be used in molecular simulations of simple gases in the future to discover the effects of window size on the desorption and adsorption branches and other variables. This way we are aiming to elucidate whether such a rigorous approach is necessary or if previous models, such as the "Ink Bottle Pore" are sufficient.

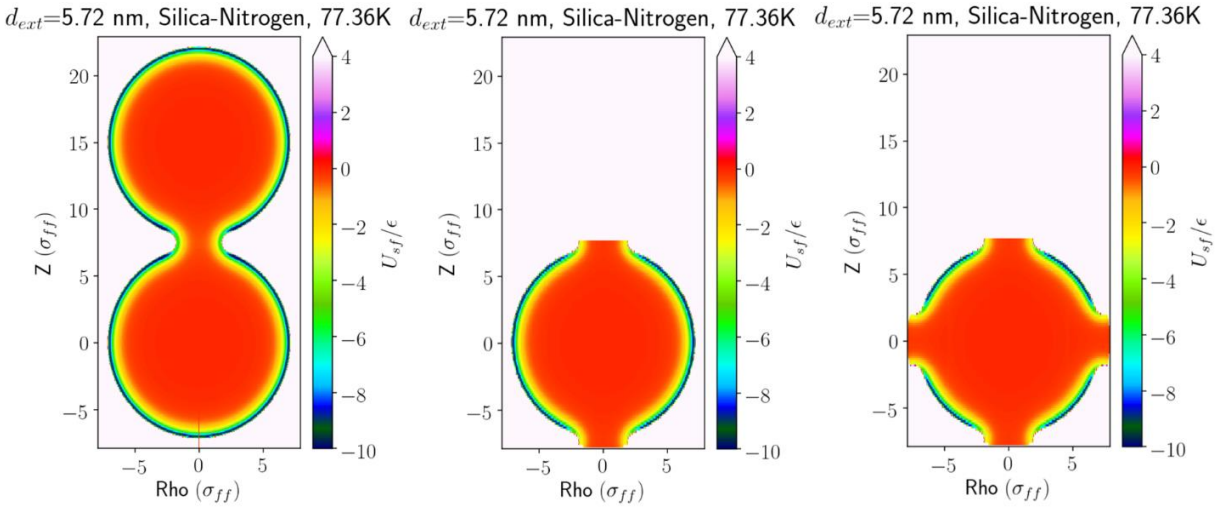

Figure 1. Models with a window size of 5 σ_{ff} for an overlapping pore, a 2-window, and a 4-window system. On the side is a color bar showing the potential at each point in the graph.

[1] Borchardt, Lars, et al. *Physical Chemistry Chemical Physics* 18.30 (2016): 20607-20614.
[2] Macías, Carlos, et al. *Carbon* 63 (2013): 487-497.
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A Low-Cost Electro-Mechanical System to create 3D scans using 2D LIDARs for Pothole Detection

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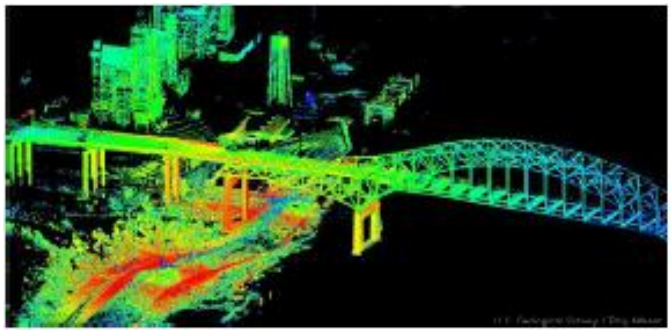
New Jersey Institute of Technology, Newark, N.J. 07102

A laser imaging detection and ranging sensor, or LIDAR, is a device that can map an environment by transmitting and receiving laser pulses and determining the distance of objects by the discrepancies in time and wavelengths of reflected laser light. The device has become widely popular for its multitude of potential applications, one of which is helping to solve 3D mapping problems. 3D mapping with LIDARs can be solved in a multitude of different ways — as such different LIDARs have their own properties and associated algorithms to solve the mapping problems.



Potholes on the roads today are costing the Department of Transportation (DOT) millions of dollars annually for repairs. In just the state of New Jersey alone, the NJ DOT spends over 4 million dollars each year to repair damage to roadways and highways[1]. Currently, the methods being used to detect potholes rely on manual measurements that include operators contracted to drive along the roadways and manually note the location and severity of potholes. There are several disadvantages of using this method: it is expensive, time consuming, and error prone. Our aim as part of an on-going effort at the Robotics and Data Lab (RADLab) in collaboration with the NJ and PA Department of Transportation is to automate the detection of potholes. We propose designing a novel electro-mechanical system that uses a 2D LIDAR to create 3D scans of potholes in an automated fashion by allowing the 2D LIDAR to move in 3 dimensions (along X, Y, and Z axis). Our proposed solution would provide automatic and accurate damage detection capabilities, quick setup time, and price point previously unavailable to our target customer segments -- traffic engineers and transportation operations personnel. The DOT as well as other infrastructure companies have expressed interest in automated solutions to detect potholes. The overall goal of this effort is to reduce the costs of pothole detection up to 50% while doubling the speed of detecting the potholes so that the DOT can allocate financial resources for other meaningful and necessary tasks.

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Theoretical Studies of Possible Topological Edge Modes in Novel Systems

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Abstract: This decade saw an immense development in the field of topology and has helped us explain various unexplainable properties. Remarkably, it is suspected that topology plays a role in a novel biological system, known as microtubules shown in Fig. 1 [1]. A better understanding of microtubules can help find a cure of cancer and other cell growth related diseases. In spite of relatively good understanding on how the microtubules grow, understanding of the shrinking process is lacking. Specifically, the onset of peeling off of polymer chains, as shown in Fig. 1(b), requires a better theoretical understanding. Experimentally, it is also suspected that the peeling off starts at the seam, as shown in Fig. 1. In this research project, we try to explore the phonon modes localized at the seam, particularly whether topology plays an important role, with the aim of explaining the onset of peeling off process. Periodic structure of microtubules allows us to borrow the concepts in solid state physics, such as phonon dispersion relation. We start by analyzing phonon modes of a simple helical coil made of monomer without seam under periodic boundary condition. We extend the model by replacing monomers with dimmers. We then add seam to the model and examine possible topological edge modes at the end of the seam, eventually to shed light on how the edges modes could affect the peeling process.

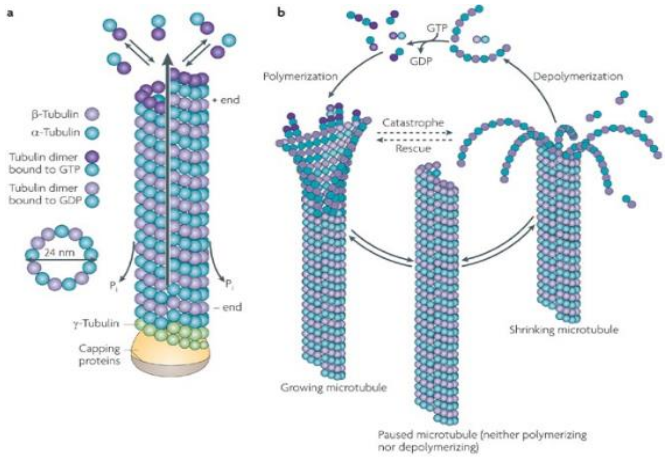

Fig.1. (a) Structure of a microtubule. (b) Shows the cycle of a microtubule.

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Producing Well-Defined Fibrous Structures in Tissue Engineering Scaffolds Using an Adaptable Collector for Electrospinning

James Nanchanatt, Advisor: Dr. Treena Arinzeh, and mentor Dr. Shuo Wang

Electrospinning is one of the most common scaffold fabrication techniques for tissue engineering as it is simple, inexpensive, and can produce fibers on the nanoscale. However, electrospinning is limited in its ability to finely control the microstructural properties due to the random arrangement of fibers. A novel electrospinning setup with a designed collector can overcome this limitation and improve repeatability of the electrospinning process from batch to batch. This collector will allow for the fabrication of cross-patterned scaffolds with improved control on spatial deposition of fibers in order to vary the interfiber spacing of the scaffolds, which is currently not possible through conventional electrospinning.

17 wt% PCL methylene chloride solution was electrospun according to our lab protocol for aligned electrospinning. The differences are that 1) A square aluminum foil was taped on the collector. 2) Once an aligned layer of fibers have been electrospun, the collector was peeled from the mandrel (while spinning is paused), rotated 90 degrees, and attached back to the mandrel by tape. Then the electrospinning resumed to create a second layer of aligned fibers that are perpendicular to the first layer, where the cross-pattern is formed. This spin-rotate-spin process was repeated until a scaffold with the desired thickness was fabricated as shown in Figure 1.

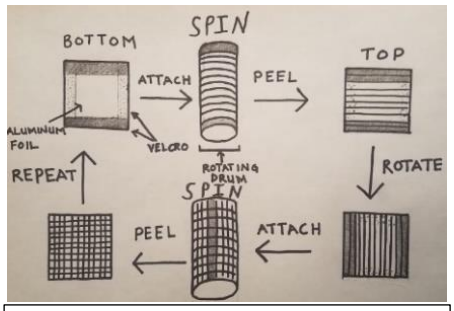

Figure 1. Illustration of the spin-rotate-spin process to create the cross-patterned structured scaffolds.

Preliminary results from SEM imaging show that the cross-patterned structure is feasible and that interfiber spacing and shape are consistent throughout the scaffold and across batches with square or rectangular interfiber spaces instead of random spaces. Further research will involve creating scaffolds with anisotropic tensile properties by varying the intervals of spinning periods to adjust the thickness of different layers, as well as creating an automatic collector that will reduce the labor involved in rotating and increase the frequency of rotations.

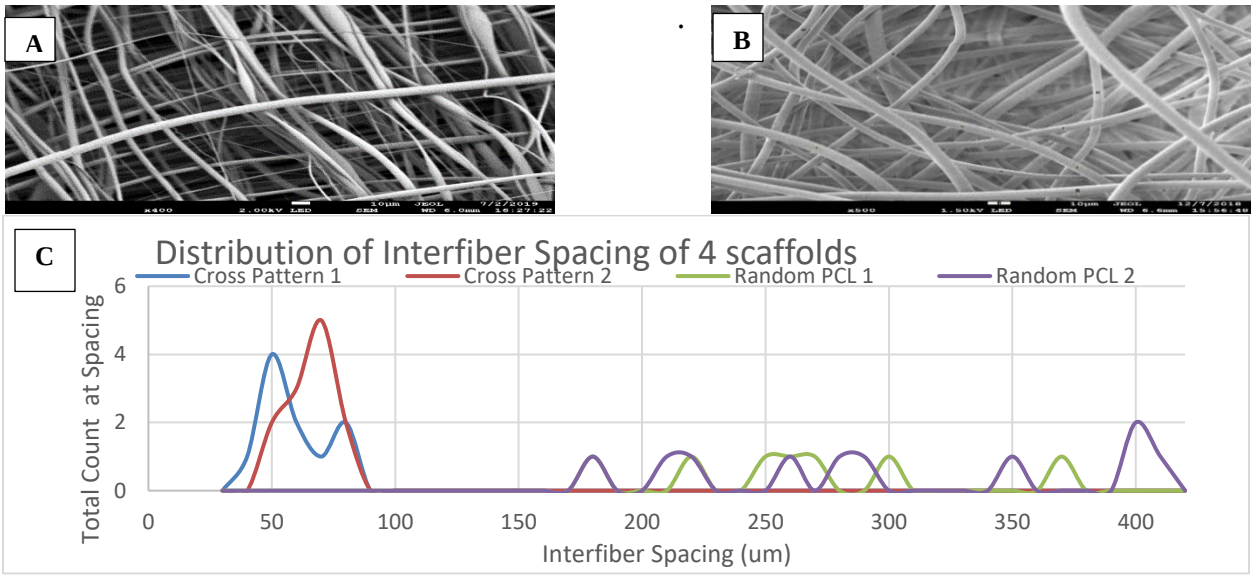

Figure 2. A) SEM imaging of PCL scaffold with cross-patterned structure and B) Random structure with similar fiber thickness. C) Interfiber spacing was calculated using ImageJ on SEM images from two sample of both scaffold structures according to our lab protocol. Greater uniformity of interfiber spacing was observed in the cross-patterned scaffolds as opposed to the random scaffolds.

Effect of contaminant mixtures in the Biodegradation rates

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Abstract: The goal of this research is to use extensive sampling methods to determine the contaminant concentration together with laboratory experiments to assess contaminant mobility from sediments and water. Sediments and water samples collected from different locations at the Ringwood Mines/Landfill Superfund Site, NJ were analyzed in the lab to determine which samples and locations has the highest amount of arsenic and benzene due to the possibility for enrichment of specific microbial degraders. Wet sediments of between 5 g to 10 g were incubated under varying conditions with 500mL to 100mL of synthetic water. The concentration of contaminants was monitored with time with most emphasis on arsenic and benzene. Benzene biodegradation experiments were carried out in two forms; under aerobic conditions using oxygen as an electron acceptor and under anaerobic condition endogenous electron acceptors present in the sediments, such as Fe(III), Mn(IV) and As(V).

Benzene concentration in water from locations with the highest concentration was measured using purge-and-trap GC and sampled periodically during and after each experiment. Benzene concentration in the sediments was also measured at the end of every experiment cycle.
Total arsenic concentration in was measured using the ICP-MS and periodically sampled during each experiment while arsenic concentration in the sediments was also measured at the end of each experiment cycle. The pH of the liquids was closely monitored during the experiment. Microbial population was determined and the beginning and end of the experiments by DNA extraction using DNA extraction soil kit and sequenced using Illumina sequencing. Sediments mineralogy was evaluated using XRD and FESEM-EDS in the sediment before and after treatment. Speciation in the sediments was also determined with XPS.

The results from these experiments are expected to inform local agencies and industries on the distribution and fate of legacy contaminants mixtures in superfund sites and wetlands in New Jersey and other states, as well as the attenuation potential of the mixtures in the contaminated site.

The Role of Neural Activity and Semaphorin Signaling in Neural Repair

Ishani Patel, Advisor: Dr. Gal Haspel
Department of Biological Sciences
New Jersey Institute of Technology

Our study focuses on understanding the mechanisms of neural repair at a cellular and molecular level. Most mammalian neurons of the central nervous system (the brain and spinal cord) do not have regenerative abilities. This deficit is the primary cause of the chronic effects of many neurodegenerative diseases, as well as neurological injuries, such as spinal cord injuries. Spinal cord injuries, caused by damage to the motor neurons of the spinal cord, often have permanent debilitating effects, including partial or complete paralysis. There are more than 12,000 incidents of SCI's in the United States annually, yet, unfortunately, there are no reliable treatment options. Through current rehabilitation treatments, patients can regain some function and sensation; often, full function is not restored. A neurons' ability to regenerate is dependent on several factors, including cell signaling and activity, however, the precise effects of the pathways and mechanisms are unknown. The limited treatment options along with the finite knowledge about neural regeneration makes research on neural repair critical.

Our project aims to use an innovative technique to determine the contribution of semaphorin signaling coupled with neural activity on dendritic branching patterns in mice cortical cells. The semaphorin signaling pathway, composed of semaphorin, the signaling protein, and plexin, the receptor protein, has a repelling effect on the direction of axonal growth during development. However, in dendrites, semaphorin is known to promote increased growth and branching. Through our study, we will determine whether dendritic growth is further affected by neural activity. We will alter neural activity within the cell using optogenetics, a technique that controls cell activity using light.

Two photosensitive opsins will be transgenically expressed within the cells: one that induces activity and has a red fluorescent tag, pCAG-ChrimsonR-tdT, and one that inhibits activity and has a cyan fluorescent tag, FCK-Arch-CFP. These opsins, when exposed to amber light (590 nm), either open a protein channel or activate an iron pump to control cell activity. All the cells will be transfected with a mixture of plasmids coding for the two optogenetic plasmids, and GFP that makes the cells visible for imaging. The random expression of the plasmids will create four experimental groups, which will be distinguishable by the different fluorescent tags on each plasmid: activated and inactivated cells (Green, Red, and Cyan), activated cells (Red and Green), inhibited cells (Cyan and Green), and a negative control (Green). During the five-day incubation period for the cells, they will be exposed to 5 Ms pulses of 590 nm light at a frequency of 100 Hz, to prevent overstimulation or habituation of the cells.

We will use Sholl analysis, a technique that uses counting within concentric circles around the cell soma to quantify parameters such as dendritic branching and length, to compare the results of our four experimental groups. We expect to see that activation will induce branching in the neurons, and this effect will be additive to the effect of semaphorin, whereas inactivation will negate the effects of the semaphorin.

Understanding Unidentifiability in Dynamic Models from Ground Truth Data

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Abstract: A really useful tool to scientists would be a machine that can take in input data and output useful equations that characterize that data and allow us to understand the dynamic mechanisms that govern the generation of these data. Different techniques exist for fitting equations to data and each one has different advantages and disadvantages. There are several difficulties associated with these tools. These difficulties are both technical (algorithmic nature) and structural (degeneracy, mathematical nature). Degeneracy refers to situations where multiple sets of parameter values can produce the same observable output (oscillatory pattern in neurons), therefore making the inverse problem (finding parameters given data) ill-posed. This is not a problem associated with uncertainty in the knowledge of a unique parameter set from which the data was generated, but a structural problem of mathematical models where multiple parameter sets are able to produce the same result, and has been observed in neurobiology experiments [1]. In this project we have developed ground truth models in order to calibrate and validate parameter estimation algorithms in the presence of degeneracy. We used "faked" data, generated by models exhibiting degeneracy in a number of attributes (e.g., oscillation frequency, oscillations amplitude, plateau/saturation level) and the so-called genetic algorithms [2] to estimate the parameters used in generating these data. Genetic algorithms are based on the theory of natural selection, where we make a random initial population of parameter set values and keep "breeding" them until we get the most "fit" parameters. The end result is a collection of parameter sets distributed in some fashion that minimizes the error between the data and the simulated models according to some metric. In the absence of degeneracy the distribution of estimated parameter sets is expected centered on the "true values" with a distribution width that is smaller the lower the noise levels used to generate the data (in the noiseless case, the distribution would be a delta function). In contrast, we show that because of degeneracy in a given attribute or attributes the estimated parameters sets are widely distributed with no apparent systematic rule except that of maintaining the attribute(s) constant.

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Central Auditory Pathology of Blast Induced Tinnitus/Hearing Loss

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Center for Injury Biomechanics, Materials, and Medicine NJIT

Blast-induced traumatic brain injury (bTBI) is one of the most prevalent forms of injury to soldiers in battlefield due to the use of explosive devices that not only cause brain injury but also create loud explosions that affect the auditory system. Partial hearing loss and/or tinnitus, a phantom auditory perception, are the common auditory problems encountered by service members discharged from active duty. While both peripheral and central auditory pathways are affected in tinnitus/hearing loss, the mechanisms responsible for these events remains unknown.

Therefore, in this study I first attempted to distinguish partial hearing loss from tinnitus by exploring peripheral auditory functions including gap detection and prepulse inhibition of acoustic startle response and other behavior tests. In these tests, the startle response of the rats to four different startle sounds were quantified to diagnose the rat for tinnitus or partial hearing loss. These tests were done with rats subjected to one single 180kPa blast at the 1d, 7d, 15d, 28d, and 42d timepoints. Preliminary data shows that only a few rats showed a significant difference in startle response before and after blast injury, which was statistically insignificant. These studies are being further continued using a large number of cohorts being exposed to mild, medium, high and multiple low-level blast overpressures.

We next examined the central auditory system (CAS) abnormalities, particularly the excitatory and inhibitory neurotransmitter receptor levels which are well known markers to establish central auditory damage in the auditory cortex using the immunofluorescence method. This data showed a significant decrease in the levels of NMDAR-1, a major receptor for the ligand excitatory amino acid glutamate in auditory cortex, in rats exposed to high-level blast (180kPa) at the 4h, 24h, 7d, 15d, and 30d timepoints (Figure 2). Interestingly, among these rats there was a concomitant increase in the levels of the $GABA_A$ receptor for inhibitory amino acid GABA in the auditory cortex (Figure 1). These results clearly indicate that an imbalance of excitatory and inhibitory neurotransmission contributes to central auditory pathology in bTBI. The levels of these receptors are being analyzed in animal models of low-level repeated blast at different time points. Understanding the mechanisms of the CAS system abnormalities as related to blast injury will significantly contribute to future therapeutic interventions to mitigate blast-induced tinnitus/partial hearing loss.

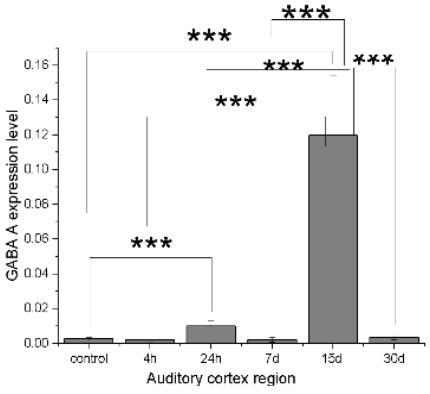

Figure 1. This figure shows an increase in the $GABA_A$ inhibitory receptor expression at five different timepoints post high level single blast (180kPa).

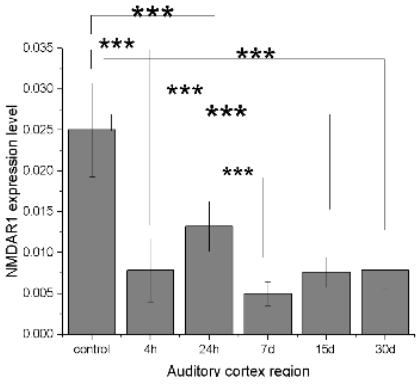

Figure 2. This figure shows a decrease in the NMDAR1 excitatory receptor expression at five different timepoints post high level single blast (180kPa).

Satellite Imagery of Insect Structures: Insights into Global Ecological Declines

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Insects form a majority of Earth's terrestrial animal biomass; they can constitute nearly two-thirds of all terrestrial biota.[1] These numerous organisms perform vital ecosystem functions that directly benefit other species, including humans. Recent data suggests that insects are decreasing in abundance at an alarming rate as part of the "sixth mass extinction", threatening the stability of ecosystems across the planet. Social insects are useful proxies as bioindicators due to their ubiquitous nature and can help to illustrate changes in ecosystems.[2] Some social insects modify their nests and local environment on a scale large enough to be observed by satellite imagery.[3] Using Google Earth software, images of these locations were collected from multiple historical snapshots. This included both ants and termites; locations containing multiple instances of social insect structures visible from satellite or aerial imaging were found in Southwestern North America, Central South America, Sub-Saharan Africa, and Northern Australia. Based on historical imaging, it is possible to see the change in the composition of insect-modified terrain over a period stretching from a year at some locations to nearly three quarters of a century at others. Significant differences in nest site composition throughout time were compared by nest number and nearest distance to neighboring nests. These data points were obtained with the program ImageJ, which provides analytical tools for 2D images. Data was then analyzed through a pipeline in R to assess general trends over time. A summary of image taking, ImageJ processing, and R analyses can be seen in **Figure I**. Preliminary results suggest sites don't decline uniformly across the globe and some site analysis may be hindered by a lack of historical satellite imagery. Thus far, the project has illuminated insights into insect colony change for certain sites along with the strengths and weaknesses of satellite imaging tools.

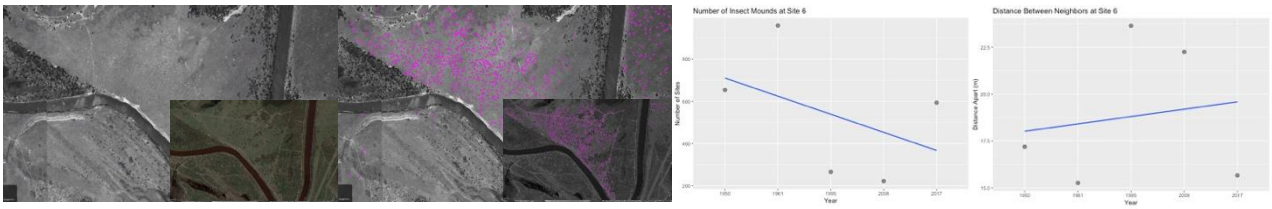

Figure I. Analysis of a site in Texas with multiple colonies of the ant species *Pogonomyrmex barbatus* (28°07'25" N 97°20'55" W). Sites are taken from 1950 up until 2017 as seen in the left most image (black and white is 1950 and color is 2017). Sites are then changed to grayscale and nests are marked with an unnatural color to be identified by ImageJ. The results of ImageJ analysis are saved and edited with an R script. The results can be seen to the right for site count and nearest neighbor distance.

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Apolipoprotein ε4 and Cholesterol Packaging in Alzheimer's Disease

Lindsey Riggs, Advisor: Dr. C. Dias, and Mentors: S. Jalali and F. Mahmoudinobar; PhD Students
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Alzheimer's Disease (AD) is a progressive loss of neurons which affects learning, memory and thinking skills. One contributing factor to the pathology of AD is the ApoE gene, which exists in three alleles known as ε2, ε3 and ε4. Individuals with the ε4 allele have a 45% chance of getting
AD, but having two copies of the allele increases the risk to about 50-90%[1]. This gene encodes for lipoproteins, which combine with fats in the body. For example, Low Density Lipoproteins (LDL), package and deliver cholesterol to the cells[2]. People with AD tend to have an abnormal accumulation of cholesterol in the brain which influences Amyloid Beta (Aβ) protein generation and is a factor in neurodegeneration[3]. Here, we worked on two computational experiments. In one experiment, we performed molecular dynamics simulations of the ApoE ε3 and ε4 proteins (fig. 1) using GROMACS which is installed at NJIT's supercomputer. We used the structure of these proteins that is available on the Protein Data Bank files (PBD) and the OPLS-AA force field. The Visual Molecular Dynamics (VMD) software was used to visualize the proteins. The overall goal of this project is to understand how ApoE ε3 and ε4 differ in terms of stability and how this may be related to the AD pathology. Different quantities, including the root-mean-square-deviation (RMSD) were used to quantify the stability of these proteins. We found that both isoforms are very similar based on their RMSD and their molecular structure (fig. 2). We started a second simulation involving the Martini force field to simulate how the ApoE ε4 protein interacts with cholesterol and water. In the second simulation, we want to analyze the relationship between the residues of the ApoE ε4 molecule and cholesterol.

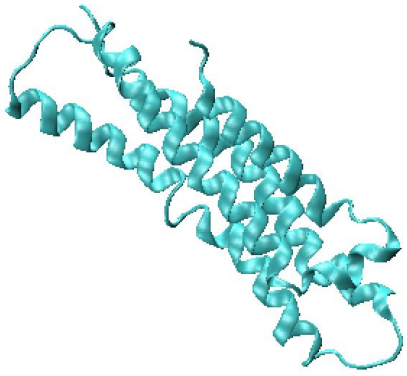

Figure 1: All atom structure shown from VMD of ApoE ε4. PBD ID: 1gs9

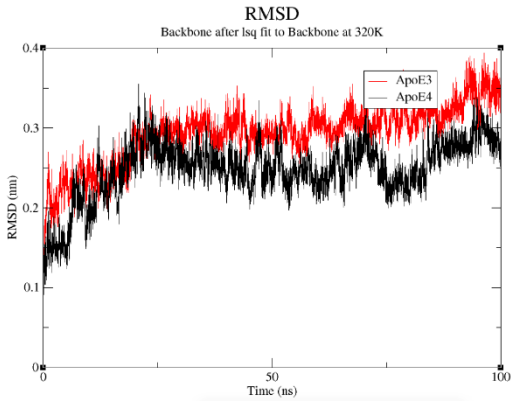

Figure 2: The RMSD graph with a least-squares-fit and calculation of the backbone for the ApoE ε3 and ε4. The RMSD shows structural stability over a period of 100ns.

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Multi-User Iterative Augmented Reality Development Application

Ian Spencer Rosenberg
Mentors: David Rodriguez, Dr. Margarita Vinnikov (MIXRLab)

Collaboration, especially in creative settings, becomes difficult when different people bring their ideas to the table. The problem is that although there may be a shared vision for a product or design, each participant has a different perception of what the final version should look like. To get all involved on the same page is difficult unless someone fabricates their vision and allows others to critique. This especially valuable if the vision can come live in 3D. Therefore, an application that can support 3D models to be projected into the real world provide can provide a powerful platform to share ideas among various stakeholders. This research aims to create an Augmented Reality (AR), collaborative space for users to create and discuss various spatial designs and strategies. Specifically, the idea uses multiple devices are viewing the same augmented content from varying perspectives. Hence, providing a sense of continuity as every user involved shares the same vision and creative space.

Figure 1: Collaborative session

To approach this problem, time was spent researching how to link different devices to create an augmented collaborative space. AR libraries created by Unity Technologies[1], Microsoft[2], Google[3], and Apple[4] have made the realistic projection of 3D models onto a real-world plane possible. We choose to use the Unity Multiplayer asset package[5] that requires to store as little information on the device as possible. Microsoft's Azure platform was also an important aspect, in that it stores the point-cloud data for cloud anchors[2]. These anchors allow for AR content to persist in a location for potentially undefined periods of time. Additionally, we choose to utilize knowledge of MySQL database tables and use PHP to access those tables. Finally, we integrated a Unity asset package TriLib that allows for loading models and their textures at run-time.

The result of this research (Figure 1) is a standalone application that uses an AR capable device and is capable of mapping space the user is in. The mapped space creates planes in which objects can be placed, of varying models. When at least one model is placed, manipulated, or deleted, changes can be uploaded to a cloud server that contains the relevant information for an anchored spot, such as the scene it belongs to, the user that placed it, and the object's internal identifier so that it may be located later.

In conclusion, we have built a project that currently supports Android platforms with an ARCore-capable camera, creates scenes, as well as upload them to the cloud. As a result, our project can be used by the director of an Opera that may direct their scene without the cost of materials for prototyping. The current work has stirred interest in applying the work done to other more expansive projects such as military and civil applications. The current system, however, requires additional devices, such as an AR-enabled camera to be incorporated as well as the system should work well both in augmented and virtual settings.

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Effects of Orthoptic Treatment on Convergence Insufficiency

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Convergence insufficiency (CI), the reduced ability to coordinate the eyes while performing near work such as reading, affects 4-9 % of the population. Typical symptoms include blurred or double vision, eyestrain, headaches, and the inability to concentrate when conducting near work. Vision symptoms in patients with CI can be remediated with Office-Based Vergence/Accommodative Therapy (OBVAT). Randomized clinical trials show that OBVAT has an effectiveness of 73% in CI patients. However, the underlying neural mechanism by which OBVAT is remediating symptoms is not completely understood. This study is designed to test the hypothesis that vision therapy will lead to CI patients having an improved ability to perform phoria adaptation.

This analysis investigated 50 CI patients who were diagnosed by one of the advisors (MS) who is an optometrist. CI was diagnosed as a near point of convergence greater than 6 cm, reduced positive fusional vergence of less than 15 Δ, and exodeviation greater than 4 prism diopters at near than at distance or failing Sheard's criteria. The phoria levels were measured subjectively using the flashed Maddox rod test and a Bernell Muscle Imbalance Measure card (Bernell Corp., South Bend IN). Of the 50 participants, half underwent active therapy and the other half underwent placebo therapy.

A 6 Δ base-in (BI) prism or a 6 Δ base-out (BO) prism was inserted in front of an eye to conduct a BI or BO phoria adaptation experiment at near (40 cm away from the participant). The details of this method are described in our prior publication. The phoria adaptation experiment was 7 min in duration. Processing and analysis of the data were performed using a custom MATLAB script. The rate of adaptation is calculated as the change in magnitude divided by the time constant of the exponential curve of best fit.

Primary results show prism-induced phoria adaptation substantially changed post OBVAT compared to baseline measurements for patients with CI, as shown in Figure 1. These results support that one mechanism by which vision therapy may lead to a reduction in vision symptoms is an improvement in the slow fusional vergence system to enhance a CI patient's ability to adapt to near or far space.

Figure 1

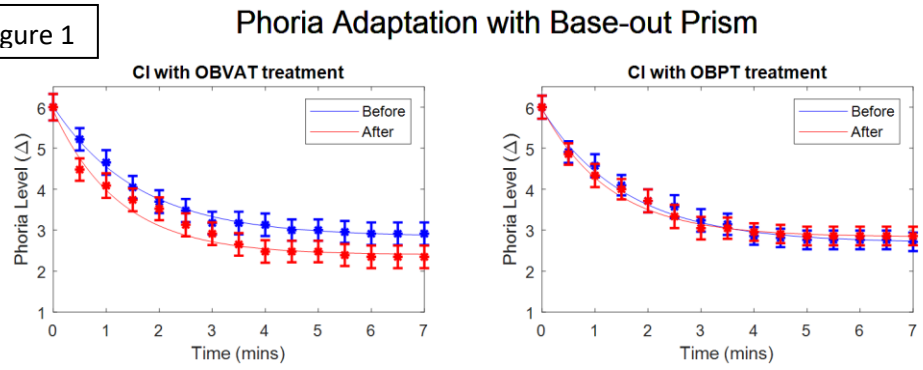

Fig. 1. Results of active (OBVAT) therapy are shown on the left while those of placebo (OBPT) therapy are shown on the right. The rate of the group data in CI participants with OBVAT improved from 1.97 Δ/min to 2.95 Δ/min with a 50% gain, which was the most substantial increase, while the CI subjects undergoing OBPT had no significant change after placebo therapy.

Cholesterol Management Using Hydrogel for PCSK9 Inhibition

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Currently, most patients manage high LDL-c levels with statins, drugs that block the enzyme that produces cholesterol. However, statins are not universally effective, and may even result in adverse side effects, such as incident diabetes [1]. This project seeks to investigate the efficacy of a new class of treatments, known as PCSK9 inhibitors. PCSK9 (proprotein convertase subtilisin/kexin type 9) is an enzyme that degrades cellular LDL receptors for LDL-c, as part of the body's natural cholesterol metabolism. By binding to LDL receptors in conjunction with LDL-c, PCSK9 forces the LDL receptor to remain in the 'active' position so it is not recycled, and instead digested by lysosomes within liver cells. Pep2-8, a biological mimic identified by Zhang et al. [2], competitively binds to PCSK9, preventing it from degrading LDL receptors. The biological mimic is delivered via injected hydrogel—a 3 dimensional polymer that slowly releases Pep2-8 at precisely the targeted location. By inhibiting the activity of PCSK9, this therapy will allow the body to naturally lower high levels of LDL-c, and may be more effective and safe than current statin therapy.

The hydrogel EPCSK9 is initially a non-viscous liquid. When hydrogelation is induced, the peptide becomes viscous and exhibits shear-thinning. Substances with this property have cross-linking between polymers under normal conditions that results in a viscous gel, but lose this cross-linking when force is applied, resulting in a material that flows like a liquid. This enables the peptide to be easily loaded into and injected from the dosing syringe as liquid; once in the body, the gel regains its viscous properties and is slowly released as a Pep2-8 drug molecule.

The therapeutic effects of EPCK9 hydrogel were investigated using an *in-vivo* mouse model. Mice were fed high fat diets, and their blood was drawn daily over the course of 8 weeks. Levels of cholesterol will be determined from the drawn mouse serum using High Pressure Liquid Chromatography, a method separates the desired LDL-c molecules, and that will be paired with Mass Spectroscopy in order to accurately determine LDL-c levels throughout the in vivo study. Mouse livers were collected and analyzed for LDL receptor quantities using SDS-PAGE and Western Blot. SDS is a molecule used to coat proteins from the liver samples, and PAGE is an experimental procedure that allows the quantification of LDL receptors by running the coated proteins through a gel that separates them by mass. Western Blot was used to visualize the differing quantities of LDL receptors separated via SDS-PAGE by electrophoretically transferring the gel results to a membrane that was incubated with two different antibodies. The primary antibody binds to the LDL receptors, allowing quantification, and the secondary antibody binds to the primary, and fluoresces to allow visualization of the proteins of interest.

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1. Spence, J. D., & Dresser, G. K. (2016). Overcoming Challenges With Statin Therapy. *Journal of the American Heart Association, 5*(1). doi:10.1161/jaha.115.002497

2. Lowe, J. (2013). Faculty of 1000 evaluation for Identification of a small peptide that inhibits PCSK9 binding to the low density lipoprotein receptor. *F1000 - Post-publication Peer Review of the Biomedical Literature*. doi:10.3410/f.718175417.793486831

Microwave Desalination: A Molecular Dynamics Approach

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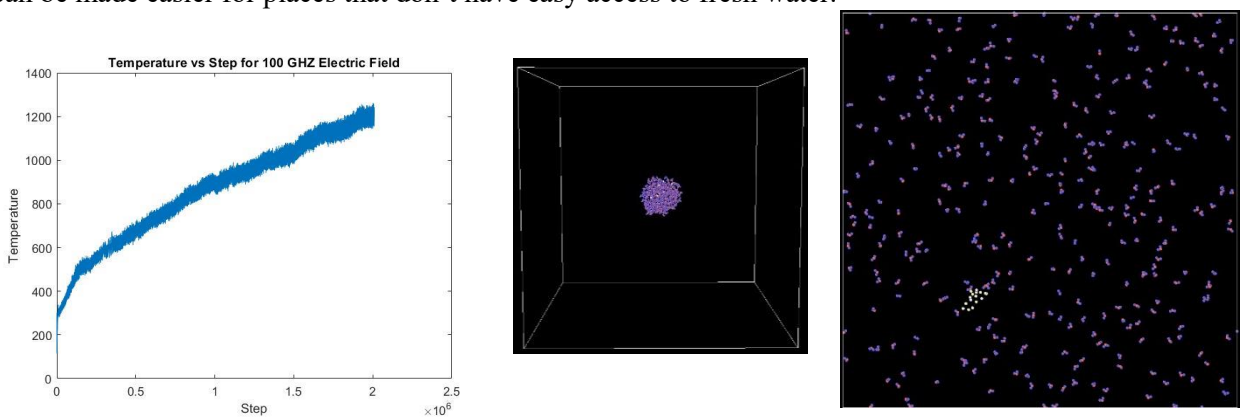
Abstract: Water Desalination is a method of purifying ocean water that is very costly and difficult to maintain. With a lack of fresh water readily available for a great amount of people, lowering the cost of this process is vital in helping places with a looming water crisis have access to the water they need. Currently, there are about 780 million people worldwide who do not have access to an improved water source**[1]**. The field of research in water desalination is very large in scale and there are many different methods that attempt to lower the cost of this process. The way that our research is different is that we are attempting to figure out a way to accomplish this task for even common folk to use. Our method of research for making water desalination is by using microwave heating.

In our research, our goal is to show the water desalination process using Molecular Dynamics, something which has never been done before. In order to do so, we used three main softwares which include: LAMMPS, Ovito, and MATLAB. Each of these programs were integral in creating our simulations. We used MATLAB to create the data files for the water droplets that would be readable by the computing software LAMMPS. Ovito was used in order to visualize the results that we would get from LAMMPS. Since microwave heating has not been applied in molecular dynamics before, extensive research was done into the topic and how microwave heating works. After having a clear understanding of this process, we were able to learn that there are two main components in microwave heating which include an electric field and a magnetic field. The magnetic field however is negligible due to its minor impact on the system. After understanding this, we created the water droplets using MATLAB and were able to add a block of NaCl (salt) to the system in order to replicate a drop of saltwater. We then applied the electric field using LAMMPS and were able to see the mixture of water and NaCl and eventually the evaporation of the water. After obtaining results we did a cluster analysis of the NaCl to see that the results we were getting seemed to be accurate as to what should actually happen. We applied frequencies of 2.5 Ghz, 10 Ghz, 25 Ghz, 50 Ghz and 100 Ghz, obtaining plausible results for all of the above. We will then work with an experimentalist who has a method of catching the vapor that will occur after the microwave heating is applied to further our results. We wish to publish a paper on our conclusion in hopes that the process of water desalination can be made easier for places that don't have easy access to fresh water.



Figures: Upward trend of temperature caused by an electric field which shows evaporation occurs successfully (left), simulation image of salt water before heating (center), and evaporated water with NaCl cluster showing the separation of the two after heating has occurred (right).

[1] "Global WASH Fast Facts | Global Water, Sanitation and Hygiene | Healthy Water | CDC." *Centers for Disease Control and Prevention*, Centers for Disease Control and Prevention, www.cdc.gov/healthywater/global/wash_statistics.html.

Evaluating the Effect of Skull and Brain Stiffness on Shock Wave Propagation in a Rodent Finite Element Model

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The injury mechanisms that characterize blast-induced traumatic brain injury (bTBI) have proven to be difficult to investigate. Studies with humans are impractical and, therefore, animal models are often used. Finite element (FE) modelling provides the necessary tools for identifying and characterizing a rodent FE model, but requires accurate material models of the brain and skull. These material models will be used in the simulation of bTBI exposures with varying overpressures, the results of which will be compared to experimentally-measured intracranial pressures (ICPs) to identify the best constitutive material models that can aid researchers in selecting an appropriate constitutive model for the study of bTBI.

The rodent FE model used was developed from a micro computed tomography and magnetic resonance imaging scan of a 10-week old male Sprague Dawley rat which was segmented into the skin and soft tissues, skull, brain, and dura. The material properties for these biological tissues were represented using constitutive material models found in literature. The brain constitutive model was varied by parametrically varying the brain material properties, altering the elastic modulus of the linear viscoelastic material between 1.314 kPa and 13.14 MPa. Additionally, several viscoelastic models reported in literature were examined. Similarly, the linear elastic constitutive material model of the skulls was parametrically varied, with the elastic moduli varying between 100 MPa and 20 GPa with the Poisson's ratio changing between 0.22 and 0.3. These models were subjected to a mild primary blast wave of varying overpressures between the lower end (70 kPa) and upper end (180 kPa) of blasts associated with mild bTBI. The influence of the skull and brain material properties on the time varying pressure and strain profiles, including the maximum ICP, the ICP profile, the pressure transmission pathway, and logarithmic strain values within the rat head, was examined.

The baseline model, using the most common material models for the brain and skull, was shown to accurately predict ICPs under a mild shock (70-180 kPa) by comparing simulated incident pressure at the test location and simulated ICP with experimental measurements during a blast exposure ($n=4$, $p<0.01$). Parametric variation of the brain material properties highlighted that the ICP was largely insensitive to the viscoelastic brain constitutive model and highly dependent on the elastic modulus. Varying the material properties of the skull increased maximum ICPs and strain values in more compliant skulls. More compliant bone material models introduced oscillations in the ICP profile, which are associated with increased flexure of the cranium. This is evidenced by the increase in skull strain as pressure waves pass through.

The developed model demonstrates that a spike in ICP is exhibited closely following the incident overpressure. This work identifies an appropriate constitutive model of a rat skull for use in FE research through the cross-validation of simulation and experimental results. It further identifies the effects of blast loading on rodents with varying skull and brain material properties, validated with experimental ICP and strain measurements. Further work will seek to connect observed mechanical loading pathways and patterns to microscale injury cascades.

Robotic Leg Prototype for Balance Stability Analysis and Control

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Abstract: Innovative technologies have allowed humans to make many cutting-edge inventions. The possibility of replicating human anatomy and physiology have led to the most challenging engineering projects. As such, the goal of this project was to develop a small-scale robotic leg prototype as a research platform that represented a simplified model of an anthropomorphic biped system. The robotic leg prototype for this short-term summer project was targeted to achieve balance in the anterior-posterior directions of the sagittal plane. In anatomical terms, the sagittal plane divides the body into right and left parts and involves flexion and extension motions. The data from this research was then used to validate the novel Balance Stability Boundary (BSB) criterion as a method for the analysis and control of balance in legged systems. The BSB criterion is a computational method that can quantify the balance properties of a given system beforehand, by the generation of a graph representing a stability map. This stability map determines whether an individual/robot is balanced or not. If the center-of-mass (COM) of a robot is within the BSB, then the legged system can be balanced by means of joint actuation only; otherwise, outside of the BSB the system is in an unbalanced state and must shift foot positions or receive external support to attain stability. The extrapolated COM was determined by using the velocity and position vectors to generate the BSB graph.

The robotic leg prototype consisted of 3 joints (hip, knee, ankle) and 4 links (torso, upper leg, lower leg, foot). The length of each link was determined by applying human proportions to the small-scale leg. A 3D printing machine at the NJIT Makerspace was utilized to create the structure of the robot (links) as well as the plastic foot plate, which was attached to the ankle joint of the robot. The joints were actuated by the Dynamixels servo-motors, which were controlled by an Arduino microcontroller through a Dynamixel Shield. Using C++ programming, the Arduino was capable of sending, receiving, and storing data such as angular positions and velocities of the joints, allowing for the creation of a static movement region for this robotic leg as demonstrated in Figure 1. Dynamixels also provided the flexibility for "daisy chaining", which is the ability to link the actuators to one another rather than directly to the shield, allowing for longer connections.

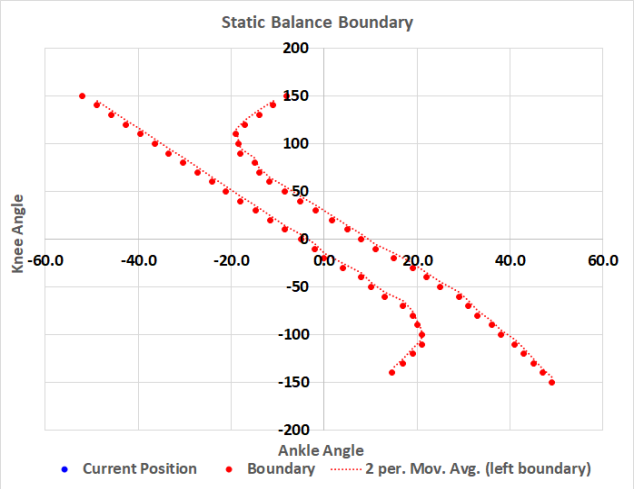

Figure 1. An experimental dual-joint configuration static balance region which is identified by the region in-between the two boundary lines.

Numerical Models for Morphology and Optics of Soot Nanoparticles

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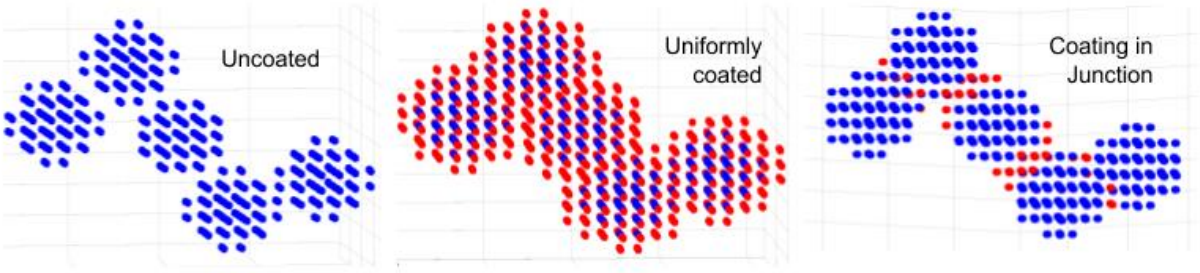
Soot, also commonly called black carbon, is formed from the incomplete combustion of carbonaceous materials. Atmospheric soot is made up of small nanoparticles, which are clumps of even smaller graphitic spheres. Soot nanoparticles absorb light strongly, and this makes soot the second biggest contributor to global warming, right after CO_2. The interaction of soot with light depends on the arrangements of the graphitic spheres and the presence of other chemicals, which condense on soot particles to form a coating layer. The arrangement of small spheres is usually open at first, but it may become compact in the presence of a coating layer. This coating can either be spread uniformly over the soot particles or can be concentrated in the junctions between the spheres. The way the coating layer is distributed governs the light absorption and scattering by soot. I have developed computer simulations to model these different soot particles. The soot particles and the coating layer in this model are represented by distinct units of volume, which are assigned appropriate refractive indices (see figure below). These models were then fed into ADDA, which uses Discrete Dipole Approximation (DDA) to calculate the light absorption and scattering by solving Maxwell's equations for the interaction of light with these dipoles.



Using my program, I created three models of soot - uncoated, uniformly coated, and with coating in junctions. It was observed that when the soot particles were coated, both light absorption and scattering were increased. Further, for the same amount of coating, when the coating was concentrated in junctions, the light absorption and scattering were higher than when the coating was distributed uniformly. In the future, I plan to validate my computations against experimental measurements on soot particles generated in the lab using combustion. The current numerical methodology - DDA - is computationally expensive and, thus, cannot be used directly in atmospheric models. I will use data obtained in experiments and DDA calculations to develop an approximation for light absorption and scattering by soot in a computationally efficient way and within a reasonable margin of error.

Development of Tap2Talk Design for Medical Patients With Speech and Motion Deficiencies

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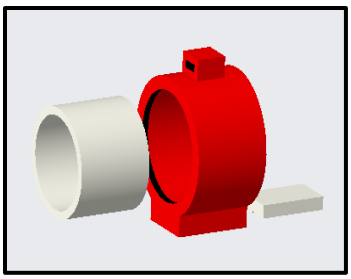
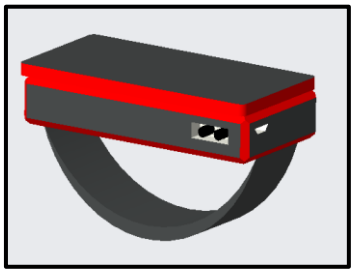
In the United States, there are anywhere from 6-8 million cases of individuals suffering from communication disorders such as apraxia of speech. These disorders are onset from a large number of incidents such as heart attacks, strokes, vehicular accidents, or work injuries. Despite such a largely affected population, the current market does not provide an easily accessible and affordable communicative tool for individuals with both speech and motion deficiencies. The need for a communicative solution is especially critical during the period of time between when an individual has been diagnosed and is completing therapeutic recovery. Currently, those devices available on the market can range anywhere from $250 to $2000 with those having greater levels of customization being even more expensive. Therefore the goal of this project is to design and develop an assistive speech rehabilitation device called Tap2Talk, which would allow such individuals to effortlessly control a menu of communicative phrases on their smartphone.

In an effort to cater to those with motor skill disorders, our design uses a touch sensor in a wearable ring to to control a smartphone application. The ring is wired to a wristband that houses a microcontroller and a bluetooth module to wirelessly connect with the user's smartphone.

A single hand gesture allows the user to navigate through the smartphone application menus and select from a number of pre-defined phrases, which are read aloud from the smartphone's speakers once the selection is made.



Ring w/ Sensor



Wristband w/ Micrcontroller

Smartphone Application

Investigation of Particle Noise Produced by Tip Sonication

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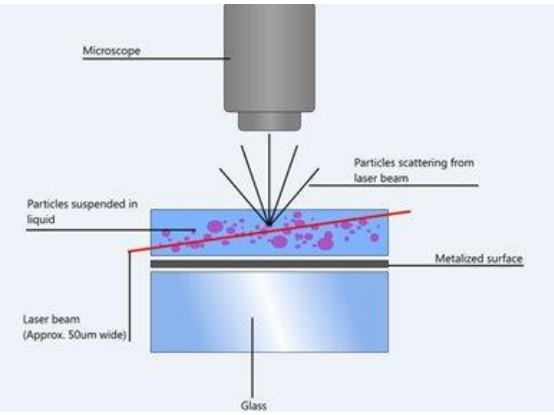
The tip sonication of nanoparticles can cause micelle formation in test tubes which can result in major data misinterpretation and faulty results for researchers analyzing nanoparticles. The process of tip sonication is implemented by all researchers who work with nanoparticles to disperse particles. This method is often applied when nanoparticles are synthesized. Low retention, plastic microcentrifuge tubes are typically implemented to store particles, however, previous research has discerned contamination following tip sonication in these tubes. The contamination generated by particle noise from the tube potentially can result in major inaccuracies.

We seek to optimize the process of sonication and reduce data misinterpretation through determining conditions which minimize particle formation. We investigated how particle concentration under different conditions, including brand of tube used, amplitude and process time, can impact the concentration of particle noise produced. Furthermore, we conducted experiments in which we tip sonicate several samples before we tip sonicate the sample we will be analyzing with the nanosight tracking analysis device in order to ensure that the device has been thoroughly cleansed. Another cleansing method we used was implementing a bath sonicator to sonicate microcentrifuge tubes submerged in ethanol in a sealed, large falcon tube. In addition, we have conducted experimentation to confirm that the particles we are examining are not bubbles by examining each sample twice. The second examination has been conducted in intervals of ten, twenty and thirty minutes. To apply tip sonication, we will implement a Qsonica sonicator.



The contamination of micelle particles can be examined closely under the Malvern's Nanosight NS300. Through the analysis of particle size and analysis of size distribution, this device utilizes the properties of both light scattering and Brownian motion. The nanoparticles are suspended in the chamber of the Nanosight. A laser beam passes through a prism edged glass flat within the sample chamber. As this occurs, the particles which are in suspension scatter light. A microscope with x20 magnification detects the scattering of light and the CMOS (complementary metal-oxide semiconductor) camera records frames of this. Malvern provides us with software which calculates sizes and size distributions of the particles which are recorded.

Future work in this project will include tip sonication with dry ice as it has been oncluded that sonication under conditions of lower temperature are optimal.

Molecular Mechanism of the Circadian clock in Cyanobacteria

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Abstract: The circadian clock is a 24-hour biological rhythm in the body which controls many time-related activities, such as sleep and wakefulness. The simplest circadian clock is that of the cyanobacterium; it is the only one that can be reconstituted *in vitro*, making it feasible to study. The oscillator in cyanobacteria is composed of three proteins: KaiA, KaiB, and KaiC. Mixing these proteins expressed from E. coli in a test tube can generate the circadian oscillation of KaiC phosphorylation. The A-loop of KaiC is naturally buried in a network of hydrogen bonds. KaiA activates KaiC phosphorylation by exposing the A-loop of KaiC. KaiB then sequesters KaiA by binding to it, causing the A-loop conformation to return to its buried position and KaiC to dephosphorylate. These processes of phosphorylation and dephosphorylation continue, generating a 24-hour cycle. Previously published data have deduced that breaking the hydrogen bond network can also expose the A-loop, causing KaiC to phosphorylate [1]. This experiment will determine if KaiA truly needs to be present to promote KaiC phosphorylation. Confirming the role of this protein can provide insight into the molecular mechanisms behind the circadian clock. One can further understand how environmental time cues, such as temperature, the light-dark cycle, and alterations of the biochemical system, can synchronize the 24-hour circadian cycle.

In this study, site-directed single mutations at the Glutamate-487 residue of the A-loop will be performed to break the hydrogen bond network. E487S will modify this amino acid to Serine and E487D to Aspartate. If a mutation that breaks the hydrogen bonds induces KaiC phosphorylation, without the presence of KaiA, it can then be said that KaiA is not necessary to initiate KaiC phosphorylation. Analysis of KaiC's *in vitro* oscillation rhythm will confirm the functional role of the protein KaiA. Understanding the molecular mechanism of the clock may help uncover the links between biological clocks and medical problems related to the clock's disruption.

[1] Kim, Y.I., et al., (2008). The day/night switch in KaiC, a central oscillator component of the circadian clock of cyanobacteria. *Proc Natl Acad Sci U S A, 105*(35): p. 12825-30.

Computational Modeling of Friction Between Two-Dimensional Materials

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Abstract: Nanoscale tribology, the science of friction, wear, and lubrication at the nanoscale, is an active field of research because it has implications in many fields of pure and applied science[4]. This makes this research valuable for lubrication industries. The global lubricants market size was valued at USD 128.51 billion in 2018, which included industrial, automotive, marine, and aerospace applications[5]. These industries are trying to implement different Two-Dimensional (2D) materials like graphene and boron nitride (hBN), so that they can make more innovative lubricants which are cheaper and more efficient. This all starts by understanding these materials at the nanoscale level. Computational results studying friction between bilayers (two sheets) of these 2D materials at the nanoscale can provide input to experimentalists for optimal experimental design, which would save a great amount of time, manpower, and money. This work would also create a better understanding of the physics of friction at that level.

The goal of our research was to compute this friction computationally, or rather shear stress, between different bilayers of 2D materials, including (1) graphene – graphene, (2) boron nitride – boron nitride (3) graphene – molybdenum disulfide, (4) molybdenum disulfide – molybdenum disulfide, and (5) graphene – hydrogen covered graphene. To computationally model this friction, we used Molecular Dynamics (MD) simulations with the open source software LAMMPS (Large-scale Atomic/Molecular Massively Parallel Simulator). The visualization tool Ovito was used to visualize the simulations, and the programming language MATLAB was used to plot shear stress and compute the coordinates of each atom for each system. Energy minimization was performed for a single sheet of each 2D material to confirm theoretical lattice constants (distances between unique pairs of atoms) before analyzing friction. The gap distance for each bilayer was also confirmed before by minimizing the force on each sheet to zero. Hydrogen coverage percentage between the bilayers also play a role in the friction[6], and different percentages were considered when computing shear stress for the graphene bilayer. For future research we hope to consider different bilayers and study friction when sliding the sheets at different loading angles (directions).

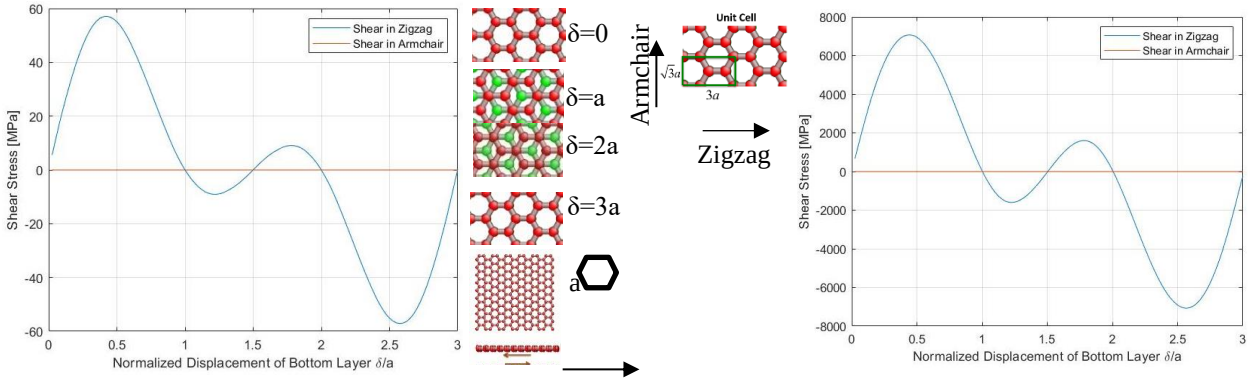

Figure: Shear stress in zigzag and armchair directions for graphene-graphene (left) and hBN-hBN (right) bilayers by sliding/displacing the bottom sheet (green) in the zigzag direction (center).

[4] B. Bhusna, J. N. Israelachvili, U. Landman, "Nanotribology: friction, wear and lubrication at the atomic scale", Nature, 373, 6523, 607-616, 1995
[5] "Lubricants Market Size, Share & Trends Analysis Report By Product (Industrial, Automotive, Marine, Aerospace), By Region, And Segment Forecast, 2019 - 2025", Market Research Report, Report ID: 978-1-68038-123-8, May 2019
[6] Yalin Dong et al., "Atomic roughness enhanced friction on hydrogenated graphene", Nanotechnology 24 375701, 2013

In Vitro Modeling of Traumatic Brain Injury

Nirali Trivedi
Research Advisor: Dr. Joshua Berlin, Co-Signer: Dr. Bryan Pfister
Department of Pharmacology and Physiology at RBHS

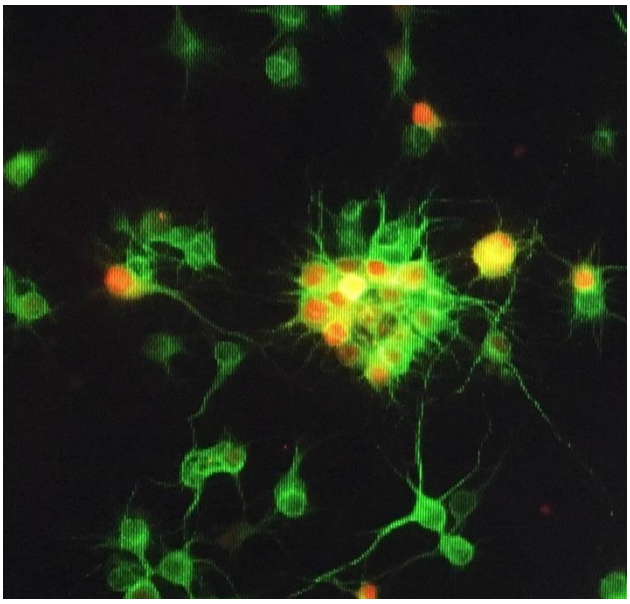

Figure 1: Stained neural cells

Traumatic brain injury impacts millions of individuals throughout the world. Research in the traumatic injury field focuses on understanding mechanisms that initiate deficits in the cognition and motor function after injury. In this regard, in vitro models of injury are particularly valuable to study cellular and molecular injury mechanisms. The goal of this project is to utilize neuronal cell cultures obtained from mice to study mild traumatic brain injury, as a model to the neural deficits seen in patients. This research model begins with cell cultures of fetal cortical neurons that are maintained until mature neuronal networks are present. To characterize these cultured neurons, calcium imaging experiments were performed. It was determined through these experiments that spontaneous calcium transients were present at 13 days in culture, indicating that the neurons were active. Synchronized calcium transients were noted at 21 days in culture, indicating that the neurons were communicating in neural networks. Further experiments include more calcium imaging as well as possible stretch injury protocol implementation, concentrating on the effects of mild traumatic brain injury. When the mouse neuronal culture system is successfully implemented, experiments using electrophysiology, calcium transient measurements and knockout mice will be used to analyze the activity of both injured and non-injured neurons. Data gathered from the experiments and analysis of the activity can lead to the development of more effective treatments for patients affected by traumatic brain injury, leading to the alleviation of detrimental side effects such as seizures and cognitive impairments.

Brain Function and Neuroplasticity with TBI

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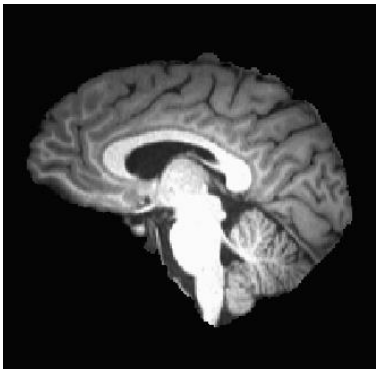
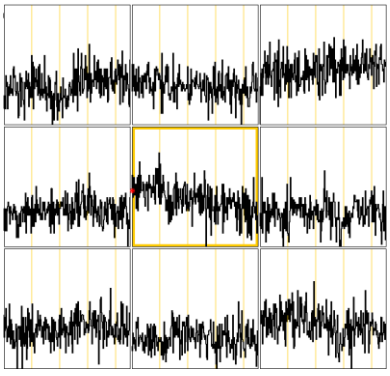
Traumatic Brain Injury (TBI) is a serious health problem worldwide that substantially contributes to numerous deaths and can cause moderate to severe disability. Beyond damaging cells and tissues, injuries to the brain can interfere with synaptic connections between neurons and change how parts of the brain communicate with each other. After the synaptic connection are dismantled, neuroplasticity allows the brain to create new connections that may be different than how the brain originally functioned. Functional MRI (fMRI) is an effective way to map the flow of oxygenated hemoglobin and highlight these synaptic connections at a high resolution. fMRI has laid the foundation of understanding cortical pathways and the mechanisms underlying neuroplastic changes that many studies have used to demonstrate the full effects of cognitive therapy after Traumatic Brain Injury. While these studies have portrayed neuroplasticity for specific portions and/or function of the body, how this self-healing process is able to improve function in not only the damaged portion of the brain but also the interconnections to other portions of the brain is still not fully understood. This project works specifically with resting state fMRI (rs-fMRI) scans, where the subjects are not asked to perform an explicit task.

This summer, preprocessing of datasets was performed using two standard software packages: Analysis of Functional Neuroimages (AFNI) and Statistical Parametric Mapping Version 12 (SPM12). The first datasets included the brains of rats with TBI that were scanned before and after their injury. For each rat, MRI data, both structural and functional data was collected before injury, 2 days after injury, 1-week, 2-week, and 4-weeks after the injury. We also analyzed MRI data of human who were drug users and healthy controls. This was performed to avoid the effects of those factors when analyzing human datasets with traumatic brain injuries. Preprocessing steps includes correction of any head motion during scanning, truncating large signal spikes, aligning functional scans with anatomical scans to allow single-subject analysis, normalizing all images to a predetermined template provided by the software, extracting white matter and cerebral spinal fluid data, smoothing spatial noise, and filtering out data signals that are not within a certain bandpass. By carefully completing these steps, the project is prepared for future work that will consist of analyzing the components of these datasets to determine the underlying resting state functional networks in the brain and how these connections are affected by Traumatic Brain Injury.





Figures 1 and 2: an example of an fMRI scan of a healthy subject and its associated blood oxygen level signals

Neuromodulation of Sensory Encoding

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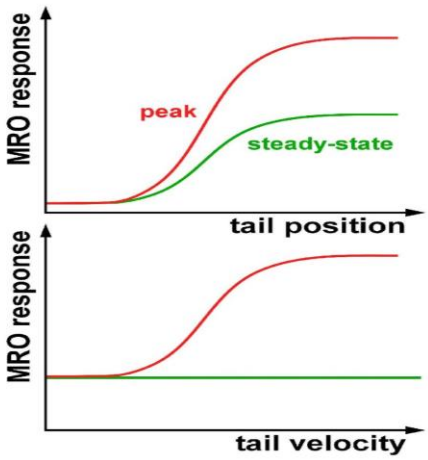
Abstract: Neuromodulator imbalances are the major causes for many common mental disorders including ADHD, depression, Parkinson's, and schizophrenia, to name a few. The purpose of this project is to fully understand the effect of neuromodulators on sensory transduction and the way in which a physical stimulus is encoded into a temporal pattern of neural action potentials. The specific patterns that can be altered due to neuromodulator presence that I will be focusing on will be absolute magnitude, time course, and relative change of these neural action potentials. Over the course of the fellowship, electrical impulse information from the neural pathways of the crayfish tail will be observed to analyze differences produced by the introduction of neuromodulators dopamine and serotonin into the neural circuit. It is hypothesized that neuromodulators can differentially impact how a stimulus is encoded to produce a sensory response. For example, one modulator may preferentially change the sensitivity to velocity, while another preferentially changes the sensitivity to position. This project will be able to bridge the gap that exists between neuromodulators in sensory encoding and the differential physical response they can create. Insight into such effects would allow for increased knowledge in the mental disorder space and subsequent drug development to attack the disorders with a new perspective.
Experiments are performed with crayfish, a freshwater organism that relies on its muscle receptor organ (MRO1) to control impulses that create tail flexion and speed in its tail. Identified single receptors on each side of each tail segment signal position and movement of dorsoventral tail bending, which is used both for postural regulation, locomotion, and escape responses. Temporal patterns of action potential responses can easily be decoded to quantitatively assess information about the angle of tail bending and the velocity of the bending. There is a computer-controlled actuator to precisely control magnitude and speed of passive tail movements that can be imposed while performing electrophysiological recordings of the sensory nerve activity.



The figure to the left shows the sigmoidal curve produced by MRO1 stimulus in the crayfish tail with an apparent saturation point for both peak and steady state values. The addition of neuromodulators is expected to increase or decrease these frequency values significantly.

Blood Brain Barrier and Monocytes in Blast Traumatic Brain Injury

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Blast traumatic brain injuries (blast TBI) are commonplace in the armed services. Exposure to blast TBI can lead to chronic neuroinflammation, which then causes neurological and behavioral deficits. Blast shockwaves can increase blood brain barrier (BBB) permeability, which allows bloodborne particles and cells such as blood monocytes to enter the brain and release pro-inflammatory neurochemicals, contributing to neural damage. In this study, we investigate whether infiltration or blood monocytes is associated with increased BBB permeability after blast, and whether depleting monocytes prevents behavioral changes observed after moderate blast TBI exposure (180 kPa). To this end, we use double transgenic mice – CCR2 RFP/+:CX3CR1 GFP/+, where infiltrating monocytes are tagged with RFP and resident immune cells (microglia) are tagged with GFP. In order to investigate BBB integrity, mice were subjected to moderate blast and the entry of intravenously administered Evans Blue dye in the blood, brain and liver were tested at 0h (control), 4h, 1d, and 3d. To identify the contribution of infiltrated monocytes, clodronate liposomes were administered to deplete total monocytes and behavioral assays including elevated plus maze, open field test and novel object recognition test were performed at an acute (1d – 3d) and chronic (28d – 30d) timepoint after blast TBI. DIL dye-containing liposomes were used as vehicle control. In this study, we established a Evans Blue dosage for mice and a blood-serum based validation method for efficient dye delivery. Spectrophotometric analysis of brain lysates indicates that blast TBI resulted in a transient increase in BBB permeability at 4h but recovered to control levels at 1d and 3d. Confocal imaging of brain tissue is underway and is expected to reveal temporal and regional variations in BBB permeability changes within regions such as prefrontal cortex, hippocampus and thalamus. The effect of clodronate-mediated monocyte depletion on behavioral outcomes is inconclusive at present, warrants an increase in sample size, and is currently under investigation. In summary, our study confirms that BBB permeability is altered after blast TBI and may underlie the infiltration of monocytes and subsequent behavioral deficits.

Minocycline Loaded Albumin Nanoparticle (myn-ANP) Synthesis and Characterization: Potential Nanomedicine Approach to Traumatic Brain Injury

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Traumatic Brain Injury (TBI) is a common cause of fatality for soldiers during war and results in many long term harmful neurological injuries. There are approximately 1.7 million people currently suffering from TBI in the United States alone, and according to the World Health Organization, it is a major cause of death and disability. Microglia are the first line of defense whenever there is an injury and they produce an excessive of pro-inflammatory mediators which increases the brain damage and hinders the functional neurological recovery. Minocycline has shown potential for the treatment of neurological diseases due to its ability to penetrate the blood brain barrier (BBB) and potency. However, to attain the neuroprotective effects in most CNS models, the required dose of minocycline (~20-100mg/kg multiple doses) is significantly higher than the dose (~3mg/kg per day) used to clinically treat infectious and inflammatory diseases. Minocycline inhibits microglial activation, through blockade of NF-kappa B nuclear translocation and is highly toxic. As a result, a targeted delivery of minocycline to the injured site and injured cells in the brain is necessary. Over the summer, we worked to formulate and characterize minocycline encapsulated albumin nanoparticles as preliminary studies to target TBI.

Optimized minocycline loaded albumin nanoparticles were prepared through a desolvation method. Different ratios of ethanol to water were tested in order to create a size of 100-200 nm of nanoparticle. In addition, pH was adjusted to 9 through the addition of 1 M NaOH and was set to a stirring condition of (1000 rpm) was also used to characterize the nanoparticle. We were able to optimize the results and are able to consistently get a nanoparticle size of 236.6 nm. The High Performance Liquid Chromatography machine was used to detect the concentration of different amounts of minocycline. In order to use it to calculate encapsulation efficiency and loading capacity, we created a calibration curve. This was obtained by making different microgram concentrations of minocycline and then running it through the machine. We observed that there is a 99% encapsulation efficiency.

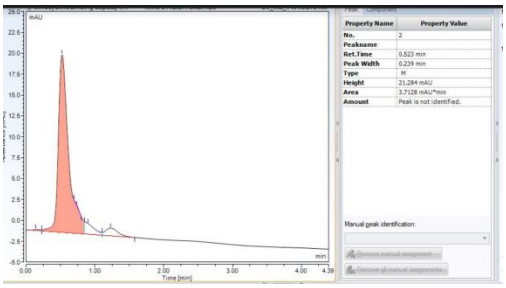

Fig 1. Chromatogram used for quantification of free minocycline in MINO BSA 5

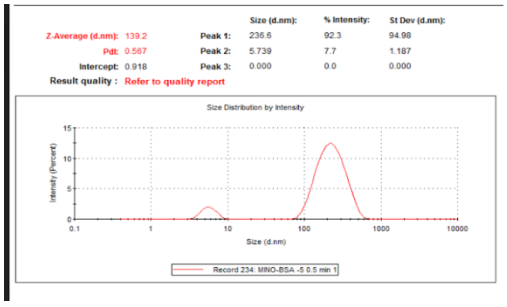

Fig 2. Size reading of Nanoparticle from MINO BSA 5

In Situ Ozone Nanobubble Technology for Water Disinfection and Pollutant Degradation

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John A. Reif, Jr. Department of Civil and Environmental Engineering
New Jersey Institute of Technology

Microbial and pollutant contamination in drinking water distribution system (DWDS) negatively impact public health as well as pertinent infrastructure's integrity such as corrosion. Majority of bacterial biomass in the DWDS is associated with thin biofilms on the walls of water mains and other surfaces. Despite widespread use of residual disinfection in the United States and other countries to limit the growth of microbial populations in DWDS, there are well-known drawbacks in traditional disinfection such as disinfection by production (DBP) formation. The goal of this summer research is to develop and implement an innovative green process using reactive ozone nanobubbles (NBs) that promote rapid oxidation and decomposition of organic water pollutants and biomass. We quantified ozone yield, quantum efficiency of photochemical conversion of oxygen under VUV irradiation and evaluate the effects of oxygen NBs on photochemical generation of ozone as well as the radical formation in water. Approximately 4 ppm ozone was obtained within 30 seconds of UV irradiation, accounting for approximately 0.3% of oxygen that was converted to ozone. As a comparison, the commercial ozonator using the high-voltage electrode and air as a gas source usually yields a maximum level of 30 ppm. Although the produced concentration of ozone and conversion rate are relatively lower, our method costs approximately 93 KWh per kg-ozone, which is higher than the electrolysis method (208 KWh per kg-ozone). Furthermore, we will investigate the antibacterial and antialgal effects of O_3/O_2 NB systems and evaluate the disinfection power and microbial disruption mechanisms. This new process holds potential to be implemented for water disinfection, biofilm prevention and removal, persistent micropollutant removal, and water remediation.

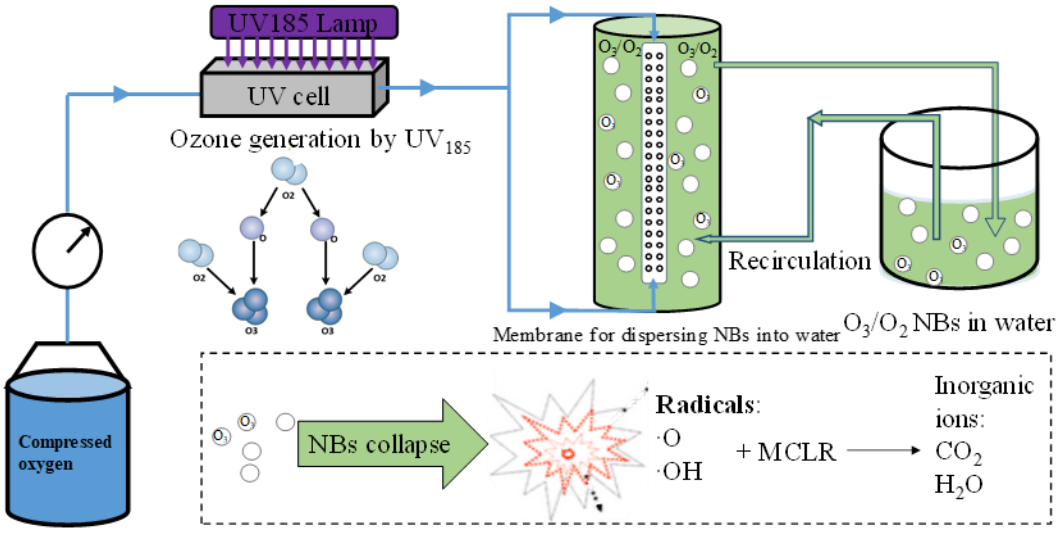

Fig. 1. Schematic of the ozone/oxygen nanobubble generation system.

Magnetic Spinners Model Provides a Material's Phonon Spectrum

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Abstract: The goal of this project is to propose an educational model using magnetic spinners that demonstrates the individual interactions between the building blocks—such as atoms, molecules, or proteins—of a material and how these individual interactions provide insight into the vibrational properties of a material. In physics classrooms, the standard technique for introducing vibrations is by presenting wave propagation through standing waves in a string or sound propagation in a sound tube. These experiments show students how constructive and destructive waves can create harmonic resonant modes and is easily relatable to how musical instruments work to create different sounds because of different resonant modes. These experiments are a simple and effective first introduction, but they are limited in giving an intuitive sense of how vibrations propagate at the atomic level to generate bulk vibrational properties. Furthermore, they give no instruction on how to understand or to measure non-resonant modes or unique resonant modes that are not standing modes. In our model, a line of spinners is mounted onto a material and coupled with magnets to represent the interactions between the individual building blocks of a material. We can then propagate vibrational energy through this system by using a computer-automated actuator magnetically coupled to one of the spinners. Accelerometers attached to the spinners track the vibrational energy of each spinner over a range of frequencies at which the system is actuated; this ultimately allows us to plot a phonon spectrum.

The experimental spectra of two different magnetic spinner models are plotted below. A periodic system of equally spaced spinners yields continuous resonant peaks with the number of peaks being equivalent to the number of spinners in the system. By dimerizing the periodic system by removing four arms off of every other fidget spinner, and in turn altering their moments of inertia, a forbidden gap region is created. A band gap is a range of frequencies where no vibration will propagate through the system—an example of soundproofing. The range of a band region in our model can be precisely engineered by altering the weight, or moment of inertia, of the magnetic spinners. These plots provide evidence that our model can show how the vibrational properties of a material are based on their different individual atomic interactions.

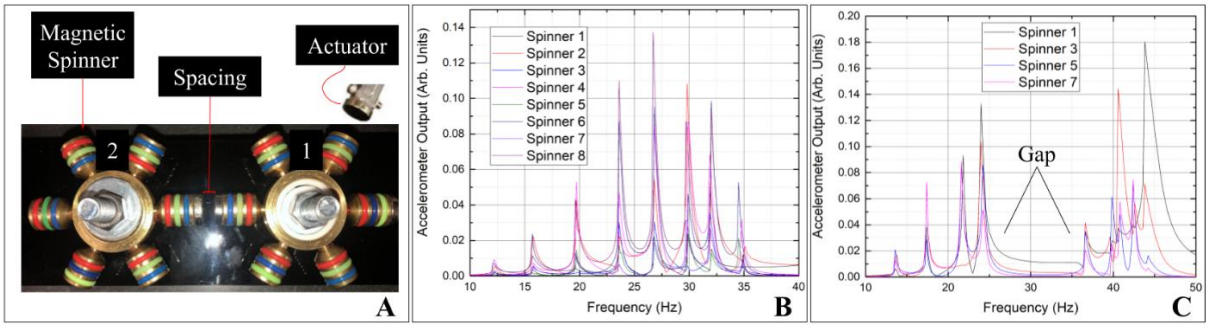

Figure 1: (A) An example of a magnetic spinner model setup. **(B)** Experimental spectrum showing the resonant peaks of a periodic magnetic spinner system, where each 6-arm spinner is equally spaced 5 mm apart. **(C)** Experimental spectrum showing the creation of a forbidden gap by removing 4 arms off of every other fidget spinner in the periodic system.

Fabrication of Microfluidic Cell Culture Systems for Bacterial and Eukaryotic Cells

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Microfluidic cell cultures systems, in which cells are cultured in chambers with dimensions of the order of micrometers, are becoming prominent in the field of cell biology. Compared to traditional methods of cell culturing in flasks and petri dishes, these microsystems are less expensive, handling a reduced cell population and thus requiring lower volumes of media. Further, the implementation of perfusion in these systems allows for better control of the cell microenvironment to mimic physiological conditions.

Eukaryotic cells are, however, more difficult to culture than bacterial cells due to their larger size and smaller surface area to volume ratio, which limit the diffusion of nutrients and gases across their membranes. Moreover, when exposed to flow-induced shear stress, the cells may detach from the substrate. Consequently, to determine the optimal conditions for growing cells in flowing media, we have developed bacterial biofilms at varying flow rates inside a single-channel microfluidic device. Ultimately, using these conditions, we will grow monolayers of eukaryotic cells, specifically the cells that constitute the blood-brain barrier (BBB), for modeling purposes.

The device is assembled as pictured in **Figure 1**. The top layer is made from polydimethylsiloxane (PDMS), which is notable for its gas permeability, optical transparency, and high biocompatibility. An inlet and outlet have been punched into the PDMS to allow for fluid flow. The channel in which the cells are cultured is etched in polypropylene (PP) film. The bottom glass slide contains a set of interdigitated gold electrodes for studying cellular activity, utilizing electrode cell-substrate impedance sensing (ECIS). The channel-electrode interface is coated with gelatin attachment factor. *Escherichia coli* (*E. coli*) are seeded to the gelatin surface. The cells are matured in static conditions for four days in a humidified 37°C, 5% CO_2 incubator. After maturation, the cells are subjected to perfusion culture for 24 to 48 hours. The biofilm structure is visualized and confirmed using confocal microscopy.

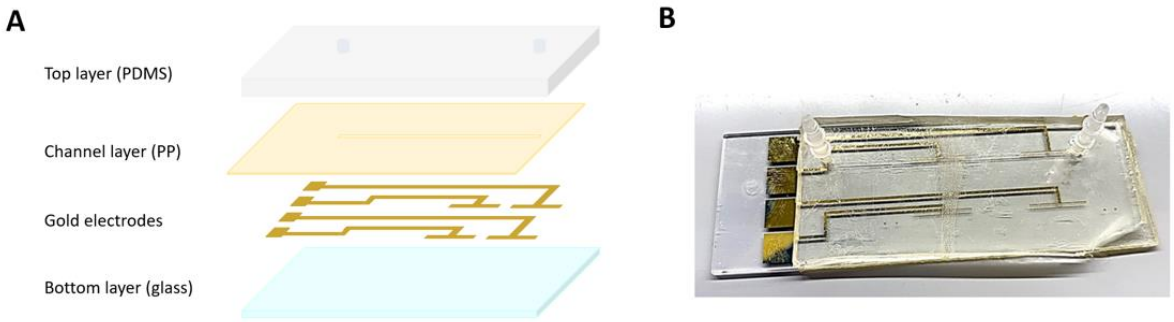

Figure 1. (A) Schematic of microfluidic cell culture chip (B) Assembled chip

Dynamics of a Cone-shaped Meniscus on a Substrate-supported Drop under an Electric Potential

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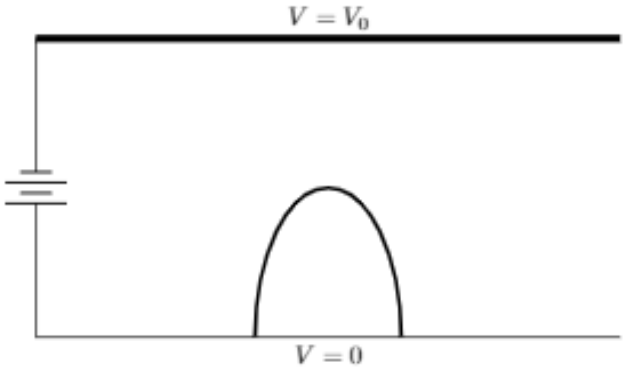
The use of electrical forces to manipulate liquids has a wide variety of applications, such as in electro-spraying in combustion systems, ink-jet printing, and mixing and fission in microfluidics. Under an applied electric field, a stationary drop of fluid deforms to form a cone-shaped meniscus, or what is known as a Taylor cone. While recent studies have experimentally quantified the effects that an electric field has on a droplet of fluid, we use a theoretical approach and develop an analytical framework to approximate the upward force on the droplet to predict the drop deformation and to gain mathematical insight into this phenomenon. To this end, we first simplify the problem by considering a two-dimensional geometry, corresponding to a cylindrical droplet as opposed to a spherical droplet. This two-dimensional geometry then allows us to derive conformal maps to obtain exact tractable solutions to Laplace's equation, which then gives us the electric field surrounding the droplet and the total upward electrical force exerted on the droplet. We apply this approach to analyze both conducting drops and dielectric drops, which corresponds to a large variety of fluids that are used in applications. Furthermore, we classify all stable and unstable equilibrium that arise in each of these cases and obtain lower bounds for the maximum potential and height of the droplet before spontaneous shoot up and droplet ejection occurs.



RONALD E. MCNAIR POSTBACCALAUREATE ACHIEVEMENT PROGRAM

Effect of Tank Bottom Shapes on Power Dissipation and N_{js} in Stirred Vessels Under Different Baffling Configurations

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Mechanically stirred mixing vessels are widely used in the chemical, biochemical, food, and other related industries to homogenize the liquid content of the vessel and any phase dispersed in it, such as finely divided solid particles. The power, P, dissipated by the impeller in these systems and the minimum agitation speed, N_{js}, to just suspend solid particles in the liquid are two of the most critical parameters for scaling up mixing processes from laboratory scale to industrial scale. Both P (and its non-dimensional value P_o) and N_{js} depend on several factors including type of impeller, its diameter, vessel geometry, and the dynamic conditions at which the mixing is operated (agitation speed). Although most correlations available in the literature for Po and N_{js} were obtained at the laboratory scale using flat-bottom vessel, vessels with hemispherical or torispherical bottoms are actually used in industrial applications. The effect of the shape of the vessel bottom on P_o and N_{js} has not been investigated so far and is the focus of this work.

In agitated vessels, the degree of solid suspension is classified into three levels: on-bottom motion, complete off-bottom suspension, and uniform suspension. Enough agitation is important to completely suspend the solids off the vessel bottom. Below this needed agitation, the total surface area of the solid suspended within the liquid is not completely or efficiently utilized. Therefore, it is important to be able to determine the impeller agitation speed denoted by N_{js}, at which the just suspended state is achieved. Although N_{js} is critical to many industrial mixing processes, little information is available in the literature on the effect of the tank bottom on N_{js}. Therefore, the main objective of this part of the work was to determine N_{js} and the power dissipation at these measured N_{js} values for different tank bottom shapes experimentally. By using the newly developed method in the Mixing Lab at NJIT, the area covered by the unsuspended solids was measured at increasing agitation speeds, starting at low speeds below N_{js} and increased until all particles became suspended; thus, N_{js} could be determined.

Raspberry Pi as FSO Transceiver using UART Communication for Drone-Assisted Networking

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Recent advancements in drone technology have created the unique opportunity to deploy cellular networks on a platform of portable drones. Drone-mounted base-stations (DBSs) can autonomously move in space and can fly at a relatively higher altitude than Macro Base Stations (MBSs). It can improve the coverage and capacity of the networks to serve immense user demands due to the potential Line-of-Sight (LoS) connection between the user and the DBSs. Nowadays, a large number of institutions and research facilities are conducting research on Unmanned aerial vehicle (UAV)-assisted networking to improve its reliability and flexibility. In traditional UAV-assisted networks, access node and DBS employ FSO Transceiver or RF Transceiver to establish the backhaul link (the link between DBS and MBS). However, in research labs, Universal Software Radio Peripheral (USRP), which is costly as well as heavy, is commonly used as an RF transceiver to establish the backhaul link. The aim of this research is to establish the backhaul link using the Raspberry-Pi as it is inexpensive, light-weighted and capable of transmitting data at relatively high speed. Raspberry-Pi has a built-in Universal Asynchronous Receiver/Transmitter (UART) which is a serial communication protocol that transfers data bit by bit. Raspberry-Pi UART transmitter uses a laser to convert the data into the optical signal and the UART receiver uses the laser detector to convert the optical signal into data. Future research will concentrate on using Serial Peripheral Interface (SPI) to achieve a higher data rate.

Examination of water stress on the morphological evolution of *Capsella bursa-pastoris*

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Department of Biology

New Jersey Institute of Technology, Newark, NJ 07102

As urbanization increases at a significant rate around the world, it is important for humans to understand how this rapid growth can affect the environments they develop. Previous research shows that the evolution of plants and animals can be affected by urbanization occurring in their ecosystems. Such effects can vary from change in mating calls to physiological change. The effects of urbanization on morphology of the common herb *Capsella bursa-pastoris* also known as "shepherd's purse" will be examined. *Capsella bursa-pastoris* is often found in areas that experience high abiotic stress. This plant has short generation times, self-pollinates, and is an abundant species. That being said, *Capsella bursa-pastoris* is an ideal model species for this study. The main abiotic stressor examined was water stress, specifically flood and drought conditions. In urban environments with a majority of concrete streets, it is common for the soil to have low porosity due to being surrounded by concrete. That being said, flooding becomes a recurring issue in such an environment. Plants in urban areas may also experience extended periods of drought due to low water availability. These factors are important to understand in order to better understand our relationship. Germinated seeds of different populations were grown under artificial conditions (for 10 weeks) and experienced flood and drought treatments. After these treatments, various morphological traits such as leaf shape (or leaf surface area), stomatal density, and pubescence were observed. These traits will determine changes in the morphology of shepherd's purse. We are looking to prove that urban plants have evolved to better adapt themselves for their constantly changing environment. It is expected for urban plants to display a lobed shape with smaller surface area to aid in water retention. Urban plants display dense (enlarged) stomata on their leaves to decrease the amount of water vapor that exits the leaves through transpiration. The urban plants show more trichome on their leaves to aid them in the capturing of water or water vapor.

Alignment analysis of Cardiomyocytes on Patterned vs Flat Scaffolds

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According to the Center for Disease Control, heart disease was the leading cause of death in the United States in 2016, being responsible for 1 in every 4 deaths. Furthermore, about 735,000 Americans suffer from a myocardial infarction every year. Currently, there is little understanding of heart diseases and specifically, the transition that the heart tissue goes through during an infarction. Although induced myocardial infarction in animals serves as a helpful model, there are genetic and physiological differences that makes it difficult to use the same models for human studies, thereby increasing the need for a heart model to allow for disease studies. The purpose of this study is to create a scaffold similar in architecture to that of the native cardiac tissue to allow for disease studies on a human based model. We are investigating the effect of using a patterned scaffold on the alignment of cardiomyocytes by comparing patterned and flat scaffolds in terms of cell count and nuclear alignment. Patterned scaffolds are created by stretching polydimethylsiloxane (PDMS) strips to 20% of their length, followed by UV-Ozone treatment for three hours and finally releasing the strips. Human cardiomyocytes (HCMs) are seeded on fibronectin coated PDMS scaffolds at a density of 100,000 cells/ml and imaged at days 1, 4 and 7. Nuclear alignment in patterned vs flat scaffolds was 46.5%:27.0% of cells between 20 and -20 degrees from the horizontal at day 4 and 34.3%:20.3% at day 7. Cell count in patterned vs flat scaffold was 144:37 at day 4 and 303:64 at day 7. Preliminary results show an increase in nuclear alignment in patterned scaffolds, furthermore, a higher cell count at both day 4 and 7.

Investigation of interlayer strength of 3D-printed Polymers

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Department of Biomedical Engineering

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FDM (Fused deposition modeling) 3D printing is a manufacturing process which enables the creation of complex and customized objects in a layer-by-layer fashion. Due to its versatility, FDM technology has been increasingly adopted by many industries. Although FDM-based products are widely used, the parts usually possess anisotropic and weaker mechanical properties compared to the parts made by conventional manufacturing methods such as injection molding. Therefore, understanding and improving the mechanical properties of FDM-printed products are crucial for broadening the applications of 3D printing technology. Previous studies conducted on 3D printing have focused on mechanical strength as a function of variety of processing parameters. However, only a few studies have been conducted on the effects of processing parameters on interlayer bonding strength. Interlayer bonding strength is important because it can determine how well the design can withstand tension, compression, and torsion forces before breaking. In this study, we will use DOE (design of experiments) for analysis and performance screening tests, to identify important factors that influence the interlayer strength of ABS-printed parts. The approach of this study is to focus on four important process parameters such as layer height, layer time, temperature, and speed on. The layers of the built-up materials were stacked in the Z-direction during the printing process. Mechanical tests including tensile test (ASTM D638 type V) and three-point bending test (ISO 178) will be performed to study the effect of the above-mentioned processing parameters on interlayer strength and to understand the feasibility of the use of these two tests in assessing interlayer strength of the 3d printed objects.

3D Printing PCL/HA Based Scaffolds for Bone Regeneration

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Department of Biomedical Engineering
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Osteoporosis is a disease where bone loses its density and quality over a period of time. Current tissue engineering approaches are focusing on regenerating bone tissue using scaffolds that serve as temporary templates with specific mechanical and biological properties similar to bone. Previous research focused on building PCL/HA scaffolds for bone regeneration using a variety of extrusion-based 3D Printing methods; however, the optimal method has not been studied yet. The aim of this project is to identify the optimal 3D printing approach to fabricate biocomposite scaffolds from poly(caprolactone)/hydroxyapatite (PCL/HA). We propose to fabricate scaffolds using three different 3D printing approaches based on extrusion-based printing: filament printing, direct ink writing (DIW) from melt, and DIW from solution. The properties of the scaffolds such as, surface properties, porosity, HA distribution, and mechanical behavior will be compared. The print resolution of the scaffolds and their ability to induce osteogenic differentiation of stem cells will determine the best 3D printing technique.

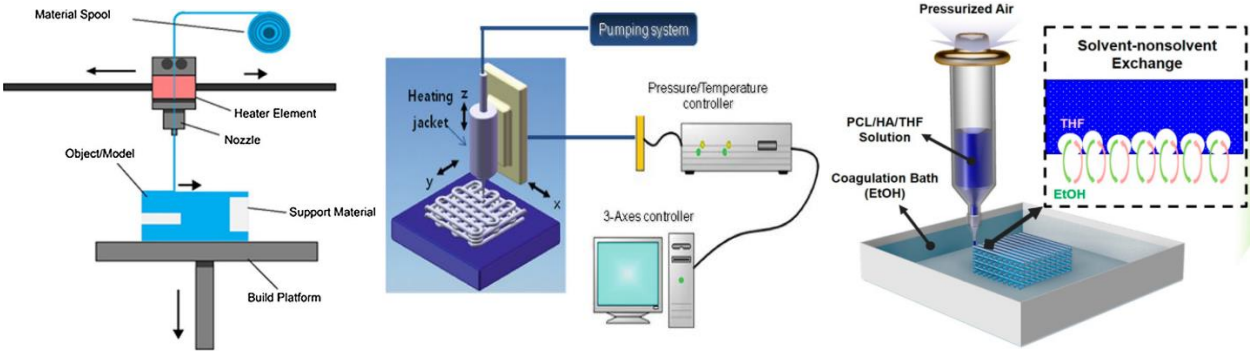

Figure1: Examples of the three different 3D printing methods from left to right: filament printing, direct ink writing (DIW) from melt, and DIW from solution.

Shear-Enhanced ESSENCE Biosensor for the Detection of a target DNA

Felix B. De Dios, Advisor: Dr. Sagnik Basuray, Mentor: Zhenglong Li and Yu-Hsuan Cheng

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DNA contains all the genetic information of a living organism, often indicating the presence of diseases or disorders. Detecting a specific DNA strand can be a tedious process that takes significant resources, time, and money to carry out. There is a need for an inexpensive, effective, and simpler manner to detect desired DNA, or any other biomolecule. Here we have shown a shear-enhanced, microfluidic biosensor that has a channel packed with multi-walled carbon nanotubes (MWCNT) on non-planar gold interdigitated electrodes. The MWCNT in the biosensor is dotted with a single stranded DNA, a capture oligonucleotide, with the coding 5'-/5AmMC6/CGTCCAAGCGGGCTGACTCATCAAG-3', attached to it. A fluid consisting of phosphate-buffered saline (PBS), with the target DNA strand, 5'-CTTGATGAGTCAGCCCGCTTGGACG-3', is pumped through the chip. The goal is to create an inexpensive but effective and selective manner to detect target DNA. To do so, electro-chemical impedance spectrum (EIS) is used. An EIS instrument detects the differences in electrical impedance with just the capture DNA against the target DNA hybridized with the capture DNA. We have also tested MWCNT purchased from a company against MWCNT that is oxidized in the lab. Different PBS concentrations/pH and EIS input voltage were also tested. The results show that the difference in the EIS signal was best for lab oxidized MWCNT. Further optimization experiments are currently on the detection of proteins or antigens and a bigger difference in the EIS signal is desired for future use.

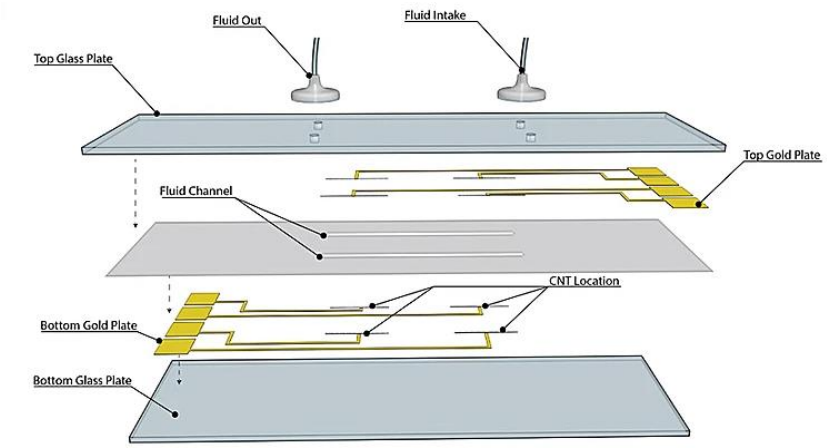

Figure 1: Image of the biosensor made for the experiments.

Design of a Cable Driven Exoskeleton for Hand Rehabilitation Post Stroke

Cruz Donato, Advisors: Sergei Adamovich and Mentor: Ashley Mont

Department of Biomedical Engineering

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Stroke is one of the leading causes of disability in the United States, specifically due to hemiparesis, the paralyzation of one side of the body. Post-stroke rehabilitation methods often use repetitive tasks replicating activities of daily living to help stroke patients regain motor function. However, most inpatient therapy focuses on treating lower extremity movement rather than upper extremity movement, and as a result stroke survivors often struggle with distal upper extremity movement. Robotic devices have been created to help in the rehabilitation process. As effective as these devices have been, the designs could be improved to decrease weight, amount of material, and possibly, cost. These devices could also work with software at home that would administer tasks to the patients such as games in order to provide more positive reinforcement and more individualized therapy. In this research, the design of a cable-driven, hand exoskeleton for stroke rehabilitation is described. Individual parts of the exoskeleton were modeled on Creo Parametric 5.0, and measured to fit on to a healthy individual in the laboratory. After the parts were modeled on Creo, they were 3D printed in Acrylonitrile butadiene styrene (ABS) to prototype, and, later on, printed in NinjaFlex, a more flexible material that would be more appropriate for fit and comfortability. Actuonix linear actuators were used to extend the index finger and thumb attached to the actuators by a cable. The linear actuators were programmed using Arduino and a motor driver to retract for one second and extend for one second. This provided cyclic stretching of the fingers, replicating an effective stretching paradigm done in a previous study. Fishing line was used as the cables connecting the linear actuators and corresponding digits. In the future, the exoskeleton is expected to administer cyclic stretching to the digits, as well as be incorporated in a virtual reality system developed previously in the lab.

Database of Mechanism Animations

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Department of Mechanical and Industrial Engineering

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Manufacturing systems represent the arrangement and operation of machines, tools, materials, people and information to produce a value-added physical, informational or service product whose success and cost is characterized by measurable parameters. When forming concept designs for manufacturing systems, it is imperative that engineers determine the best mechanisms for the task. Professor Balraj Subra Mani has taken the initiative by cataloging a wide array of mechanical design ideas by forming a public database titled designwell™. Our research aims to construct mechanism animations on 3D design Software, Creo Parametric 5.0 in order to demonstrate the intended motion of various mechanisms. Design processes associated with mechanism animations uploaded to this search enabled, relational database are explored. After completing individual components, parts are combined in relation to fixed datum planes and constraints. Servo motors are then implemented to form an independent animation. Applied kinematic equations detail the functionality of the closed systems created for the website. Finalized mechanism designs include a delta head for robotic manufacturing (Figure 1), differential gear drive used for car transmission (Figure 2), and various reference gears meant for implementation in future designs (Figure 3). Information uploaded to the database will serve as a reference for both students and professionals seeking mechanism animations that may be implemented in higher-order manufacturing systems. Link listed below provides access to database:

http://www.designwell.me/

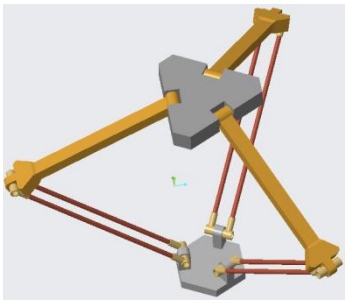

Figure 1. Delta Head

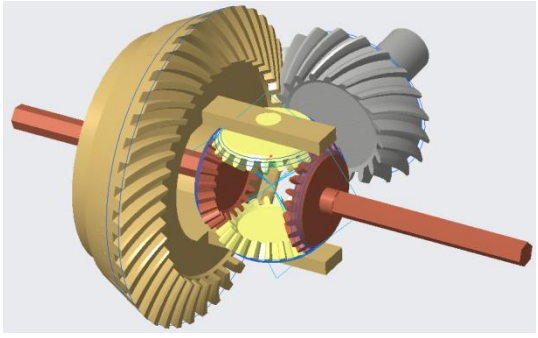

Figure 2. Differential Gear Drive

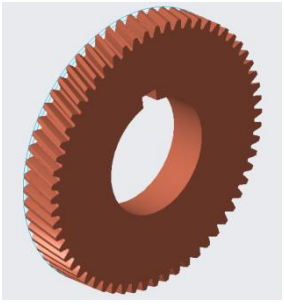

Figure 3. Helical Gear

Database of Mechanism Animations

Jaime Siguenza, Advisor: Professor Balraj Subra Mani
Department of Mechanical and Industrial Engineering
New Jersey Institute of Technology, Newark, NJ

Mechanisms convert an input motion and force to a desired set of outputs. Mechanisms form the foundation of any complex machinery. In order to apply these mechanisms it is critical to understand its functionality. The individual parts of the mechanism are modeled in the 3D modeling software, Creo Parametric 5.0 and then assembled in a separated assembly file. The motors and constraints are added so that the mechanism can function as intended. Once assembled the mechanism motion is recorded and converted into a video. The finalized mechanism designs include a delta head for robotic manufacturing (Figure 1), differential gear drive used to decrease drag on the wheels of a car when turning (Figure 2), and references gears to construct complex mechanism (Figure 3). We have created a database to present mechanism animations on the website known as designwell™. The mechanism animations presented in designwell™ website are intended to provide a wealth of design ideas to students, engineers involved in machine design, and idea-seeking entrepreneurs. To further examine the mechanism following the link: http://www.designwell.me/

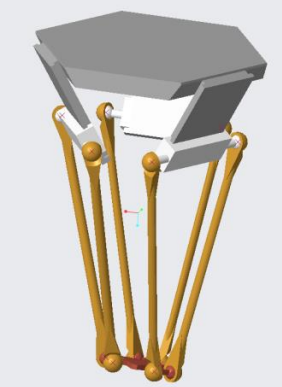

Figure 1. Delta Head

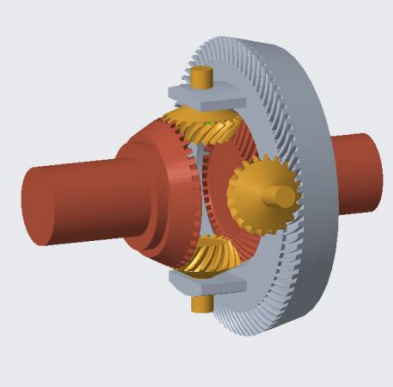

Figure 2. Car Differential Gear Drive

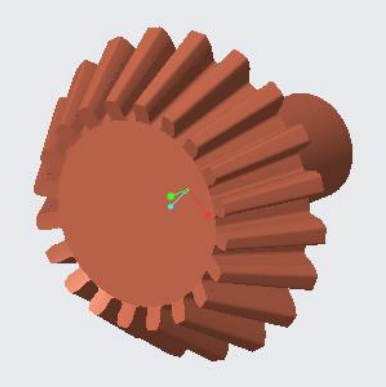

Figure 3. Staigth Tooth Bevel Gear

HONORS SUMMER RESEARCH FELLOWSHIP

Materials - Photon Interactions in Multilayers

Deva Craig, Jonathan Martinez, Jessy Nemati, Serlly Vega and Nuggehalli M. Ravindra
Department of Physics
New Jersey Institute of Technology, Newark, NJ 07102, USA

Abstract: This study investigates the optical properties such as transmittance, reflectance, and absorptance/emittance of multilayer films of various thicknesses, in the wavelength range of 0.1-10μm. By mathematically modelling the multilayers, using the transfer matrix method, we investigate the optical properties of various layered films. The types of multilayers investigated include Si/Ge, buried oxides such as SiO_2 and SiN_4 in semiconductors and antireflection coatings for applications in solar cells. Surface roughness is considered in some of these case studies. The simulated optical properties are compared with similar studies from the literature. Using these simulations, we attempt to predict the properties of an optimized configuration of multilayered films for these applications.

Effects of UV exposure on the mechanical behavior of Cellulose Acetate

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The purpose of this research is to investigate changes in the mechanical behavior of cellulose acetate polymer samples as they undergo exposure to ultraviolet irradiation. As mentioned by Ach (2006), after 18 months, cellulose acetate will decompose by more than half its original weight. Although empirical dependencies between temperature/humidity and cellulose acetate degradation rate have been observed, the consequences of cellulose acetate subject to UV irradiation is not very well defined. Especially not well known are the subsequent changes in mechanical behavior during degradation. The overall objective of this research project is to experimentally quantify how UV irradiation influences the degradation and subsequent mechanical behavior of cellulose acetate. Over the course of this research project, cellulose acetate samples will be exposed to UV radiation under precisely controlled conditions and exposure times, the samples will then be tested for changes in the mechanical behavior.

Figure 1 shows the mechanical behavior of two samples of cellulose acetate. It can be seen that cellulose acetate obeys Hooke's law until the plastic begins to deform. After the deformation begins, the sample of cellulose acetate will barely increase in nominal stress. The final portion of the lines represents the unloading process. This shows that cellulose acetate does not return to its original shape. Figure 2 shows data taken from samples that have been under direct UV light for varying amounts of time.

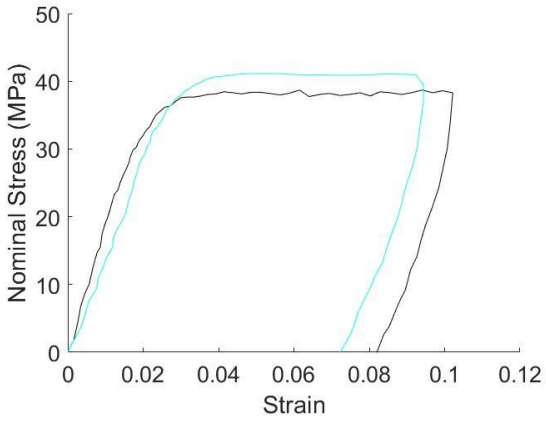

Figure 1

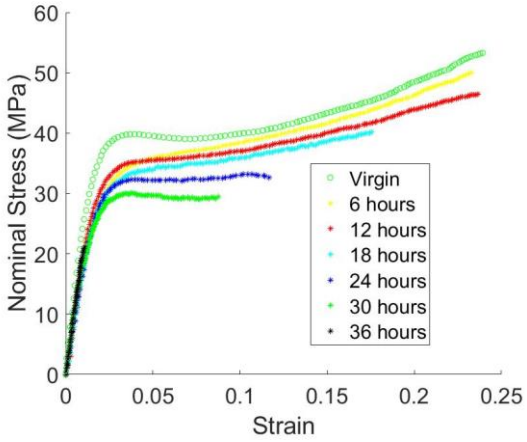

Figure 2

The Effect of Autonomous Vehicles on Human Driving Behavior

Nishaant Goswamy, Advisor: Dr. Cong Wang
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New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: Autonomous vehicles, including trucks, buses, and cars, will become more prominent on the roads. Currently, consumers are purchasing vehicles with built-in semi-autonomous driving features that still require a driver. However, soon major tech companies like Uber and Waymo will implement full level autonomous vehicles to the network. Therefore, it is essential to understand whether integrating autonomous vehicles on roads will be beneficial or not. We need to understand how the future of traffic flow will work when over a dozen autonomous vehicles are driving on the road along with other drivers. On current roads, not all drivers strictly follow the general rules of the road. Drivers sometimes change lanes without signaling or do not come to a full stop at intersections. Pedestrians occasionally jaywalk at intersections at busy intersections. Hence, these are a few of the many scenarios that autonomous vehicles will come across and are significant issues that need to be resolved.

Our research project focuses on building a physical platform that will allow us to simulate driving scenarios to observe and analyze how drivers and autonomous vehicles will respond. The platform will be a scaled 14:1 model city of Newark with modified RC cars that will be user-driven alongside with other autonomous RC cars. The drivers will operate with a full-sized steering wheel and be driving from a first-person perspective inside the model cars. The self-driving vehicles will be fitted with lidar sensors and a camera to enable the car to autonomously drive. We will gather data quantitatively such as the speed of nearby drivers, stopping distance, lane changing, compliance to traffic signs, etc. Later we can analyze that data to make qualitative conclusions on human driving behavior, optimizing traffic flow, and enhancing autonomous vehicle's driving capabilities.
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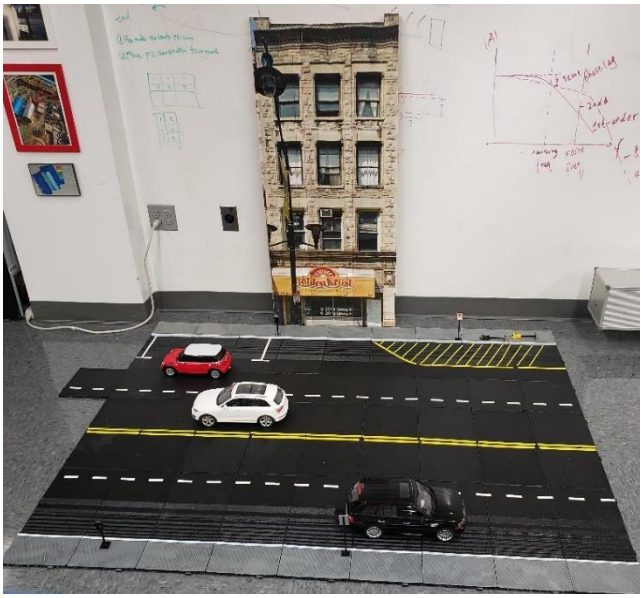

Figure 1: Proposed Model City Platform model

An Exploratory Study into the Effects of Total Sleep Deprivation using fNIRS

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Department of Biomedical Engineering
New Jersey Institute of Technology, Newark, N.J. 07102

College students who work nights on end finishing projects or studying for tests with little to no sleep go entirely unquestioned. Applauded, even. Since 1985, in the United States, the number of adults sleeping less than six hours a night has increased by 31%. Previous studies using functional magnetic resonance imaging, or fMRI, have indicated that healthy patients who experience one to two nights of total sleep deprivation exhibit a lower accuracy rate and longer reaction time in neurobehavioral tasks compared to results during restful wakefulness. Additionally, fMRI has confirmed that areas of the brain in task-activated studies exhibit different amounts of activation, especially in the prefrontal cortex and parietal cortex.

Our research project seeks to use functional near-infrared spectroscopy, or fNIRS, in order to quantify how cognitive function and brain activity is affected by sleep deprivation. To our knowledge, fNIRS has never been used in this capacity. Although fMRI is recognized as the gold standard of brain imaging, We seek to use fNIRS, which has been shown to offer comparable robustness. fNIRS detects changes in oxygenated and deoxygenated hemoglobin concentrations based on the absorbance of infrared light. In the present study, we utilized different neurobehavioral tasks that demonstrate brain activity covering attention, memory, working memory, decision making, and interference resolution, which are particular brain functions that have shown to be most affected by sleep.

Thus far, we have scanned 13 participants for both normal sleep and total sleep deprivation. Initial results have demonstrated differences in hemodynamic function correlated with whether or not the participant slept. In the coming weeks, more scans will be taken and data must be further processed before a full analysis of results is conducted.

The purpose of this study is to add to existing literature surrounding the effects of total sleep deprivation. Additionally, unlike fMRI, since fNIRS is a portable neuroimaging technique, validating our scans against previous fMRI studies opens up the ability to study more physically demanding tasks. For example, future studies may involve studying the effects of sleep deprivation on motor function while driving, walking, playing sports, etc. Elucidating the cognitive consequences of sleep deprivation is extremely important in a world observing a continued decline in sleep duration, and will aid our understanding of the function of sleep in mental health and cognitive impairment.

Formulation and Characterization of Apocynin-Loaded Albumin Nanoparticles (apo-ANP): Potential Application in Traumatic Brain Injury

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Center for Injury, Biomechanics, Materials, and Medicine:
Department of Biomedical Engineering
New Jersey Institute of Technology, Newark, N.J. 07102

The blood-brain barrier (BBB), formed by brain endothelial cells linked together by tight junctions, restricts the transfer of most drug (anticancer, anti-inflammatory, antibacterial, and a wide variety of central nervous system (CNS)-active drugs) from the bloodstream into the brain. The limitations imposed by the BBB, nonselective distribution, and undesirable toxicity of drugs in the brain have hindered the effective treatment of different brain diseases. Similarly, apocynin, though promising as an anti-inflammatory drug and NADPH oxidase inhibitor, when directly administered to treat brain injury, faces the shortcomings of poor water solubility, rapid excretion, and toxicity, making it necessary to employ a targeted drug delivery approach. Our research uses nanoparticles as the delivery mechanism, for given their high stability, biodegradability, small size, large surface area, and ability to be conjugated with different ligands, they are ideal for facilitating drug delivery to the brain. Albumin was used as the protein for formulating the nanoparticles, owing to its biocompatibility, high reproducibility, and functional groups for further covalent modification. The purpose of this summer research study is to optimize formulation, characterize, conjugate, and test the stability of the apocynin-loaded albumin nanoparticles, as a precursor to actual in vitro studies.

Optimized apocynin-loaded albumin-based nanoparticles were prepared via a modified desolvation method. A mass ratio of apocynin and BSA were stirred (1000 rpm) at room temperature for drug absorption onto albumin. After 3 hours, the solution pH value was adjusted to optimal level (9) through addition of 1 M NaOH. The mixture was then desolvated by addition of ethanol using a peristaltic pump (Peristaltic infusion pump) at a rate of 1 mL/min under stirring conditions (1000 rpm). After addition of chemical crosslinking agent glutaraldehyde, the nanoparticles were lyophilized and then characterized by size and surface charge (Malvern zetasizer), and high-performance liquid chromatography (HPLC). From this, we were able to consistently achieve a nanoparticle size of approximately 195 nm. The HPLC was used to quantify the amount of apocynin loaded into the nanoparticle by measuring the peak formed from the sample against a calibration curve plotted from known concentrations of apocynin. Through this, we observed an encapsulation efficiency of 95%. In the future, we will proceed to functionalize this nanoparticle with different ligands, such as transferrin or Apolipoprotein E, to enable the nanoparticle to partake in receptor-mediated transcytosis.

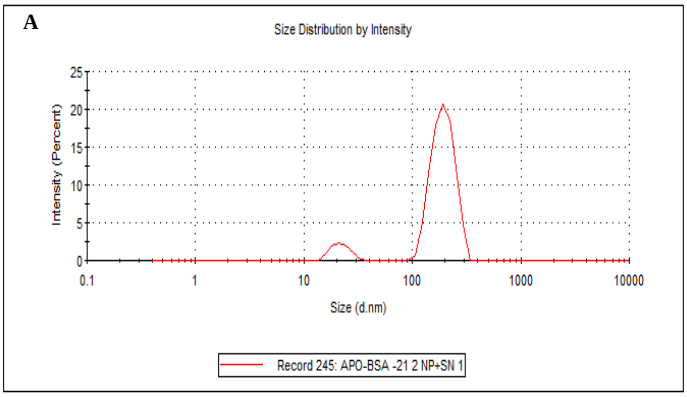

Fig A. Size distribution of Apo-BSA NP 21 after lyophilization

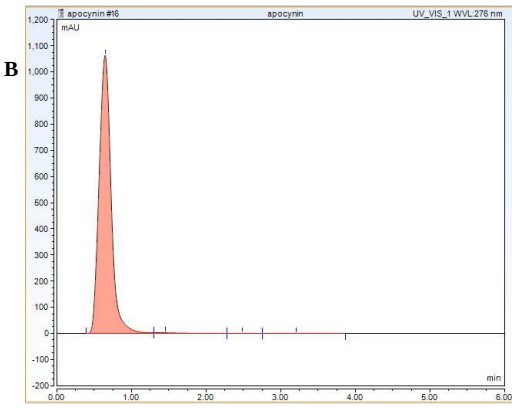

Fig B. Chromatogram of Apo-BSA NP 21 after lyophilization

Using Ozone Nanobubbles and Ultrasound to treat Sediment Contamination

Brian McGlew, Advisor: Dr. Jay Meegoda, and Mentor: Shaini, PhD Student
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Abstract: Due to the era of industrialization, sediments worldwide have been contaminated with many harmful organic and inorganic compounds. The contaminants affect the surrounding communities and wildlife in a variety of negative ways. Because of the large scale of the contamination, sites are difficult to cleanup completely, and many projects leave contamination behind even after treatment. A commonly used solution for contaminated river sediments in the United States is dredging and capping. This has shown limited effectiveness, moves contamination to different sites (landfills) and has the potential to suspend contaminants and spread them downstream. In addition, such projects are expensive (8 mile Passaic River project estimate: 1.7 billion dollars) for having limited success. An in-situ treatment has the potential to eliminate many of these issues of limited remediation effectiveness, spreading of contaminants, and cost. Using ozone nanobubbles and ultrasound combines two emerging technologies to remediate sediments in-situ. Ultrasound agitates sediments and encourages the shearing of absorption bonds between contaminants and sediment particles, making contaminants more available for oxidation by ozone. Ozone is added to the water as nanobubbles because of their long residence time in water and increase in the surface area of the volume of ozone, increasing reaction rates. By oxidizing the contaminants, they become more water soluble and less toxic. The project has tested this method on synthetic sediments purposely contaminated with heavy metals and polyaromatic hydrocarbons (PAHs) and shown positive results.[7] [8]

Polychlorinated biphenyls (PCBs) are currently being studied for use with this method. PCB contamination often collects in "hotspots", containing over 1,000 ppm concentration in the sediment. Although PCBs no longer are produced, disposal of older electrical components and leeching have led to continued contamination. PCBs have shown to adhere very strongly to sediments due to their high hydrophobicity and resist natural biological degradation.[9] Although not chlorinated, biphenyl shares many properties with PCBs due to its structure, easily adheres to sediments. It is being used for its lower toxicity.

Tests have been conducted and results are promising for the efficacy of this method with PCB contaminated sediments. Further research will involve different PCB mixtures, and contamination with multiple types of contaminants, as interactions between contaminants could affect the treatment process.

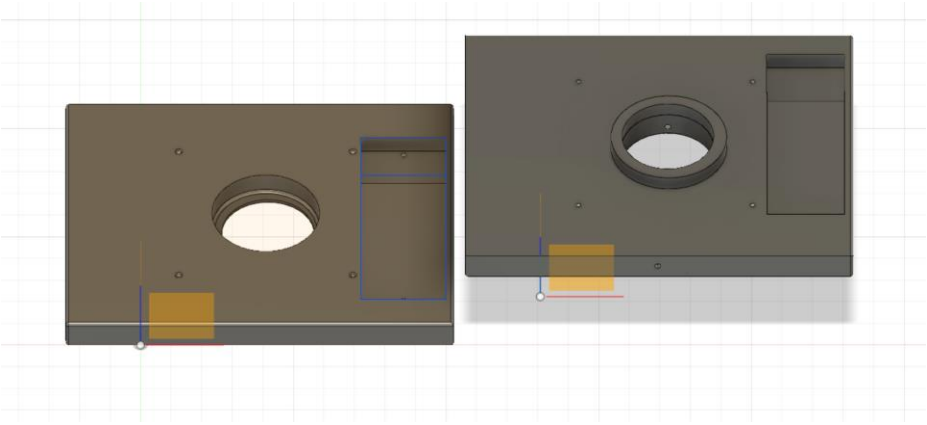
[7] Meegoda, Batagoda, and Aluthgun Hewage, *Briefing: In Situ Decontamination of Sediments Using Ozone Nanobubbles and Ultrasound*.
[8] Batagoda, Aluthgun Hewage, and Meegoda, "Remediation of Heavy Metal Contaminated Sediments Using Ultrasound and Ozone Nano-Bubbles."
[9] National Research Council, "Distribution and Dynamics of PCBs in the Environment."

Fabrication of a Microscope Stage Compatible Incubator for Live Cell Imaging

George Mina
Advisors: Dr. Bryan Pfister, Dr. Joshua Berlin
Department of Biomedical Engineering
New Jersey Institute of Technology Newark, New Jersey

Traumatic brain injury (TBI) affects people from all walks of life, including athletes, soldiers, drivers, and cyclists. Even though TBI is a far-reaching issue, most current medical therapies treat only the symptoms of TBI since many of the mechanisms that damage the brain following TBI are still unknown. Our study focuses on how TBI affects the brain up to 24 hours after injury, in the window of time when treatment might be most beneficial to minimize clinical symptoms. In order to simulate a TBI *in vitro*, neurons are cultured on a flexible silicone substrate and exposed to a rapid pneumatic air pressure pulse which causes the silicone to stretch and therefore create a neuronal stretch injury. Due to variability in neuronal cultures, imaging a group of neurons pre and post injury is essential to obtaining data about the changes in physiological pathways post injury. To do this effectively *in vitro*, neurons must be observed for 24 hours in a sterile, controlled environment so that cells can be kept alive and healthy during experimental maneuvers. These conditions require that cells are incubated at defined temperature, pH, and humidity. The aim of this project is to design a microscope compatible incubator system that (1) provides an environment compatible for cell survival, (2) fits on a microscope stage, (3) allows stretch injury via a pneumatic pressure device and (4) permits long term optical imaging techniques to be performed. We have designed a microscope compatible incubator that allows for injury and imaging. We are currently in the process fabricating, testing and fine tuning the heating and humidity controls. We will also be testing environmental controls of the incubator to be sure that neurons can be used for planned *in vitro* TBI experiments.

Fig1. Rendering of microscope compatible incubator.



Changes in Synaptic Proteins as a Function of Time in Blast-Induced Traumatic Brain Injury

Chandni Patel
Faculty Mentors: Dr. Venkata Kakulavarapu and Dr. Namas Chandra
Center for Injury Biomechanics, Materials and Medicine, NJIT

Blast-induced traumatic brain injury (bTBI) is most prevalent TBI in military personnel resulting in mortality when severe or lead to cognitive and motor deficits at mild-to-moderate bTBI. Service members returning from combat operations display a wide-spectrum of neurological abnormalities. The injury propagation of bTBI is different from blunt TBI wherein the supersonic shockwave diffuses throughout the brain and contributes to neuropathophysiological changes in various brain regions. Studies from this laboratory have identified disruption of blood brain barrier permeability (BBB), induction of oxidative stress and neuroinflammation as major pathological factors contributing to bTBI. Additionally, several neurobehavioral and neurocognitive deficits were identified in animals exposed to low-level repeated blast TBI. Since the majority of neurocognitive deficits develop due to electrophysiological abnormalities as well as changes in pre-and-post synaptic proteins, the latter, result in neurotransmitter dysfunction, the present study investigated changes in the synaptic proteins in animal model of repeated low-level blast TBI. Accordingly, rats were exposed to low BOP of 10 psi (70 kPa) 5-successive times within a short duration (within < 5 min) in the helium-driven shock tube housed in CIBM3 at NJIT. Rats were subjected to several behavioral tasks for up to 30 days and then transcardially perfused with 4% paraformaldehyde. 20 µm think sections were prepared from various brain regions including frontal cortex and hippocampus and immunostained for levels of synaptic proteins. Results showed that the levels of PSD95, a post-synaptic protein abundantly present in different brain regions was profoundly reduced in frontal cortex, indicating that defective post-synaptic function contributes to our previously observed neurobehavioral deficits. Several studies elucidating the involvement of other synaptic proteins such as synaptophysin, synaptobrevin and synapsin are being carried out. Overall, these studies strongly suggest that alterations in synaptic protein levels contribute to neurobehavioral deficits observed in repeated low-level blast TBI. Therapeutic agents that stabilize synaptic proteins may have beneficial effects to ameliorate neurobehavioral deficits in blast TBI.

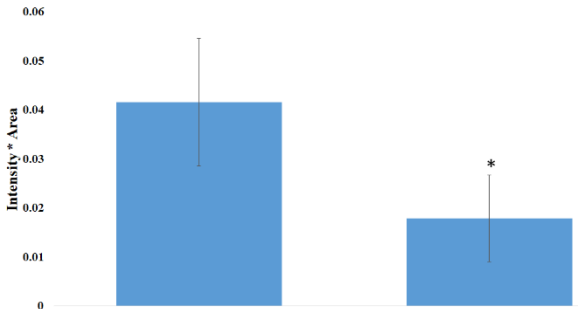


Figure: Quantification immunofluorescence of PSD-95 protein levels in frontal cortex from rats exposed to low-level repeated blast at 10 psi for 5 successive times. Note a profound reduction in PSD95 protein levels suggesting post-synaptic changes contribute to neurobehavioral deficits observed in low-level repeated blast TBI.

The Effect of Land Area on Ecological Niches: A study of ants and islands

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New Jersey Institute of Technology, Newark, NJ 07102 USA

As human-driven changes in ecology occur with greater frequency, it is important to rapidly assess biodiversity and fully understand the impact that our decisions will have on it. How is the structure of an ecosystem affected by its size? Islands offer practical and isolated samples to measure biodiversity in relation to land mass (MacArthur and Wilson, 2001). The aim of this project is to assess the composition of ecological niches relative to island size to uncover broadly applicable patterns in ecosystem community assembly. As bioindicators, ants provide insight into the biodiversity of entire ecosystems - their species number and functionality in the ecosystem act as a proxy for the community as a whole (Andersen 1997). Moreover, ants occupy a range of ecological niches, from subterranean predators to arboreal omnivores Through published accounts of species distributions, I have constructed a dataset of species occupation spanning 77 Caribbean and Pacific islands, ranging in size from 109,880 km^2 to .237 km^2. Each species was then placed into ecological classifications as defined in Weiser and Kaspari (2006) with specifications for both foraging type and feeding type.

Data from the Caribbean suggest a consistent relationship in the proportion of feeding groups and foraging groups on each island. For example, there appears to be relatively consistent ratio of predatory and omnivorous species of ~1:5. Moreover the data indicate that highly specialized ant species exist more frequently on larger islands. The future of this project looks to collect more data from islands around the world, as well as examine the role of invasive species in shaping habitat ecology. Results have the potential to inform conservation decisions and make recommendation for minimum size habitat fragments in the future.

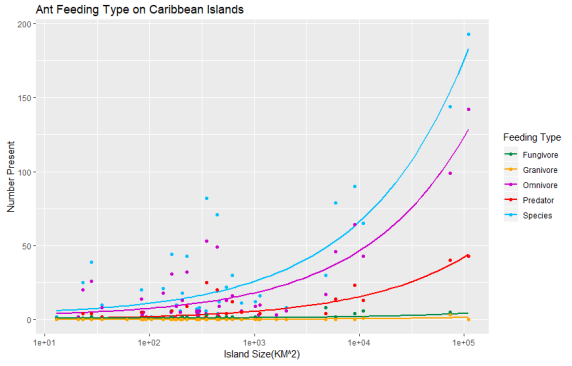

Figure 1 (left) ants of given feeding types in relation to island size.

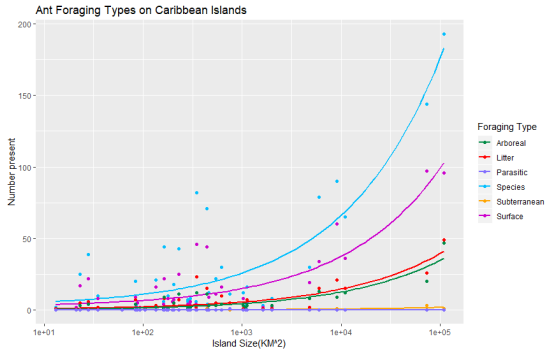

Figure 2 (right) ants of given foraging type in relation to island size

1. Andersen, A.N., 1997. Using ants as bioindicators: multiscale issues in ant community ecology. Conservation Ecology, 1 1-17].
2. MacArthur, R.H. and Wilson, E.O., 2001. The theory of island biogeography (Vol. 1). Princeton university press.
3. Weiser, M. D. and Kaspari, M. 2006. Ecological morphospace of New World ants. Ecological Entomology, 31: 131-142. doi:10.1111/j.0307-6946.2006.00759.x

Collection and Analysis of Global Navigation Satellite System (GNSS) Positioning Data with SBAS and RTK for Autonomous Lawn Mowers

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Martin Tuchman School of Management
New Jersey Institute of Technology, Newark, NJ 07102 USA

Have you ever watched the seemingly aimless wanderings of a robotic vacuum cleaner and thought to yourself "there must be a better solution?" They bounce around the carpet covered pinball machine of your house, bumping into walls and furniture, retracing their path, and then off to a remote corner of the kitchen where they become momentarily trapped. In Europe, there is a growing market for small robotic lawn mowers that use similar technology, bouncing around the perimeter of the property in a similarly aimless manner. These robotic lawn mowers have failed to significantly impact the North American market because they cannot effectively mow large areas and do not leave the stripes which Americans view as essential to a well-manicured lawn. The root problem is that existing robotic vacuums and lawn mowers lack precise positioning.

The current Global Navigation Satellite System (GNSS) work well for autonomous navigation in ships and planes. However, they lack the precision and accuracy crucial to applications such as autonomous lawn mowers. GNSS is imprecise because of signal disruptions as the signal travels from the satellites, through the atmosphere, and to the receiver, as well as drifts in timing and position. This can result in an imprecision of several meters, unacceptable for autonomous mowers. Another factor that can affect GNSS accuracy is obstacles such as trees and buildings. The reflections off these obstacles can cause inaccuracy as it changes the distance which the signal travels. In order to compensate for these inaccuracies, a base station is needed.

A base station is a receiver that remains stationary. The base station can track the drift of the satellite signal over time and provide correction factors to the rover, the mobile receiver that is being tracked. The three most common correction methods are Satellite Based Augmentation System (SBAS), Real Time Kinematics (RTK), and cloud-based correction systems. SBAS uses a handful of ground-based stations to send correction data to the satellites themselves. This is convenient as any receiver can take advantage of this correction data as it is integrated into the signal from the satellite. However, they are limited to accuracies in the meter range as the network of base stations is relatively small. RTK and cloud-based correction systems, comparatively, offer positioning resolution on the centimeter scale. RTK requires the user to have a second receiver which uses a radio system to communicate with the rover. Cloud-based systems offer over-the-internet correction data provided by the third-party providers receiver network.

In this research project, SBAS and RTK setups are used to collect location data in various patterns. Tests are conducted in open areas with a clear sky view as well as in areas with obstacles such as trees and houses. This provide real world data for the environments that autonomous mowers are likely to encounter. The coordinates of each point are recorded and converted to distances from a "zero point." This data is then analyzed to find the accuracy precision, and other characteristics of the positioning data. In the experiments performed to date, the SBAS positioning data was found to be precise to about one meter (97 cm). The RTK research has not yet been concluded but is expected to significantly reduce the range of error.

Rodent to human scaling laws: The evaluation of biofidelic materials for the rat head model under shock wave loading

Zenit Winfield, Mentor: Jose J. Rodriguez, Advisors: Drs. Maciej Skotak and Namas Chandra.

Introduction: Blast-induced traumatic brain injury (bTBI) is an active research area covering clinical studies and experimental modeling aimed at the identification of injury mechanisms. Among military personnel, bTBI is one of the leading modalities of injury and has been associated with permanent neurological deficits and behavioral changes. However, controversy on the mechanisms of injury remains. In order to understand how shock waves cause injury, it is important to elucidate how they interact with biological structures. Rodents are the most frequently utilized pre-clinical model of bTBI in the controlled laboratory settings, and it is imperative to understand how the material properties affect the shock wave propagation. Models are useful to understand such impacts. The aim of this work is to create a biofidelic model that replicates the shape factors of a rat head and evaluate the mechanical response to shock loading through comparison with in vivo injury metrics, the intracranial pressure (ICP) and skull strain.

Materials and Methods: The model utilized purchased rat skulls of similar size. We filled the skull with 10% or 20% gelatin (VYSE Professional Grade Ballistic Gelatin) dissolved in water, or its silicone-resembling equivalent, 10% Synthetic Ballistic Gelatin (Clear Ballistics). Geometrically accurate head models were prepared based on negative molds derived from CT scans of rats. Each specimen was fixed inside the 9x9 square inch shock tube and exposed to a single shock wave with three nominal peak overpressures (70, 130, 180 kPa). The ICP and incident overpressure waveforms were recorded at 1.0 MHz for duration of 50 milliseconds. The peak overpressure and impulse were quantified in Origin 2018. One-way ANOVA with post-hoc Bonferroni and Tukey HSD tests were performed in SPSS 25, and $p = 0.008$ was used as statistical significance threshold.

Results and Discussion: For peak overpressure, we noted significant difference between data for live rat and: 1) 20% semi-surrogate, 2) 10% full ballistic surrogate, and 3) 20% skin/10% brain semi-surrogate. For impulse, the results indicated that all models were significantly different from the live rat. Incident pressures for both figures are not significantly different showing excellent shot-to-shot repeatability that conditions of blast were the same.

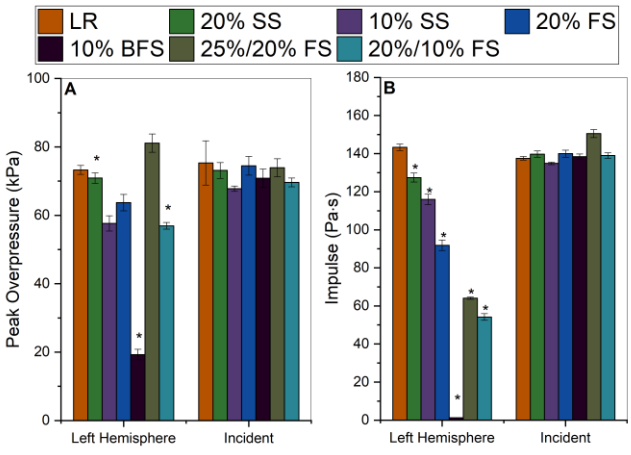

Figure 1 A comparison of: A) peak ICP, and B) impulse values for various materials used to build rat head models. The following acronyms are used: LR - Live Rat, SS - Semi-Surrogate, FS - Full-Surrogate, BFS - Ballistic Full-Surrogate. Bars marked with the asterisk (*) represents groups significantly different from live rat. Data are presented as average ± SEM.

Conclusions: 10% Ballistic Gelatin Full-Surrogate was significantly different in all measures, this is important because Clear Ballistics is a commonly used substitute for skin and brain. Due to the repeated insignificance between the 20% Full-Surrogate and 25%/20% Full-Surrogate versus the live rat, they proved to be the closest full models.

NSF REU - COMPUTATIONAL DATA ANALYTICS FOR ADVANCING HUMAN SERVICES

Machine Learning Approaches for Long-Short Portfolio Optimization

Alexander Barrett, Mohamad Sherif, Ruohan Wu

Advisor: Dr. Zhi Wei

Mentor: Cheng Zhong

It is commonly believed that financial markets are predictable to some extent as observed in many empirical studies. Many machine learning methods have been applied to predict stock returns, dated decades back. However, the literature on long-short portfolio optimization using machine learning approaches remain limited. Long-short portfolios aim to enhance return of investment in specific market segments by exploiting profitable opportunities through taking a long position on undervalued stocks while selling short overpriced stocks. To create an optimized portfolio, the most overvalued and undervalued stocks must be identified through prediction. We create a novel method of predicting stock market trends and thereby balancing long-short portfolio.

The stock data from the Center for Research in Security Prices (CRSP) is used for the purpose of this study. Specifically, the data for individual stock returns and prices, S&P 500 index return, industry categories, number of shares outstanding, sharecode, exchange code, and trading volume spanning over 15 years (2004-18). The data is divided into three parts along time for model training, validation, and testing. Using this dataset, linear regression, Random Forest, Support Vector Regression (SVR), Gradient Boosting, and neural network models are implemented for stock price prediction. For a given month in our data set, we rank the predicted return of each stock, and comprise our long-short portfolio of the top and bottom 10% of these predicted stocks. We then aggregate these returns over time to compute the cumulative return of a given model, and use this as the metric of comparison between models. We find that most of our models positive return over a five year period. In particular, our Gradient Boosting model yielded a return that was approximately 26% greater than the return of the S&P 500 index over a five year span. This work contributes to vastly growing interest in building more efficient tools to predict the stock market. Future work in this project would involve the usage of deep learning methods and alternative machine learning models for increased predictive accuracy.

A Detailed Look Into Existing Software Auto-Fix Techniques

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Advisor: Dr. David Shaohua Wang[3], Mentor: Yi Li[3]

Department of Informatics

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Within the workflow of software development, a major portion of time is dedicated to fixing mistakes in programs. A popular adage that reflects this reality states, "If debugging is the process of removing software bugs, then programming must be the process of putting them in." However, with recent advances in machine learning algorithms, Automated Program Repair (APR) methods hold promise to automate the tedious task of correcting faulty programs. Recently, APR tools have been implemented in two distinct fashions: rule-based, where fix ingredients are found in a search space with the assistance of machine learning, and learning-based, where code patches are rather predicted from deep learning models.

While a variety of these powerful and original APR tools have been explored, a baseline study of the differences between the types of bug fixes and the run time of these procedures has not. In this study, we present an overlook of the landscape of APR tools in order to provide insights of the current state of automatic program repair research. We run a number of state-of-the-art APR tools such as LSRepair and AVATAR on benchmark datasets containing buggy programs, and report on the quantity and type of bugs these techniques can fix in a set time limit. This study considers the following run times: 30 minutes, 1 hour, 2 hours, 3 hours, 4 hours, and 5 hours. By running these techniques in parallel and averaging the correct bug fixes produced, we are able to discover the effectiveness of each procedure given the limited run time.

With this analysis, future research can contextualize the effectiveness of novel approaches in the backdrop of cutting edge past work. In addition, ensemble models could be built using a combination of select systems reviewed in this study to produce a greater number of correct patches.

Auto-Human Eye Blink Detection Dataset Labeling

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The initial labeling of new datasets used for training models is expensive and time consuming. Manually generation of labels requires hours of repetitive, human labor while algorithmic methods produce cheaper but inaccurate results [1]. Since these labels are used as the ground truth for evaluating predictive methods, accuracy is imperative. Therefore we combine algorithmic labeling with manual labeling to achieve 100% accuracy with fewer hours of human labor. We base our algorithm on the Eye Aspect Ratio (EAR) method [2]. The algorithm generates an EAR threshold, produces initial blink labels, and marks suspicious points to be manually investigated. Intersect-Over-Union Evaluation determines the labels' accuracy, precision, and recall. Automatically generated EAR thresholds outperform any single hardcoded threshold and approach the accuracy of EAR thresholds manually selected for each dataset. Furthermore, a frame count threshold and EAR graphs pinpoint the sections requiring human inspection.

[1] AltexSoft, "How to Organize Data Labeling for Machine Learning: Approaches and Tools," 2019. [Online]. Available: https://www.kdnuggets.com/2018/05/data-labeling-machine-learning.html.

[2] T. Soukupova and J. Cech, "Real-Time Eye Blink Detection using Facial Landmarks," *Computer Vision Winter Workshop,* 2016.

Spatiotemporal Analysis of Racial Bias in NYPD Stop, Question, and Frisk Procedures

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The treatment of racial minorities by law enforcement personnel during routine stops has become a heavily debated topic in the United States. Determining the levels of bias in these stops could have tremendous implications on police-civilian relations. Our research examines racial bias within the NYPD's Stop, Question, and Frisk (SQF) procedures, which have disproportionately stopped black and hispanic individuals over their white counterparts. We determine racial bias via the threshold test, a Bayesian statistical model that calculates a race and precinct-specific search threshold — the point at which a police officer decides to search an individual for contraband. Lower search thresholds for certain races imply racial bias against these races. However, previous threshold test models have not accounted for spatiotemporal factors, including the fluctuation of racial bias within police precincts over time and the amount of crime in the neighborhoods where stops occur. To better understand racially-biased policing, the NYPD's SQF Datasets and aggregated Historical NYC Crime Data from 2003 to 2018 will be used to determine how racial bias in SQF procedures varies according to these factors.

The datasets were first cleaned and filtered using R. The threshold model was applied to infer race and precinct-specific search thresholds, which were plotted against crime numbers. Minority search thresholds were compared to white search thresholds to determine the amount of racial bias within each precinct over time. The model-predicted search and hit rates (the search success rate) were compared to the actual values to determine the robustness of the model. Python scripts employing geocoding APIs were utilized to determine the coordinates of stops. This information allowed us to visualize racial bias within the NYPD's stops across space and time with QGIS, a geographic information system software.

While there was no significant correlation between the search thresholds and neighborhood crime numbers, white search thresholds were consistently higher than black and Hispanic search thresholds, implying consistent racial bias against these racial minorities. The model was generally accurate at predicting the search rate of all races but slightly increased in error when predicting the hit rate. This information, along with a robust visualization platform for racial bias, provides valuable tools for policymakers, police, and residents to make informed decisions about policing practices in the places that they call home.

NSF REU-
EXPEDITIONS IN TRAINING, RESEARCH, AND EDUCATION FOR MATHEMATICS AND STATISTICS THROUGH QUANTITATIVE EXPLORATIONS OF DATA (EXTREEMS-QED)

Machine Learning Models for the Dynamics of Ferrofluids

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The magnetic properties of ferrofluids allow for the potential of delivering drugs more precisely towards specific locations in the human body. The probability of successfully targeting a location is modeled via simulation of the motion these particles in a blood vessel where a magnetic field is applied. Several machine learning techniques are used to improve this success rate by exploring relationships with respect to various physical parameters. A significant dependence on the initial position of the particle is indicated.

NSF REU - FUSION OF DATA AND POWER FOR A CONTROLLABLE POWER DELIVERY GRID

Design and Experimental Tests of an Energy Packet Switch Testbed for a Digital Microgrid

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

Abstract: We proposed the design and electrical description of an energy packet switch for forwarding and delivery of energy in digital power grids and microgrid. The proposed switch will receive energy from one or multiple power sources in the form of energy packets, store them in energy containers, and forward them to requesting loads connected to one or multiple output ports of the switch. The energy containers are supercapacitors and this principle can be transported to the use of hypercapacitors and high-performance batteries. We also designed and implemented data-controlled load that are compatible with the energy switch. These loads receive these discrete amounts of finely-controlled energy rather than discretionary amounts after. We implemented a 2x2 energy packet switch and performed extenuating tests to demonstrate its operation and capabilities. The switch and loads communicate using the Internet Protocol and apply a request-grant protocol similar to that used for Internet browsing. The result is a digital microgrid that can collect and distribute energy with fine control and reliability such that it can be used in cases of scarce energy and emergencies. The tests showcase a new model for distribution and management of energy that is highly efficient and that may signify the future of energy distribution. Results or this work were recently accepted for presentation in IEEE international conference. This project is supported in part by NSF Award 1641033.

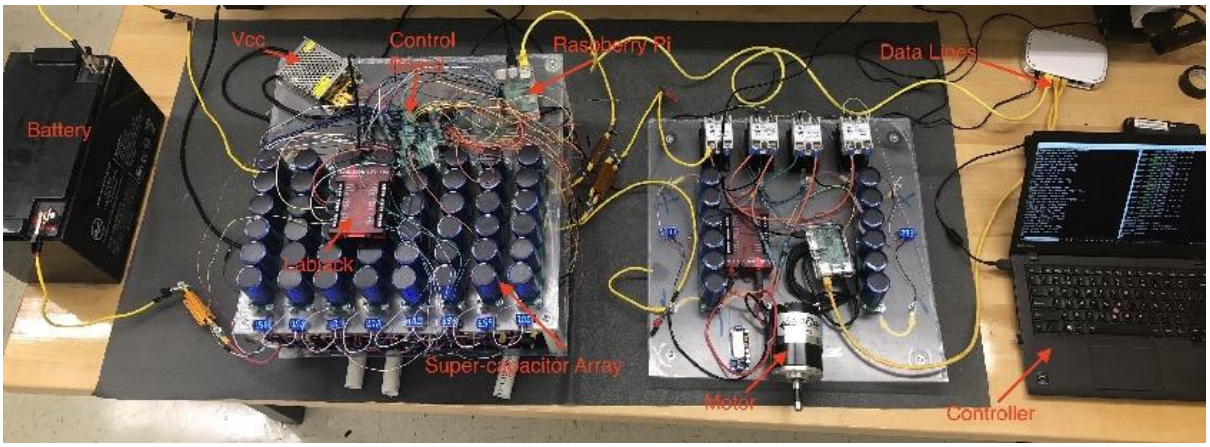

Figure 1 Photograph of Implemented Energy Packet Switch Testbed at the Networking Research Laboratory, ECE Dept., NJIT.

NSF REU –

OPTICS AND PHOTONICS: TECHNOLOGIES, SYSTEMS, AND DEVICES

Enhancing the Light Extraction Efficiency in Ultraviolet Light-Emitting Diodes Based on AlInN Nanowire Structures

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Nanowire ultraviolet light-emitting diodes (UV-LEDs) have critical and potential applications in health care, food production, water purification, and laboratory equipment. The potential success of conventional thin-film UV-LEDs have suffered from their poor light extraction efficiencies. However, the efficiency and performance of AlInN nanowire UV-LEDs can theoretically accomplish significantly high numbers by controlling the nanowire radius and spacing between nanowires. This study applies three-dimensional finite-difference-time-domain (3D FDTD) simulation to imitate a nanowire structure and calculate the outputs in terms of light extraction efficiency (LEE) of the desired nanowire LED design. The schematic structure of a singular AlInN nanowire structure is shown in figure 1(a). The simulations are conducted by varying the radius of each nanowire and spacing between the nanowires and by arranging the nanowire structures in different array patterns such as square, hexagon, and random. The LEE is monitored from the outer surroundings of the nanowire structure. The transverse magnetic field emission is monitored from the top of the nanowire structure. The optimized radius and spacing pair in a pattern arrangement with the maximum LEE is the objective for this study. The simulation data shows that AlInN nanowire UV-LED structures can be achieve a theoretical LEE of ~98% shown in figure 1(b). In this simulation, the impact of top metal contact as well as p-GaN contact layers are not considered. These results provide important information to fabricate and characterize a physical AlInN nanowire UV-LED device and its characteristics for future research.

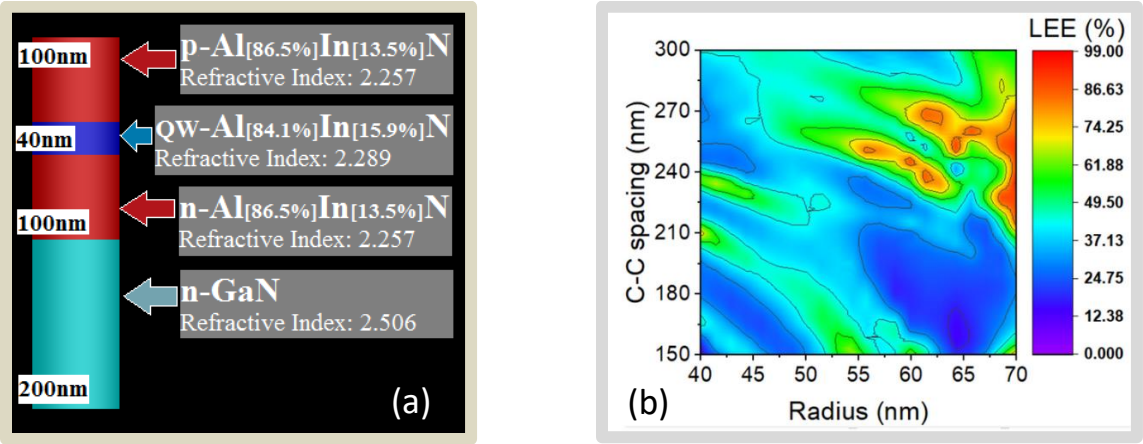

Figure 1: (a) 2D design of the AlInN nanowire structure with labeled layers, compositions, refractive indexes, and heights. (b) Contour plot representing the LEE of the AlInN nanowire UV-LEDs versus the nanowire radius on the x-axis, and -nanowire C-C spacing on the y-axis.

Use of Rhenium Disulfide to Improve Sensitivity of the Lab on a Chip Device

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Recent studies on ReS_2 show excellent optical and electrical properties. ReS_2 is being used for energy storage, photodetectors and biodetectors. In previous research, a nanoporous substance made of treated carbon nanotubes (CNT) was packed inside a channel. A sample was passed through the chip and the target biomarkers bind to the CNT. The current response from the nanowire due to the applied AC voltage was measured. A change in the response indicates a change in impedance caused by excess target biomarkers in the electrode. This Lab on a Chip (LOC) device has the potential to significantly improve accessibility and early detection of time sensitive diseases such as cancer. Biomarkers are present in the blood before physical symptoms may appear, thus allowing for earlier detection. The LOC device must be sensitive enough to capture small concentrations of biomarkers to avoid false negatives. This study investigates the use of ReS_2 to increase the sensitivity of the chip, as compared to CNT. An EIS machine was used to measure the impedance. Untreated carbon nanotubes and TiO_2 were tested as negative and positive controls. To test the sensitivity of these materials, different concentrations of KCl were passed through the chip. For each concentration, different voltages and configurations were tested to observe the change in conductance. These nanowires are reactive to visible light, and therefore were tested with and without light. Expected results are that the ReS_2 chip will show a higher change in impedance with light, which will indicate higher sensitivity. Future studies will investigate the change in impedance when ReS_2 is treated with single stranded DNA, complementary to the sequences that indicate disease.

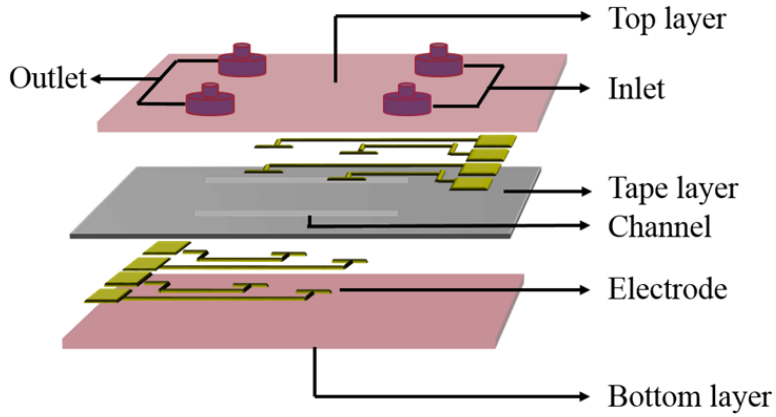

Figure 1: Lab on a chip design

Visualization and Characterization of Etched-Based On-Chip Plasma Self-Separation

Arijit Dutta, Advisor: Dr. Eon Soo Lee, and Mentor: Ben Ingis
Mechanical and Industrial Engineering Department
New Jersey Institute of Technology, Newark, NJ 07102

One of the most important aspects of cancer treatment is detecting it as soon as possible. A new quicker and more cost-effective solution has been developed in the form of a micro biochip which, using a few microliters of the patient's blood, can detect the type and progression of cancer based on biomarkers in the blood. Such a device could be used at regular doctor appointments and give results within a few minutes of taking blood. A very important aspect of this device is the filtration of the blood. The antigens, typically in the fluid plasma part of blood, must be filtered from the red blood cells to improve the accuracy of the sensors. The filtration of blood on a microscopic scale has been researched but not much progress has been made. In this experiment Armour Etch cream is used on a microscope slide. This cream, typically found out local hardware stores for frosting glass, etches microscopic cavities into the slide. Silicon-polymer channels, made of Polydimethylsiloxane (PDMS), are placed on the etched pattern. Blood mimicking fluid (BMF) is then put into the supply channel and filters through the sensing channel, where the sensors would be placed, by means of the microscopic cavities.

The main goal of this filtration method testing is to determine the different parameters that will maximize flowrate through the channels while also filtering the plasma from the red blood cells. A MATLAB code will process the video recording of each trial and, through image processing, give quantitative values for flow rate. The different parameters include but are not limited to the amount of time the cream is on the slide, the amount of times the cream is applied, and the distance between the supply and sensing channels. Before each test, the PDMS channels must be plasma exposed to make them more hydrophilic which allows a smoother flow of liquid through the channels. The channel distances that will be tested are 0.1 mm, 0.25 mm, 0.5 mm, 0.75 mm, 1.0 mm with the same etched region. The number of times that the cream will be applied are from 1 to 4 times. The amount of the time the cream is applied on the slide will be 15, 30, 45, and 60 seconds.

There are many variables that need to be controlled. For example, the size of the etched region must be held constant for all the trials as well as the placement of the channels onto the slide. Such factors could skew results greatly and so must be determined before proceeding with the experiment. Future work on this project will consist of running through the experiment with these other independent variables being held constant. This will ensure that the results are only a result of the variable we want to see (time of cream on slide, number of times that cream is applied, and channel distances). From these results, the most efficient and cost-effective filtration method will be developed and integrated into the overall micro biochip.

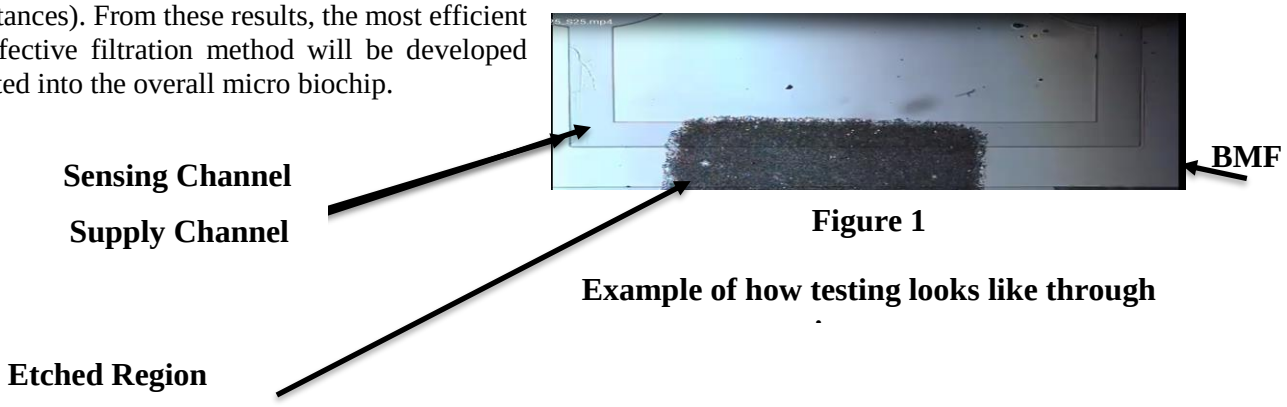

Figure 1

Example of how testing looks like through .

Silver Nanowires as Infrared Transparent Electrodes

Ethan Espin
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Abstract: Infrared detecting technology requires transparent and conductive electrodes which are not present in current times. Infrared Cameras, for example, are used in the commercial and military sector to identify targets, thieves, and criminals in low light and dark settings. The materials used to fabricate the Infrared Transparent Contacts (ITC), although reliable, is proven to be expensive and less effective compared to potential alternatives. Such materials consist mainly of very thin metal contacts and carbon nanotubes. Silver nanowires (Ag NWs) are shown to be an excellent infrared detecting electrode through the material's high mechanical flexibility, high transparency, and low sheet resistance. The objectives of this research are to understand the (1) infrared transparency and (2) electrical conductivity characteristics of silver nanowire-derived films as a function of processing conditions with the purpose of producing an optimized infrared transparent conducting film. Former research determined that using diameters of Ag NWs in the range of 100nm-120nm and lengths of 20 um or longer exhibits properties that are optimal for infrared detecting applications. For this reason, two diameter sizes, 115nm and 120nm, are used in the fabrication and experimental phase to determine the ideal Ag NW dimensions. Diluted samples of the initial as-received solution were prepared to test a variety of silver nanowire samples. The silver nanowire samples were fabricated by spin-coated the various solutions onto sapphire substrates for 60 seconds at an RPM of 2000. The samples were then annealed at various temperature and times to analyze the diverse resistivities. Resistivity was tested with a Hall Measurement System which contained a four-probe resistivity testing chamber for the samples. Optical transmittance of the silver nanowires film deposited on the sapphire substrate will be characterized using FTIR (Fourier Transform Infrared) spectroscopy.

Multi-Platform Optics and Photonics Educational App

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The traditional method of teaching geometric optics relies on textbooks and outdated websites for a visual demonstration of the content of geometric optics courses. Geometric optics define light as a ray, which makes it useful for approximating the paths of light under certain circumstances. The definition of light as a ray makes geometric optics heavily reliant on visualization. The Multi-Platform Optics and Photonics Educational App is designed to enhance the learning environment for students studying geometric optics by using a visual and interactive approach. The application was developed using the game engine Unity and its' physics library. Based on data collected through the previous version of the application, changes in the Graphical User Interface design and mechanics were determined for the feedback collection system and the quiz system. The FeedbackPanel Graphical User Interface was enlarged from 490 of width and 923.5 of height to the full extent in width and height of the devise's screen to accommodate more feedback fields and to prevent the accidental clicking buttons outside of the feedback panel. The feedback form was also modified to allow users to provide anonymous feedback. Text input fields were substituted with dropdown lists to maintain consistency of data within the same attribute. A quiz feature to evaluate the users was added to the scenes of the Concave Lens module, Convex Lens module, and the Mirrors module. The new quiz evaluates the users employing multiple choice questions, true or false questions, and mathematical exercise questions. The results of the quiz are shown to the user and sent to the Firebase database of the project anonymously.

Applications of Visible Light Communication Systems for Intelligent Consumer Messaging and Indoor Positioning

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Visible light communication (VLC) has been a candidate for a future wireless communication system since visible light has a much broader bandwidth that more users can access compared to the bandwidth of radio waves. For the purpose of indoor use such as retail stores, Wi-Fi may have electromagnetic interference as the number of users increases. Also, radio waves can penetrate metals but are attenuated as they go through. Using visible light for wireless communication has advantages in that it is electromagnetic interference free and has a bigger frequency bandwidth. This research is aiming to provide a low-cost and simple scheme of indoor messaging and localization using RGB light emitting diodes (LEDs) and light sensors where the LEDs work as signal transmitters and the sensors work as signal receivers. We hope to make a wireless communication system for consumers to be able to localize themselves as well as to get a real time product information when they use the system. The reason for using RGB LEDs is that combinations of the light colors can generate much more different codes than that of single white light LEDs. In this research, characteristics of RGB LEDs and photosensors are investigated. Data of light intensity is measured by the photodiode, and a method for localization is proposed based on the data of the received light intensity. Also, by using this data, we suppose that a simple messaging scheme can be constructed.

Kalman Filter Implementation in Compression Optical Coherence Elastography Tissue Motion Tracking

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Optical Coherence Elastography is a technical extension of Optical Coherence Tomography, pictured below, involving compression of the sample and taking several OCT measurements. The resulting combination of OCT images is and OCE image and this image gives information about elastic properties in the tissue sample. Research on elastic properties of cancerous tissue has shown more rigid structure which can be discerned from non-cancerous tissue. OCE provides promising direction for detecting these cancerous tissues because of OCE's sensitivity to small motion. Properly tracking this motion, however, is necessary to understand the properties of the tissue. Kalman Filter motion tracking was explored as a solution to this problem.

Using depth resolved data from and OCT measurement camera Kalman Filters have shown that tracking tissue motion is possible even filtering out light scattering phenomena which add noise to the data. A 3-dimensional kernel was developed in MATLAB which could, for each depth of the sample, track the motion of the tissue over time as the sample was compressed. The resulting code proved that Kalman Filters can be used to track tissue compressive motion. The predictive stage of the Kalman Filter was accurate producing little error from measurement update; however, this needs further exploration using a much more advanced Kalman Filter known as the Extended Kalman Filter. Real time implementation of this filter will provide information on the tissue while being probed. Current methods require large machines and caches for data but the Kalman Filter's iterative design allows it to track this motion using sequential prediction and measurement without the need for storing the large amounts of data in memory.

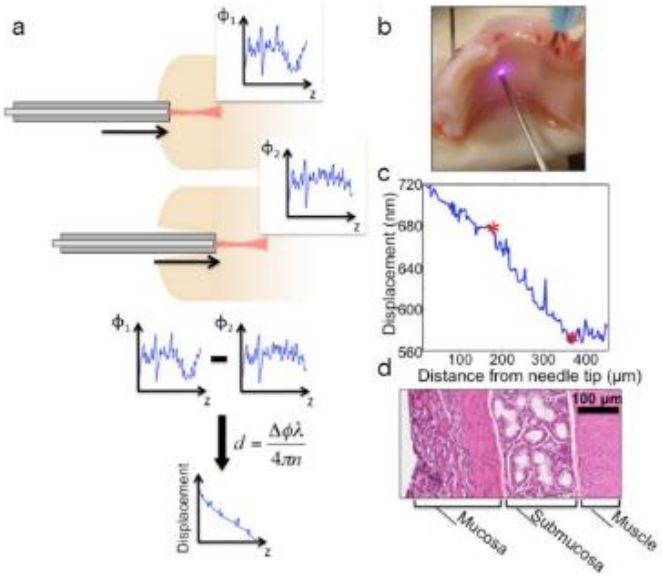

Fig. 1. A Diagram Showing how OCE images are taken, and the noise associated with OCE

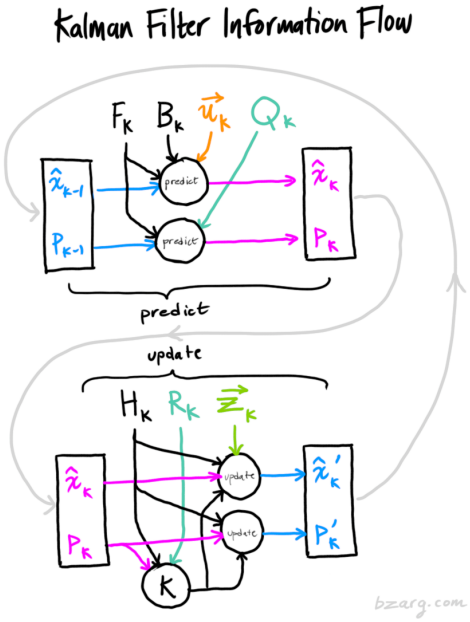

Fig. 2. Kalman Filter Information Flow Diagram

Denoising fNIRS Data by Integrating Independent Component Analysis and Short Channel Separation Regression

Devynn Saunders, Advisor: Dr. Xiaobo Li, Mentors: Yuyang Luo, Meng Cao, Ziyan Wu
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Functional Near Infrared Spectroscopy (fNIRS) is a versatile neuroimaging technique that allows the blood oxygen level dependent (BOLD) signal to be measured while a subject performs a cognitive task. It is a low cost, transportable, and safe method of measuring changes in oxygenated and deoxygenated hemoglobin concentrations to interpret brain activity. This method can be used to study subjects with neurological or psychiatric disorders, or to simply gain a better understanding of brain functionality during cognitive tasks. In comparison to Functional Magnetic Resonance Imaging (fMRI), fNIRS can be used in more realistic environments to monitor cortical activity in real life scenarios. But, to interpret and analyze fNIRS data, the signal must be filtered to regress out physiological noise and motion artifacts. Previous studies' present various noise reduction methods, but no consensus on a standard method of filtering has been determined.

Other studies have shown that short channel separation regression significantly improves the recovered hemodynamic response function (HRF) due to the technique's sensitivity to the superficial (i.e. skin and skull) layers of the head. This method incorporates additional short source detector separation optodes as regressors (see Fig.1). Subtracting the short channel from the long channel allows for a better estimate of the HRF because the superficial signal contamination is minimized.

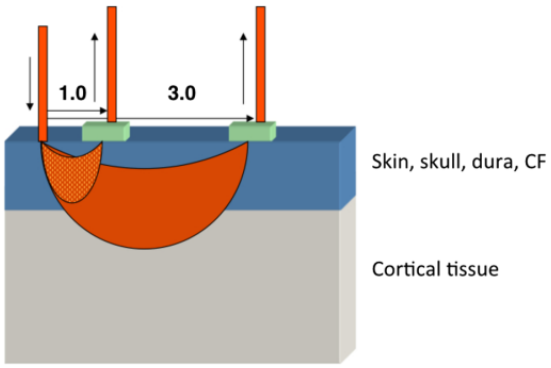

Fig 1: Short Channel Separation Diagram. Simplified diagram of the short channel separation (1 cm) and long channel separation (3cm) used in short channel separation regression.

To more effectively utilize this technique to improve the HRF, our proposal was to integrate Independent Component Analysis (ICA), and short channel separation regression. First, ICA was performed to remove components of the signal that include motion artifact and physiological noise from both long and short channels. Then, short channel separation regression was integrated to remove the highly contaminating effects of the superficial layers. Lastly, the signal was bandpass filtered between 0.1 and 1.0 Hz to remove baseline fluctuations. The data was collected from a normal control group, using a task-block style visual sustained attention test. The improvements on the recovered HRF were quantified using contrast-to-noise ratio (CNR), mean squared error (MSE), and the coefficient of determination (R^2). Implementing ICA, and then performing short channel separation regression, showed the greatest improvement on the estimated hemodynamic response function. Comparing the raw data to the filtered data, the CNR increased from 1.97×10^{-2} to 0.604, MSE decreased by 49.9%, and the R^2 increased from 3.60×10^{5} to 0.441 indicating that the proposed method was a reliable method of improving the estimated HRF.

CMOS Compatible RRAM Devices

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Memory technology is present in every electronic device that is capable of storing data. Currently, research is being done to make memory technology to consume less power, more durable, and store greater amounts of data. Flash memory is the most common type of memory in current devices which have large memory densities but with high power consumption and slow programming speeds. Therefore, a new type of memory device called Resistive Random Access Memory (RRAM) is being designed to replace flash memory with faster programming speeds, simpler structures, and lower power consumption. In addition, it is required that these RRAM Memory devices can have multilevel storage in a single device, which will allow in storing of greater amount of data.

The RRAM device consists of a bottom metal/Resistive dielectric/Top metal electrode. Multiple devices with various dielectric stacks with Ti/TiN/HfO_2/Al_2O_3/Ti/TiN and Ti/TiN/Al_2O_3/HfO_2/Ti/TiN assembled differently (Fig. 1). We will investigate the electrical characteristics of these devices. The experiments proceeded by applying positive voltage to the top electrode to achieve the ON state of the device and then negative voltage is applied to achieve the OFF state of the device. The multilevel storage is attempted by setting 3 different compliance currents, these control the amount of current flowing through the device and achieving different ON and OFF resistance state of the device. There has been a comparison between the TiN and Ti top electrodes influence on the Resistive switching behaviors on RRAM devices with 3 compliance currents. The Voltage and current values of each ON and OFF state are plotted (Fig. 2). The resistances will be calculated, and these resistance values will be used to analyze the multilevel storage and the sturdiness of the storage (Fig. 3).

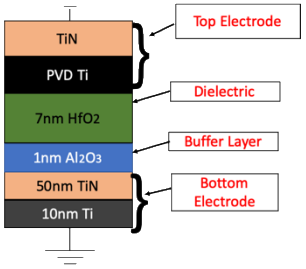

Fig. 1

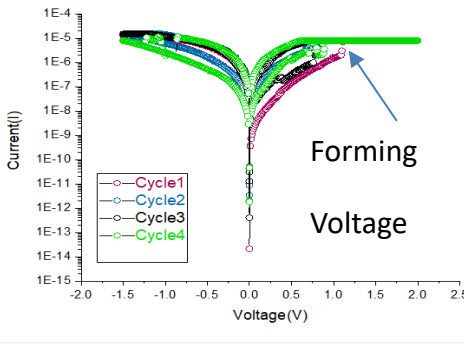

Fig. 2

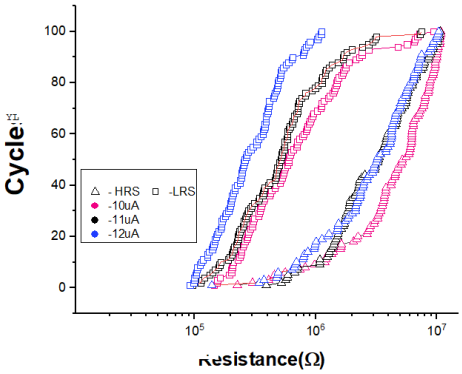

Fig. 3

NSF - Community College Biomathematical Research Initiation Program (C2BRIP)

Exploring the Viability of a PLSR-based Machine Learning Method for Predicting Circadian Phase in Cancer Patients

Elizabeth Epstein, Karen Reyes, Evan Fagan, Fritz Huggins
Mentor: Jonathan Trinidad
Advisor: Casey Diekman
Department of Mathematical Sciences
New Jersey Institute of Technology, Newark NJ 07102

The circadian clock is an internal biological timekeeping system that regulates daily patterns in physiology and behavior, such as an individual's sleep-wake cycle. The molecular mechanism underlying circadian rhythm generation is an intracellular clock composed of transcriptional and translational feedback loops, which leads to 24-hour rhythms in gene expression. The tendency for gene expression to peak at specific times of the day has implications in cancer therapy, as the effect of such treatment is tied to the manner in which genes are expressed at the time of administration. However, because there is significant variation in the phase of circadian rhythms across individuals, the practical application of circadian-based chronotherapy requires an efficient and cost-effective means through which a person's unique circadian phase can be measured. The currently accepted system used to assess an individual's circadian rhythm is a tedious and expensive process that necessitates gathering several blood samples from an individual over a relatively short period of time. While effective, this system is not practical in a clinical setting.

This project aims to explore a recently developed method for assessing an individual's circadian phase more efficiently. While a number of methods of varying levels of accuracy have been developed, most require a minimum of two samples to be taken from an individual. The Partial Least Squares Regression (PLSR) method developed by Laing et al. (2017) stands out in the fact that it requires only a single blood draw. The PLSR method uses a machine learning model to extrapolate circadian time based on an assay of about 26,000 genes. The model in its current form has only been validated for use in blood samples from healthy individuals and has never been tested on cancer patients.

We are gaining familiarity with Laing et al.'s method by first applying it to a new dataset from adipose tissue that was not part of the training set for the machine learning algorithm. Next, we will apply the method to publicly available gene expression datasets from tumor samples to assess how well the algorithm can predict circadian phase in cancerous tissues.

Laing, Emma E, et al. "Blood Transcriptome Based Biomarkers for Human Circadian Phase." *ELife*, vol. 6, 2017, doi:10.7554/elife.20214.

Mathematical Modeling of Circadian Rhythms, Tumor Growth, and Radiotherapy

Mariia Goriachi, Luis Lara, Shuhrah Chowdhury
Mentors: Jonathan Trinidad and Emel Khan
Advisor: Casey Diekman
Department of Mathematical Sciences
New Jersey Institute of Technology, Newark, NJ 07102

The goal of this project is to study how to effectively utilize circadian rhythms in aiding drug delivery against tumor growth. Circadian rhythms are 24-hour cycles in physiological processes, such as cell growth and sleep/wake. In a number of studies, researchers have shown that disruption of the circadian clock can increase or decrease the cell population growth rate. The model presented in El Cheikh et al.[10] is the first step in developing a multiscale model for the interaction between the circadian clock and the cell cycle. Another paper, written by Checkley et al.[11], discussed a mathematical model for cancer cell population growth and simulated its reaction to a combination of therapies.

In this project, we aim to integrate these two models and analyze the best time of day to administer therapies to cancer patients. We hypothesize that by taking into account the phase of circadian rhythms in healthy and cancer cells, appropriately timed therapies will be more effective in killing cancer cells while being less toxic to healthy cells. We will implement our model in MATLAB and conduct simulations to explore the complex interactions between the cell cycle, the circadian clock, and tumor growth. Combined circadian rhythm/cell population and drug PK-PD models can be a helpful tool for chronotherapy of cancer patients. Thus, this project will help provide a foundation to develop more personalized and effective treatments specific to each patient's circadian phase and tumor properties.

[10] El Cheikh, R., Bernard, S., & Khatib, N. E. (2014). Modeling circadian clock–cell cycle interaction effects on cell population growth rates. *Journal of Theoretical Biology, 363*, 318-331. doi:10.1016/j.jtbi.2014.08.008

[11] Checkley, S., Maccallum, L., Yates, J., Jasper, P., Luo, H., Tolsma, J., & Bendtsen, C. (2016). Bridging the gap between in vitro and in vivo: Dose and schedule predictions for the ATR inhibitor AZD6738. *Scientific Reports, 6*(1). doi:10.1038/srep16545

U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND ARMAMENTS CENTER

AND

NJ SPACE GRANT CORSORTIUM SUMMER RESEARCH PROGRAM

Interdisciplinary Summer Research – Collaborative Robotics:

Funded by: US Army CCDC Armaments Center

Sahar Abulaimoun, Erik Aleksanyan, Kyle Cowing, Adam Czyrsznic, Karina Dsouza, Jacqueline Farkas, Matthew Frazier, Kalib Guthrie, Kyle Lapolice, David Monroe, Brittany Morales, Aashka Patel, Benjamin Ruoff, James Smith

Mentors: *Dr. John Federici, Martina Decker, Sam Gatley, Lou Rizzo*

The exploration of GPS-denied, all-terrain environments such as caves or tunnels can be dangerous and difficult for humans. In situations when a human is unable to physically enter the environment, robotic intervention can be of aid. During the summer internship, a collaborative robotic fleet was created. The fleet will be used to navigate caves and tunnels. The mothership will carry the mini bots under its top frame. When the mothership cannot access an area, the operator will deploy one of the mini bots to continue exploring the environment. Each robot has various sensing capabilities. The robots can communicate with each other and send sensor data back to the operator through the established mesh network.

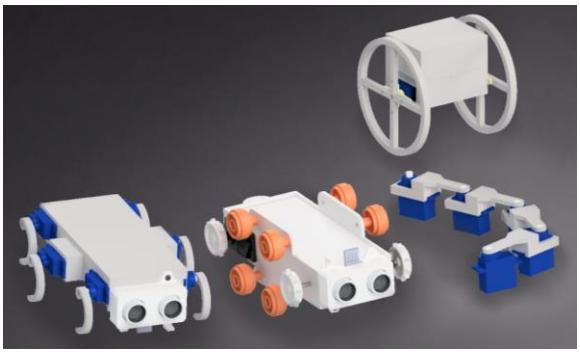

Figure 1. System of Mini-Bots. Image Credit, Matthew Frazier; AddLab

The team for the summer internship was assembled with the goal of interdisciplinary collaboration. Students have backgrounds in applied physics, biomedical engineering, computer engineering, computer science, industrial design, and mechanical engineering. With the various knowledge available among the team, the students were able to work in interdisciplinary groups to develop a collaborative robotic fleet that can explore all-terrain, GPS denied environments. In order to allow the overall project to succeed, the team learned to communicate effectively and work iteratively. Using the iterative design thinking process, the team defined the problem, empathized with the users, prototyped the elements of the project, conducted testing on the said prototypes, and refined the products. The team worked in subgroups to complete the various aspects that the overall project required such as designing the mothership,

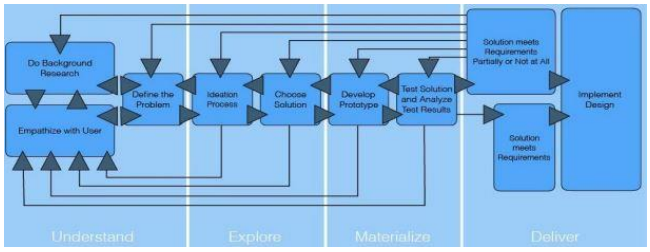

Figure 2. Design Thinking Iterative Process. Image Credit, Material Dynamics Lab

Building the mini-bots, programming the robotic fleet, creating sensor packages, and enabling the mesh network.

HERITAGE INSTITUTE OF TECHNOLOGY, INDIA

-NJIT SUMMER RESEARCH

Defence Mechanisms for Adversarial Attacks

Ishita Bardhan[a], Advisor: Dr. Abdallah Khreishah[b], Mentor: Guanxiong Liu[b]
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Output uncertainty of Machine Learning systems is a big obstacle to ensure safety-critical applications like autonomous vehicles. Although deep neural models have achieved state of the art performance on speech and visual tasks, they can be caused to misclassify an image by applying a certain hardly perceptible perturbation to examples from the datasets, with high confidence. This form of an image is called an Adversarial Example.

Thus, designs to mitigate the impact of error output become of great importance. The N-version machine learning architecture uses N (>=2) models which are functionally equivalent and undergoes training to improve the system reliability against probabilistic outputs of individual machine learning modules. Currently, people claim that it can be applied to defend adversarial examples. The key idea is to check whether the theoretical implementation of the architecture is working in practical applications.

The Double Model Single Input (DMSI) Architecture was implemented on Adversarial Attacks, which uses two different models (1 and 2) trained with the same input data set.

Initial Observation: The DMSI had a basic Convolutional Network as Model 1 and Keras Sequential model as Model 2. The two models were trained individually with the MNIST dataset (70000 images of handwritten digits). A method of adversarial attack called "Fast Gradient Attack" was applied. The individual accuracies were calculated. The intersection of the sets of input data that lead to error output by each model was divided by the sample space to find the failure probability of the system. The failure probability when subtracted from 1 gave the reliability of the system which was found to be 95.32% and was equal to the accuracy of Model 1. The fact that the error output of one module gets covered by the other gets established here.

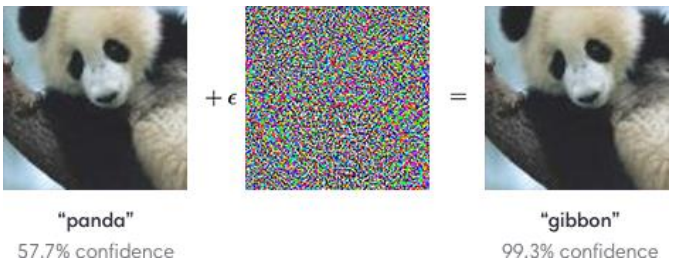

Figure 1: How a small perturbation misclassified the Panda as a Gibbon.

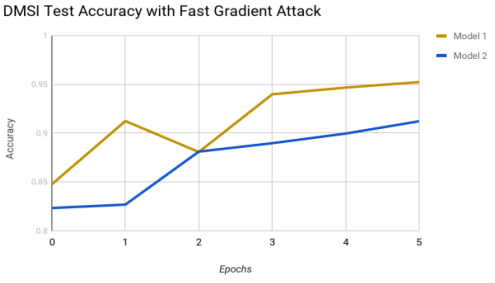

Figure 2: The plot of the accuracies of the two models in DMSI architecture.

Stability Analysis of Self-Assembling Peptide Hydrogels

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A variety of biological mimics can be attached to a self-assembling peptide domain to perform a wide range of functions that include regeneration of dental pulp, angiogenesis and anti-angiogenesis of blood vessels & neural tissue regeneration. The thixotropic nature of these Self-Assembling Peptide Hydrogels (SAPH) has been shown to mimic extracellular matrix (ECM), as published in previous literature, and we are able to tune the biophysical characteristics of the hydrogel such as stiffness and concentration.

To analyze the stability of such hydrogel systems, we start by testing degradation/stability over a one week period and a range of temperatures, specifically 4°C, 25°C and 37°C. A 2 w. % hydrogel of peptide SLKr5 was prepared in 298 mM sucrose, as detailed in previous published literature, and pH adjusted to 7 to form a stiff hydrogel. Twenty-four 50 µL aliquots of the hydrogel were prepared (3 sets of 8) & stored at the 3 respective conditions.

After all the aliquots were frozen at their respective timepoints in -80°C, High Performance Liquid Chromatography (HPLC) was performed on the diluted hydrogels from each timepoint. Analyzing the HPLC traces from the timepoints/conditions and comparing it to the standard, we are able to assess the stability of the hydrogel at 4°C, 25°C and 37°C.

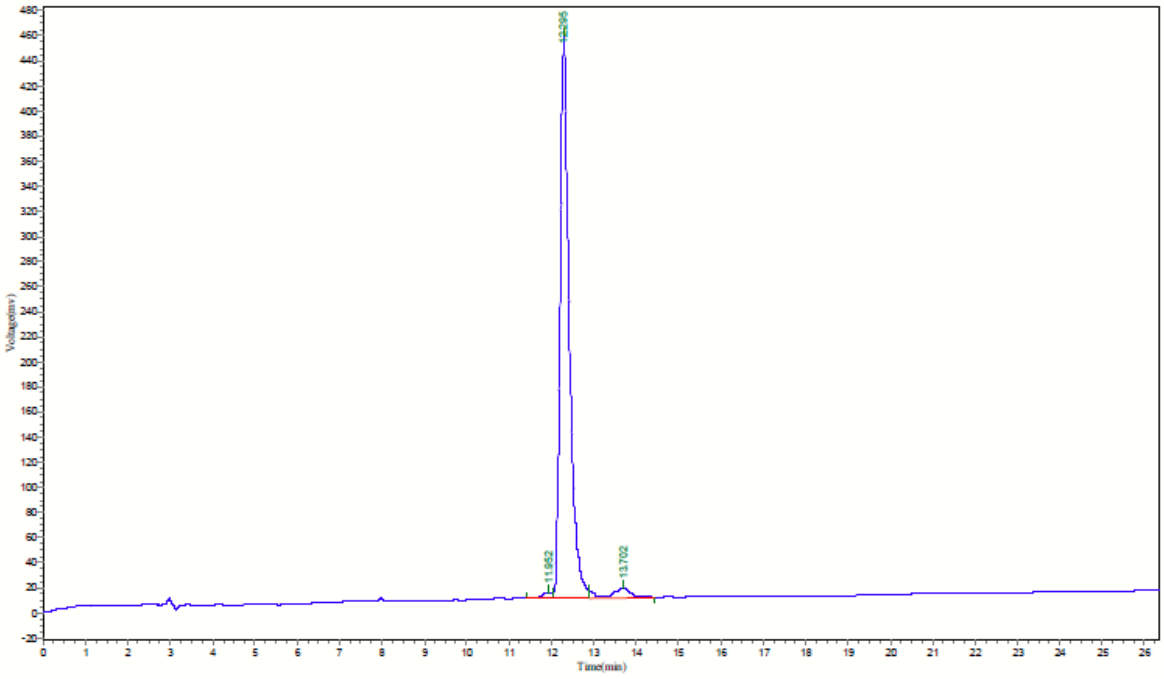

Figure 1. Expected SLKr5 HPLC trace (LifeTein)

Exploring Dimension Reduction Techniques for Deep Image Compressions

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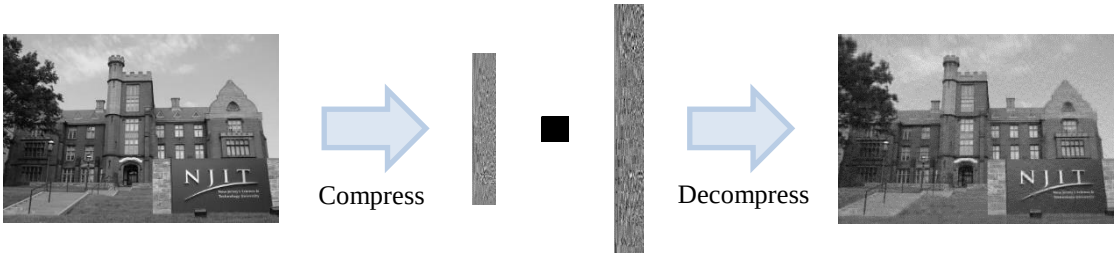
With the dawn of the digital age, data transmission and computation must be brought about carefully to maximize the efficiency and productivity of any program/machine. While reduction of data is our initial goal, we also want to maintain the quality of the uncompressed product. In this study we will focus on some of the ways to compress images via Deep Image Compression and its pros and cons. We will be focusing on 3 lossy compression techniques, namely Haar Wavelet, Principal Component Analysis (PCA), and Singular Value Decomposition (SVD).

Haar Wavelet allows for both lossless and lossy compression of data by varying a threshold value. We compress the image matrix into a sparse matrix which effectively reduces its dimension and therefore allows for more data to be stored. The sparsity of the matrix is controlled by the threshold value mentioned above and allows for more compression depending on how high the threshold is.

PCA transforms the data into a new coordinate axis by supplying it with eigenvectors with the highest eigenvalues. A higher number of eigenvectors corresponds to lesser compression ratios but greater quality.

SVD decomposes a matrix into 3 components (U, Σ, V), where U and V are orthogonal matrices and Σ contains the singular values of the original matrix. Depending on the number of eigenvectors we choose we can achieve a lower storage space and still maintain a good quality if we choose the eigenvectors with highest eigenvalues.

This study also focuses on the balance between the compression ratio and the quality of the final uncompressed file, which is controlled by the parameters we choose for each method of compression. Furthermore, we were able to use CUDA enabled GPUs to reduce the time taken for the mathematical calculations of matrix operations to reduce the overall runtime for both compression and decompression algorithms.



Original Fig. 1 Singular Value Decomposition Reconstructed

3D Printing of Anatomical Models for Pre-Surgical Planning

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New Jersey Institute of Technology, Newark NJ 07102

3D printing is an additive manufacturing technique that utilizes computer-aided design to fabricate products in a layer-by-layer manner. Over the past decades, 3D printing has become a promising manufacturing tool in many industrial fields such as automotive, consumer product, healthcare, aerospace, education/research, architecture, etc. In the healthcare industry, 3D printing is being extensively used in dentistry, fabrication of medical devices and anatomical models, pharmaceutics, and advanced research activities including tissue and organ bioprinting. In this project, we focus on fabrication of anatomical/surgical models from patient's medical images. The anatomical models are of great help for surgical education and pre-surgical planning. Due to the inherent advantages, 3D printing enables the fabrication of patient-specific anatomical models from patient's own medical images, so that the surgeons can physically feel and touch the actual sized 3D organs instead of visually observing the 3D images on the computer screen. To precisely reproduce the shape and details of real organs, 3D models are generated from the 3D CT scan of the patients′ organ, which are provided from a hospital. In this study, we focused on printing appendages of the heart and the atrium. In order to print the 3D models, Autodesk Meshmixer software was used to modify the original models. We used the Flashforge Creator Pro 3D printer for printing these organs. This printer is based on the principle of Fused Deposition Modeling (FDM), where the ink material is in a filament form. Then, printing parameters were optimized to print hard (poly(lactic acid), PLA) and soft (thermoplastic polyurethane, TPU) filaments. Some of the parameters that were changed and analyzed for printing the anatomical models are shell thickness, print speed and temperature of the material. The final printed models were compared to the original 3D model to evaluate the similarity and the loss of the details.

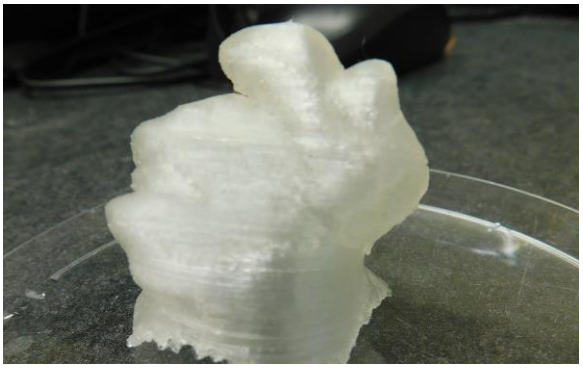

Figure 1: Right Atrial Appendage printed using PLA

Figure 2: Left Atrial Appendage printed using TPU

INVESTIGATING HYDROLYTIC STABILITY AND CHANGES IN MECHANICAL PROPERTIES OF ELECROSPUN CROSSLINKED GELATIN SCAFFOLDS

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Osteoarthritis (OA) is a degenerative joint disease that results in the loss of articular cartilage and normal joint function. It is the most common chronic condition of the joints. Articular cartilage is an avascular tissue with limited capacity to regenerate or heal after injury or degenerative disease. While current therapies can alleviate symptomatic pain, surgical interventions do not restore normal hyaline cartilage. Instead fibrocartilage forms which is mechanically inferior to native hyaline cartilage. Therefore, a growing need exists for an effective treatment to repair articular cartilage. An approach to promoting articular cartilage repair would be the use of tissue engineering constructs called scaffolds that closely mimic the native cartilage microenvironment. Electrospinning is a widely used process for fabricating these scaffolds to repair or regenerate tissues. In this study, we have electrospun gelatin, a commonly used biological material that promotes cell adhesion. However, it does not have suitable hydrolytic stability for long term biological applications unless chemically crosslinked. Hence, chemical crosslinking was performed using N-(3-dimethylaminopropyl)-N'-ethyl carbodiimide (EDC) with N-hydroxysulfosuccinimide (NHS). In this study, the effect of crosslinking time and concentration on hydrolytic stability and mechanical properties was assessed via changes in scaffold degradation, tensile mechanical properties and rheological properties.

Minimize Energy Consumption of Hadoop Jobs Under Deadline Constraints

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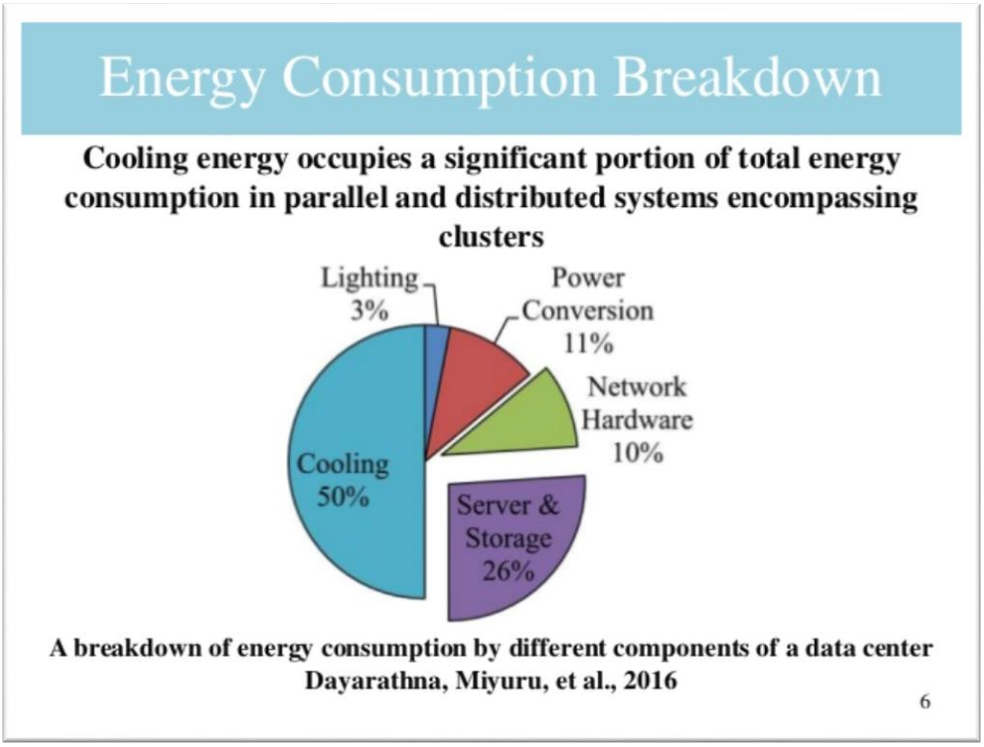
Abstract:

Big data applications require massive computing, networking, and storage resources and are typically executed in Hadoop systems deployed on large clusters for various data processing and analysis purposes. These applications have become a main consumer of energy in today's data centers, and energy efficiency is critical to the sustainability of big data systems. The goal of this research is to minimize the dynamic energy consumed by a batch of deadline-constrained Hadoop jobs on a Hadoop cluster while meeting the deadline of each Hadoop job. Extensive experiments are performed on a Hadoop cluster to measure the energy consumption and execution time of different Hadoop jobs. In these experiments, we consider a homogeneous Hadoop cluster and a workflow model consisting of *n* Hadoop jobs, each of which contains a set of map and reduce tasks. We measure the energy consumption and execution time for each map task and reduce task. Such performance measurements are then used in the design of a job mapping scheme in Hadoop so that all jobs are completed within their respective deadlines and the energy consumption is minimized. The proposed method, although focused on Hadoop systems, could be expanded and applied to other big data systems.



Buy Online, Fulfill From Store – Assignment of Products to the Fast Picking Zone

Hardik Jhamb[a], Advisor: Dr. Sanchoy Das[b], Mentor: Wen Zhu[b], Ph.D. Student
[a]Computer Science and Engineering, BRCM College of Engineering & Technology
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Abstract: This research examines the role of IT systems and advanced decision models in the Amazon fulfilment system. The most aggressive brick-and-mortar retailers, led by Walmart, are using S-Strategy or BOFS model to grow their online business. In effect they have converted the store into a fulfillment center. The key advantage is that there are no transshipments and last mile delivery occurs directly from the store. A second advantage is the ability to offer same day delivery using a local last mile delivery partner. The main goal of this project is to simulate a model in which the items can be allocated in the Fast Picking Zone (Back stock Area). This can be done by calculating the back-stock index of each item. The arrangement of the orders in the back-storage area can be a group of items bought together (frequently bought) or other items which a buyer can buy. This will depend on the frequency of the item. The future research will concentrate on the advanced picker schedule of the order fulfilment process.

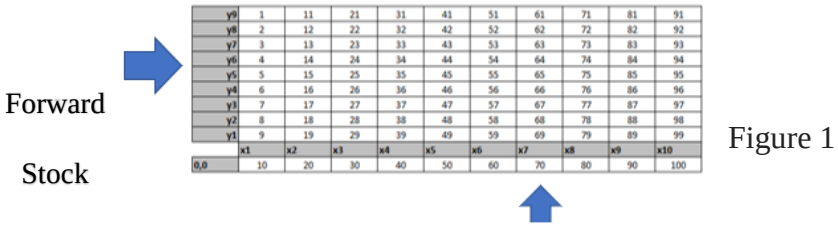

Figure 1

Figure 2

Order	Item - i A	B	C	D	E	
1	1					1
2	1					1
3	1					1
4	1	1				2
5		1	1			2
6		1		1		2
7		1		1		2
8	1	1	1			3
9			1		1	2
10			1	1	1	3
11			1	1	1	3
12				1		1
13					1	1

Figure 1: Back Stock is the fast pick area in the receiving or rear part of the store.

Figure 2: List of 13 orders containing 5 Items A, B, C, D and E out of which 3 Items will be allocated to the Back Stock.

Center for Injury Biomechanics, Materials & Medicine (CIBM3) Undergraduate Summer Research

Blood Brain Barrier Disruption as Injury Criteria in Repeated Low-level Blast-Induced Traumatic Brain Injury (RbTBI)

Alekhya Thota
Faculty Mentors: Dr. Venkata Kakulavarapu and Dr. Namas Chandra
Center for Injury Biomechanics, Materials, and Medicine, NJIT

Repeated low-level blast TBI (RbTBI) is most common in service members (SMs) and law enforcement officers during their training due to the constant use of heavy weaponry including 50 caliber rifles and Carl Gustaf recoilless rifles. Unlike severe bTBI, the pathophysiological manifestations of RbTBI are mild, hence, the service members often do not report any symptoms. However, the SMs experience a long term consequences including psychological and cognitive impairments. Additionally, there is no injury biomarker to diagnose the symptoms of RbTBI. Recent studies from this laboratory have identified blood brain barrier permeability changes as "signature-wound" in animals exposed to moderate bTBI caused by a direct mechanical force exerted by shockwaves. Further, follow up MRI studies in few SMs exposed to repeated mild bTBI report local microbleeds in certain areas of the brain consistent with subtle alterations in blood brain barrier in RbTBI. Given this, this project intends to utilize BBB permeability changes as an injury signal to calibrate the severity of RbTBI and its recovery as a function of time in animals exposed to multiple blasts at low overpressures. We hypothesize that the severity of BBB permeability will exponentially increase as the number of repeated blasts increases and that such changes may acutely create environment that later culminates into sustained (chronic) activation of secondary factors including neuroinflammation, oxidative stress and glial cell alterations. To investigate these events, rats were exposed to a low BOP of 10 psi (70 kPa) 5-successive times within a short duration (within < 5 min) in the helium-driven shock tube housed in CIBM3 at NJIT. BBB permeability changes were measured by extravasation of Evans blue dye and sodium fluorescence (NaFl); both were 2% solutions dissolved in saline and injected via tail vein two hours before sacrifice into brain parenchyma 4h after blast exposure. Additionally, microglial activation (changes in microglial number), levels of NADPH-oxidase (NOX) protein levels (as a measure of oxidative stress) and alterations in protein levels of GFAP (a measure of reactive astrocytosis) were determined by immunofluorescence analysis in the frontal cortex, hippocampus and thalamus in rats 30 days after RbTBI. Repeated low-level blast exposure to animals caused a robust disruption of BBB permeability as indicated by increased extravasation of Evans blue and NaFl into brain parenchyma (Figure 1). Interestingly, a single exposure at similar BOP (10 psi) did not show any appreciable disruption of BBB, suggesting that multiple low-level blast exerts cumulative effect as a function of number of repeated exposures (1 vs 5 times). Additionally, repeated blast displayed a robust increase in protein levels of NOX, increased activation of microglia as well as induced reactive astrocytosis even after 30 days post blast TBI (Figures 2-4). Together, these studies indicate repeated low-level blast displays a spectrum of pathological changes over a longer time period that may ultimately impact on chronic neurobehavioral changes.

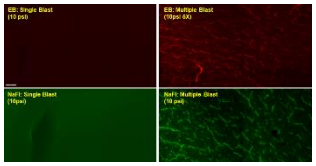

Figure 1: BBB disruption in RbTBI as shown by increased extravasation of EB and NaFl.

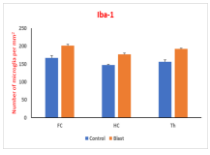

Figure 2: RbTBI induces microglial activation as shown by increased number of Iba1-positive cells in different brain regions.

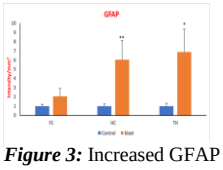

Figure 3: Increased GFAP levels in RbTBI indicating reactive astrocytosis.

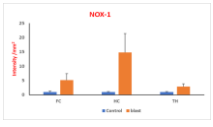

Figure 4: Increased protein levels of NOX in RbTBI indicating sustained oxidative stress

OTHER

Nonlinear Dynamics of Tandem Flapping Wings

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Abstract: The formation flight of birds has been of great interest to mathematicians and engineers for centuries (Fig.1). In this project we investigate the *Lighthill conjecture*, which states that for sufficiently fast locomotion and thus strong flows, orderly patterns could arise passively from aero- or hydrodynamic interactions, without the need for collective decision making or active control mechanisms[1]. Towards investigating this conjecture, we model the heaving motion of a single wing through an ideal fluid while tracking the wing's position and velocity. This idealized model is then altered for two tandem flapping wings in the same fluid, where forces on the follower result from vortices shed by the leader. As the flapping frequency and amplitude are varied, we observe a variety of complex "schooling modes," for which the distance between the wings oscillates either periodically or chaotically in time. The occurrence of stable (non-chaotic) "schooling modes" indicates orderly locomotion for a pair of flapping wings. These results indicate that formations of flapping swimmers might arise due to fluid interactions alone. The results from this two-wing model can further be used to gain insight into 2D lattices of flapping swimmers. This study could have extensive applications in industries like aviation, marine drones, and wind energy.

Fig.1: Formation Flight of Birds

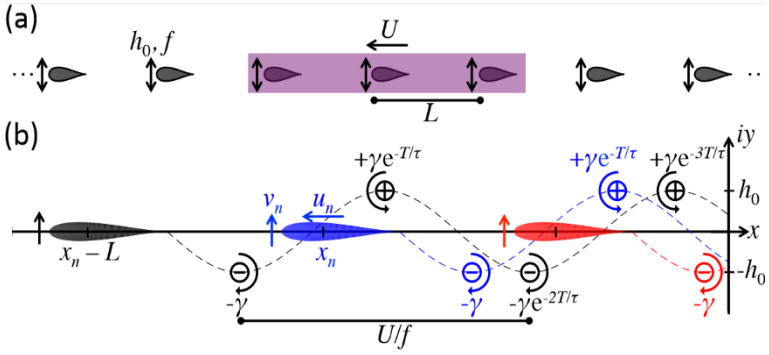

Fig.2: Point Vortex Model for Tandem Flapping Wings

[1] J. Lighthill, *Mathematical Biofluiddynamics* (SIAM, Philadelphia, 1975), Vol. 17.

Designing Amyloid-Inspired β-Sheet Fibrils from L- and D-Handed Peptides

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Amphipathic peptides are comprised of alternating polar and nonpolar amino acids that tend to self-assemble into complex, one-dimensional amyloid-like fibril structures. These peptides bind through non-covalent bonds to form β-sheets with nonpolar residues exposed on one side of the β-sheet and polar residues on the other. The translation machinery for protein synthesis evolved to utilize the left-handed chiral form of amino acids; therefore, all amino acids that occur in proteins are left-handed.[12] This is why amyloid-like fibrils have largely been investigated from amphipathic peptides made up of left-handed amino acids.

Here, two simulation systems were designed to determine and compare atomic structures of self-assembling monomers based on the amino acid sequence Ac-$(FKFE)_2$-NH_2. The first system was composed of four left-handed peptides, and the second system consisted of two left-handed (L-) and two right-handed (D-) peptides. By executing the simulating software GROMACS through the HPC Kong, we set up these four β-stranded systems inside of a cubic box, minimized the energy in the solvated environments, and performed molecular dynamics onto the designated systems. We then visualized distinct differences implemented through the modeling computer program VMD.

In the first set-up of four L-peptides, the β-strands aggregated to form pleated β-sheets, as shown in Figure 1. In a mixed left-handed (L-) and right-handed (D-) set-up, however, rather than self-assemble into fibrils composed of all L- and all D-peptides, these peptides coassemble into fibrils alternating in L- and D-peptides that orient in a rippled β-sheet structure.[13] These rippled β-sheet conformations are promising in biological applications concerning biomaterials, drug delivery, and currently incurable diseases.

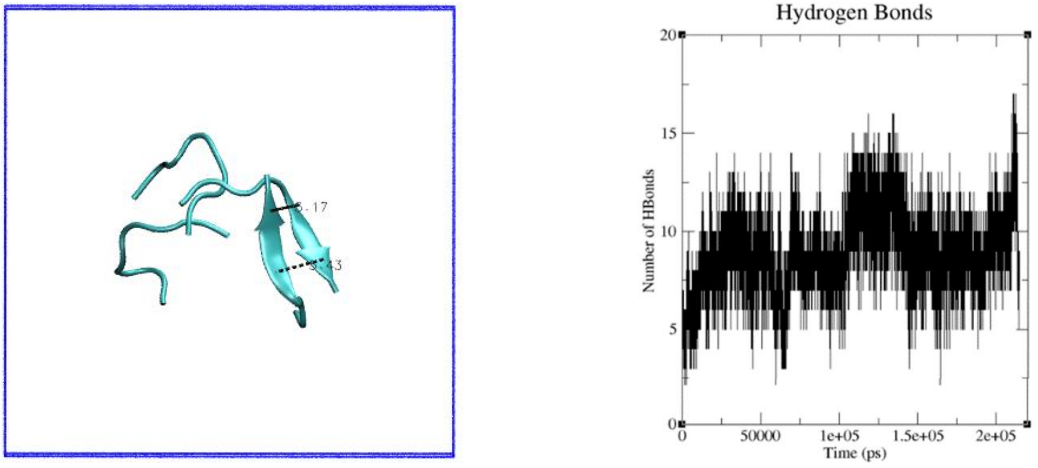

Figure 1. Schematic representation of a pleated β–sheet formed in the left-handed system (LEFT). The number of hydrogen bonds is shown as a function of time (RIGHT).

[12] Branden, C., & Tooze, J. (1999). *Introduction to Protein Structure* (2nd ed.). New York, NY: Garland Pub.

[13] Swanekamp, R. J., DiMaio, J. T., Bowerman, C. J., & Nilsson, B. L. (2012, March 14). Coassembly of Enantiomeric Amphipathic Peptides into Amyloid-Inspired Rippled β-Sheet Fibrils. Retrieved March 18, 2019, from https://pubs.acs.org/doi/10.1021/ja301642c.