NJIT
New Jersey Institute of Technology

BOOK OF ABSTRACTS
Eleventh International Undergraduate Summer Research Symposium

Friday, July 27, 2018

Book of Abstracts
Eleventh 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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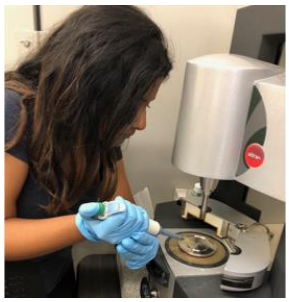


New Jersey Institute of Technology
University Heights
Newark, NJ 07102-1982

Joel S. Bloom
President

July 27, 2018

Welcome all – students, faculty, industry mentors, sponsors and friends of the university – to NJIT's Eleventh 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

July 27, 2018

A message from the Provost:

Welcome to NJIT's Eleventh 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 Eleventh 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 Pierre Deek

Fadi P. Deek
Provost and Senior Executive Vice President

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UNDERGRADUATE RESEARCH AND INNOVATION

July 27, 2018

I would like to extend warm welcome to all students and faculty advisors participating in the 2018 Eleventh 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 Eleventh NJIT International Summer Research Symposium" that contains 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 (URI) 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.

Sincerely,

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

July 27, 2018

Welcome to New Jersey Institute of Technology's Eleventh 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 2018 Research Symposium is the 18th 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 130 students from the United States and India presenting 92 research posters. This undergraduate research symposium is one of the largest such event ever 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 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
Eleventh NJIT International Undergraduate Summer Research Symposium

Friday, July 27, 2018

Table of Contents

PROVOST UNDERGRADUATE SUMMER RESEARCH PROGRAM

RONALD E. MCNAIR POSTBACCALAUREATE ACHIEVEMENT PROGRAM

HONORS SUMMER RESEARCH FELLOWSHIP

NSF REU – EXTREEMS-QED

NSF REU - OPTICS AND PHOTONICS: TECHNOLOGIES, SYSTEMS, AND DEVICES

NSF: COMMUNITY COLLEGE BIOMATHEMATICAL RESEARCH INITIATION PROGRAM (C2BRIP)

NSF and OTHER REUs

Alvin Sarmiento	Controllable Delivery power Grid -CDG	86
Jordan Sheft-Ason	Desalinaton of Water with Carbon Nanotubes	87

U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING CENTER, PICATINNY ARSENAL

Roy Baker	Interdisciplinary Summer Research – Design Process, Collaborative Robotic Fleet, and Distributed Robotics	89-91
Oliver Budd	Interdisciplinary Summer Research – Design Process, Collaborative Robotic Fleet, and Distributed Robotics	89-91
Austin Hall	Interdisciplinary Summer Research – Design Process, Collaborative Robotic Fleet, and Distributed Robotics	89-91
Preston Konopka	Interdisciplinary Summer Research – Design Process, Collaborative Robotic Fleet, and Distributed Robotics	89-91
Jonathan Martinez	Interdisciplinary Summer Research – Design Process, Collaborative Robotic Fleet, and Distributed Robotics	89-91
Nicolas Ramirez-Diaz	Interdisciplinary Summer Research – Design Process, Collaborative Robotic Fleet, and Distributed Robotics	89-91
Nicholas Warholak	Interdisciplinary Summer Research – Design Process, Collaborative Robotic Fleet, and Distributed Robotics	89-91
Anthony Yacoub	Interdisciplinary Summer Research – Design Process, Collaborative Robotic Fleet, and Distributed Robotics	89-91

NJ SPACE GRANT CORSORTIUM SUMMER RESEARCH PROGRAM

Luke Connell	Interdisciplinary Summer Research – Design Process, Collaborative Robotic Fleet, and Distributed Robotics	89-91
Gerassimos Giannoulis	Octahedral Compression and Rotations in Halide Perovskites Under Pressure	93
Nicholas Sorce	Laser Phase-Shift Range Finder for Entomological Lidars	94
Matthew Vantslot	Interdisciplinary Summer Research – Design Process, Collaborative Robotic Fleet, and Distributed Robotics	89-91

HERITAGE INSTITUTE OF TECHNOLOGY - NJIT SUMMER RESEARCH

Abhishek Agarwal	Detecting Bad Hubs in High Dimensional Data using Local Laplacian Score	96
Soumita Das	Detection of Bad Hubs from Query Results using Feature Selection	97
Sambo Dutta	Dimension reduction for compressing HPC data	98
Oindrila Ghosh	Fabrication of Robotic Arm with voice recognition	99
Yogita Mindia	Investigating the role of interfacial dielectric in $Ge/Al_2O_3/ZrO_2/TiN$ gate stacks	100
Adil Rahman	Capturing the Metadata in Continuous Integration Workflows	101
Sweta Sanganeria	Effect of Bottom Shape and Liquid Level on Power Dissipation and Power Number for Stirred Vessels under Different Baffle Configurations	102
Niyali Sen	Synthesis of metallic nanoparticles: Comparing batch to continuous micro-scale production	103

CENTER FOR INJURY BIOMECHANICS, MATERIALS & MEDICINE (CIBM3) UNDERGRADUATE SUMMER RESEARCH

Shahbaz Choudry	Evaluation of boxing gear protection efficiency	105
Ajay Gandhi	Microglia Activation After Blast Induced Traumatic Brain Injury	20
Sainithin Kuntamukkala	Neuroinflammation on Inflammasome	106
Osama Mahgob	Evaluation of boxing gear protection efficiency	105
Sushni Mukkamalla	Studying the Behavioral Effects of Blast Induced Traumatic Brain Injury	107
Waleed Mujib	Understanding changes in brain oscillations following blast induced traumatic brain injury	30
Dhruv Patel	Fundamental Understanding of the Mechanism of Cavitation	109
Swathi Pavuluri	Behavioral changes in mice following blast traumatic brain injury	108
Kaylah Ruiz	Fundamental Understanding of the Mechanism of Cavitation	109
Rahul Shah	Influence of Skull Strength on Shock Wave Propagation in Rats	38
Geetasravya Vegunta	Characterizing dynamic changes in microglia after blast induced traumatic brain injury	20
Aayush Verma	Development and validation of a computational model of the interactions of a primary shock wave with a human head surrogate	47

Provost Undergraduate Summer Research Program

Experimental Measurements of Uptake Coefficients of Gaseous Oxidized Mercury for Evaluation of its Atmospheric Deposition

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Department of Chemistry and Environmental Science
New Jersey Institute of Technology, Newark, NJ 07102

Mercury is a pollutant associated with impaired cognitive function and nervous system problems. Despite widespread awareness of the dangers of mercury, little research has been done on the specific chemical reactions that mercury undergoes as is travels from emission sources to the atmosphere and then to water and soil. The atmosphere is an important environmental reservoir, holding mercury before it deposits on land and in water. The goal of this project is to determine what common aerosols and surfaces contribute the most to the deposition of mercury from the atmosphere into the environment. Solid surfaces made of sea salt, common urban aerosols, and mixtures are studied for their ability to remove gaseous oxidized mercury from the atmosphere. Surface reactivity is determined in the form of uptake coefficients (or uptake probabilities), using chemical ionization mass spectrometry coupled with a fast flow reactor. The uptake coefficient is widely used by atmospheric modelers to evaluate the removal of oxidized mercury in the atmosphere, providing greater insight into the lifecycle of mercury.

$HgCl_2$ was used as a model compound to represent oxidized mercury. Uptake coefficients were calculated from each experimental data as a function of exposure time. Salt surfaces were found to be very reactive initially, but gradually decreased in their reactivity upon continuous exposure to mercury chloride, eventually settling on a certain level of uptake, which was significantly less than their initial reactivity. For example, magnesium sulfate had an initial uptake coefficient of 3.0×10^{-2}, but settled upon an average uptake coefficient of 2.6×10^{-4}, less than 1% of the original uptake value.

The reactivity of salts strongly depended on their chemical composition. Magnesium sulfate ($MgSO_4$) and sodium sulfate (Na_2SO_4) were most reactive. Chlorides, including sodium chloride (NaCl) and potassium chloride (KCl), were significantly less reactive than the sulfates. Nitrates, including potassium nitrate (KNO_3) and ammonium nitrate (NH_4NO_3), were found to be even less reactive than chlorides. All salts followed the same pattern of high initial reactivity, gradually decreasing to a lower steady state uptake. The main difference between salts in terms of reactivity was the amount of mercury chloride required to deactivate the surface to the point of steady state uptake and the magnitude of stead state uptake.

For sulfates, we investigated the effect of crystal hydrate water on the salt reactivity. Tubes prepared at room temperature contained water in the form of hydrate, but by heating the salt-coated tubes, the water could be removed. Crystal hydrate formulas were estimated to be $Na_2SO_4\bullet3H_2O$ and $MgSO_4\bullet7H_2O$. Water removal was monitored by measuring the decrease in the salt coating mass. The mass of $MgSO_4$-coated tubes decreased approximately by 40%, while the mass of Na2SO4- coated tubes decreased by 10%. These amounts of water corresponded to crystal hydrates $Na_2SO_4\bullet2H_2O$ and $MgSO_4\bullet2H_2O$. Dehydration was found to reduce the reactivity of the salts, noticeably shortening the amount of time it took for a salt surface to be reacted to the point of steady state uptake. However, the initial and steady state uptake coefficients remained practically unchanged.

Creation of Micro-particles for Drug Delivery Systems using Electrohydrodynamic Co-Jetting

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The size and shape of particles used as drug delivery devices play an important role in determining their function in the body. Because of this, Electrohydrodynamic co-jetting has gained popularity as a way of creating these particles, as it allows for a huge amount of control over their size and shape, and is adaptable for many materials.

EHD co-jetting is a method in which a solution pumps through two or more adjacent needles, creating a stable interface at the tip. Applying an electric field to the needles as droplets begin to form creates a Taylor Cone, where the rapid acceleration of solution causes both a reduction in jet diameter and an increase in surface area, allowing for the evaporation of the solvent and formation of particles. Wide ranges of particles and fibers can be fabricated using this method, and it has been found that there are many process parameters affecting both the size and shape of the final product. Not only does solution composition and viscosity (variables controlled with varying weight percentage of polymer in solution, type of solvents used, and ratio of solvents) effect the jet, but also the speed the solution is pumped at, magnitude of voltage applied, collection distance, and size of Taylor Cone. On top of this, conditions that can vary between two different locations or seasons, such as temperature and humidity can also have drastic effects on the outcome of the jet, making the same recipe difficult to reproduce at two different jetting stations.

The goal of this project is to study the impact that process parameters have on the morphology and size of polymer particles that they form, specifically collection distance, wt% PLGA, and pump speed. Ultimately, we will make a recipe that will create 3-5 micron particles, and a recipe that can create particles in the Nano-sized regime. Images of these particles will be collected using a Scanning Electron Microscope. Preliminary results show that by varying weight percentage of polymer in solution jetted, we can vary particle size, and that the two are directly related. In the remainder of this work, we hope to increase the consistency of our current recipes in producing particles with the intended specifications, as well as find the effects that pump speed, collection distance, and voltage applied have on the particles.

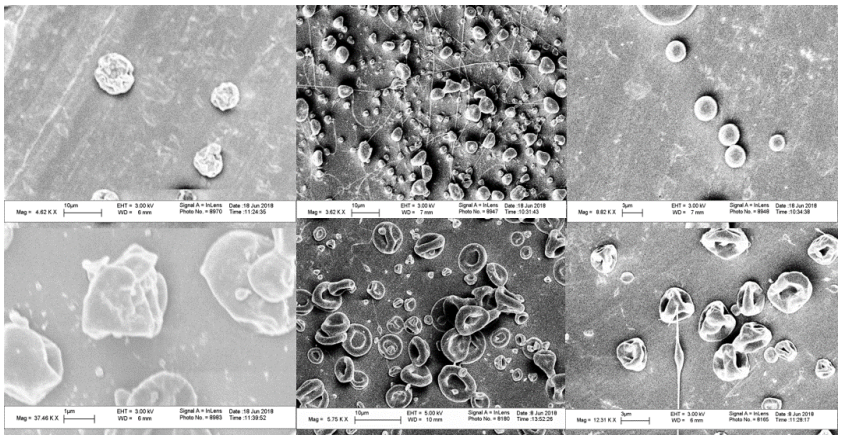

Figure 1. Particles with different size and morphologies created from different recipes.

Augmented Reality Framework for Museum Exhibits

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The United States faces a growing challenge engaging students in STEM education. Global comparisons of STEM secondary education performance place the United States in the bottom half with a steady decline. Reasons for this vary, but one major recognized factor is the quality difference between multimedia experiences available for entertainment as compared to education. Museum exhibits are public works intended to help engage visitors in scholarly and scientific inquiry using rich experiences. Unfortunately, many museums report historic lows in audience participation. With many interactive experiences available to audiences, museums have to contend with the widening range of options publically available. Augmented Reality (AR) is a technology that takes the user's perspective of the physical space and superimposes computer-graphics to construct a composite view. This helps construct a more engaging experience through visual and auditory representation. Young audiences are likely to engage with new technologies and AR in public educational institutions can increase STEM interest.

This summer, an AR application framework for museums for smartphone AR applications was developed along with documentation, tutorials online on how to use the framework to construct a solid AR application, and a sample application uploaded on the Google PlayStore for demonstration. Visitors using the applications can experience exhibits in new perspectives with deeper connections. Museums are also able to display more of their content in virtual space because they may be limited to the amount of physical space they currently possess. The framework will provide non-developers a simplified approach to create AR applications for public exhibition. This project will be further refined using an existing collaboration with the Newark Museum.

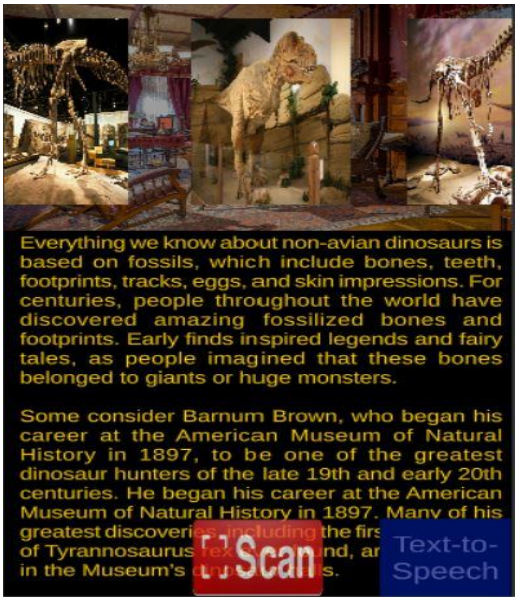

Figure 1 displays how a museum's AR application may look like on a smartphone if they were to discuss about dinosaurs.

Nickel fluoride as an ionic conductor oxidizer for new aluminum-based reactive materials

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Aluminum powders are most common metal fuel additives in diverse energetic formulations. Aluminum as a fuel is attractive due to its high energy density and accessibility. Sustained efforts have focused on modifying aluminum with the goal of accelerating its ignition and combustion and minimizing agglomeration of aluminum particles prior to ignition. One approach is to combine aluminum with a modifier, such as fluorinated oxidizer. The thermite-like reaction yielding aluminum fluoride is expected to boost ignition. Furthermore, in oxygenated environments, metal-rich aluminum-metal fluoride composites are expected to generate gas-phase combustion products, desirable for many applications. Recently, it was observed that aluminum composites with cobalt and bismuth fluorides prepared by arrested reactive milling (ARM) are readily ignited by heating but are insensitive to ignition by electrostatic discharge. This work is exploring nickel fluoride, NiF_2, as another potential additive to improve and tailor combustion of aluminum. Nickel fluoride is one the most stable and easy to handle metal fluorides. Here, it is explored as an oxidizer for a thermite-like composition for the first time. Several $Al{\cdot}NiF_2$ composite powders were prepared by ARM with the weight fraction of aluminum varied from 50 to 90 % with respective equivalence ratios for the Al-NiF_2 thermite varied from 5.3 to 47. For each composition, milling conditions were identified leading to preparation of homogeneously mixed, fully dense composite particles.
Prepared materials are examined by electron microscopy and x-ray diffraction. Samples of the prepared powders are ignited using an electrically heated filament. It is observed that the ignition temperatures increase significantly, e.g., from 400 to 1200 °C when the concentration of NiF_2 decreases from 50 to 10 %. This suggests an ability to tune the ignition temperature of the $Al{\cdot}NiF_2$ composite powders. The effect of heating rate on the ignition temperature for all prepared materials is also quantified. The prepared samples containing well-mixed equiaxial particles with the lowest ignition temperatures containing 30 and 50 wt % of NiF_2 were selected to for further testing. Experiments addressed combustion of powder clouds using constant volume expulsion (CVE) and combustion of individual powder particles ignited by a CO_2 laser beam. In CVE, pressure traces generated by burning powder cloud were measured and condensed combustion products were collected for further analyses. For comparable masses of Al and composite $Al{\cdot}NiF_2$ powders aerosolized to generate a burning cloud, $Al{\cdot}NiF_2$ has a shorter ignition delay than pure Al and produces nearly the same pressure. When the mass of the composite $Al{\cdot}NiF_2$ is increased to match the mass of pure Al in the powder charge, the composite produces a greater pressure than Al and after a shorter delay. Laser combustion experiments in air show that composites containing 30 and 50 wt. % NiF_2 show the same average particle burn times of ~0.45 ms. Correlations between burn times and particle sizes and between ignition of the prepared composites and the exothermic reactions observed in thermo-analytical measurements are presently being explored. Results of these experiments will be presented and discussed.

Analysis of Old and Young Adult Muscle Co-Contraction During Stair Ascent and Descent

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

The overall aim of the project is to understand the effects of aging on ambulatory movement. Specifically, the purpose of this study is to determine if there are differences in agonist and antagonist muscle co-contractions between young and old adults during stair ascent and descent. There is inconclusive research done on this topic. Muscle co-contraction, or muscle co-activity, is the simultaneous activation of opposing muscle pairs crossing a joint. Increased muscle co-contraction has been related to joint stiffness and increased metabolic costs in older adults. Muscle co-contractions are usually quantified using electromyography (EMG) data recorded during motion analysis experiments.

Measurements of EMG and ground reaction forces (GRF) were taken during stair ascent and stair descent trials. We measured EMG from the following muscles: tibialis anterior (TA), medial gastrocnemius (GAST), vastus lateralis (VL), and lateral hamstrings (HAMS). We analyzed EMG data from 19 healthy old adults and 20 healthy young adults. Each subject was analyzed during stair ascent and stair descent in a gait lab. EMG Signals were filtered and dynamically-normalized to maximum value found in the trials. Muscle co-contraction was calculated using:

$$\%Co-contraction = \frac{2*CommonArea(A\&B)}{(area(A)+area(B))}$$

Our results show that there is an increased muscle co-contraction during stair ascent and stair descent of the knee muscle pair (VL-HAMS) in older adults compared to younger adults. Muscle co-contraction has been used as a clinical tool to study changes in muscle strategies during gait due to aging and pathology. Our results show greater muscle co-contraction in older adults.

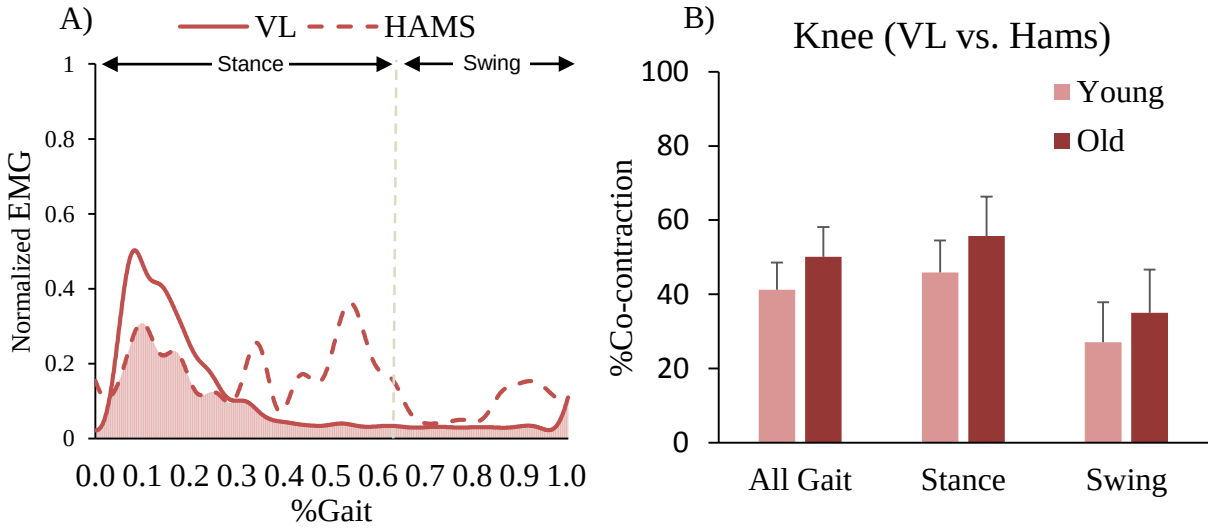

Figure 1: A) Filtered and normalized EMG of the VL and HAMS muscles from a stair ascent trial. The shaded region is the common area between the muscle pair at the knee joint. The vertical dashed line indicates the transition from stance to swing phase. B) Average muscle co-contractions at the knee joint for young and old adults. Error Bars represent one standard deviation.

A Study of Filament Eruptions and Possible Space Weather Consequences

James Chao, Advisors: Drs. Yan Xu and Haimin Wang

Distant as it may be, the sun is responsible for many types of space weather that can affect life on Earth. According to the Space Weather Prediction Center (SWPC), "Solar flares can produce strong X-rays that degrade or block high-frequency radio waves used for radio communication[1]." Furthermore, it discusses coronal mass ejections (CMEs), which are complex energy release events on the solar surface which are usually accompanied by flares and filament eruptions. The SWPC states that these events cause "Geomagnetic Storms at Earth and induce extra currents in the ground that can degrade power grid operations [1]". On March 13, 1989 Quebec, Canada experienced this in full when a solar storm caused a 12 hour blackout which closed businesses, schools, and transportation [2]. As bad as this sounds, scientists note that in worse scenarios the world could be without power for decades. This event highlights the importance of studying the sun. Although solar research has advanced significantly, there is still much about the sun that remains a mystery.

In his research article: *Study of Ribbon Separation of a Flare Associated with a Quiescent Filament Eruption, (Wang et al., 2003)* Dr. Haimin Wang, who is one of advisors of this research project, states that "[d]etecting the early manifestation of CMEs on the solar disk and their relationship with solar surface phenomena is essential to understanding the physical origin of CMEs [3]". Thus, to advance our understanding of potentially harmful solar events, such as CMEs and filament eruptions, a complete data set of historical global observation is very important.

First, this project began by identifying filament eruptions and establishing a comprehensive catalog. Thus, daily images of the sun from observatories (BBSO, KSO, NSO, and YNAO—acronyms) were examined to identify these events. The data collected was unique, covering several solar cycles from 1973 to 2018. The quality of the eruption and the images fluctuated which naturally meant that the list needed to be carefully curated to provide the best quality data for further research. The final list includes 115 major filament eruptions, with the disappearance times precisely determined. The next task was to study a particular filament eruption to investigate the correlation between the eruption and the motion of the flare ribbons. For this, the scope of the project was extended to space telescopes, such as SDO that provide full disk EUV images. This provided access to EUV 304 data, in which the filaments are of similar quality to that of H-alpha. Next, the speed of the filament eruption was measured and compared to the speed of the flare ribbon separation, in which the latter represents the magnetic reconnection rate. This study will, thus, reveal the relationship between magnetic reconnection and acceleration of filament eruptions leading to CMEs.

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[1] "Space Weather Impacts." */Www.swpc.noaa.gov*, Space Weather Prediction Center, www.swpc.noaa.gov/impacts.
[2] Odenwald, Sten. "The Day the Sun Brought Darkness." *Www.nasa.gov*, 7 Aug. 2017, www.nasa.gov/topics/earth/features/sun_darkness.html.
[3] Wang, Haimin, et al. "Study of Ribbon Separation of a Flare Associated with a Quiescent Filament Eruption." *Http://Iopscience.iop.org*, The Astrophysical Journal, 19 Apr. 2003, iopscience.iop.org/article/10.1086/376360/fulltext/.

Elucidating the Impact of Polymer–Drug Interactions on the Formation of Spray-Dried Amorphous Solid Dispersions and Drug Dissolution Enhancement

Alexander Coelho (UG researcher), Mahbubur Rahman (PhD mentor), Prof. Ecevit Bilgili (Advisor)

Otto H. York Department of Chemical and Materials Engineering

New Jersey Institute of Technology Newark, NJ 07102

Abstract

Drug–polymer amorphous solid dispersion (ASD) has emerged as platform approach for dissolution enhancement of poorly water-soluble drugs and thus improved bioavailability. Amorphous drug in ASDs exhibits higher extent/rate of dissolution compared to its crystalline counterpart. However, taking advantage of amorphous form is a major challenge due to its metastability, potentially leading to recrystallization during processing, storage, and dissolution. Drug–polymer interactions play a critical role on the stability of amorphous drug and its recrystallization, which are modulated by drug–polymer miscibility and drug:polymer mass ratio. The aim of this study is to investigate the impact of drug–polymer miscibility and various drug:polymer mass ratios on drug dissolution performance from spray-dried ASDs for different drug doses. This study will enable rational design and streamlined development of ASD formulations in pharmaceutical industry, thus saving time and money. Also, robust process or formulation development for improving the solubility and dissolution rate of these drugs could enable critically needed medicines to arrive at the market earlier. To this end, griseofulvin (GF), a model BCS class II drug, is dissolved in acetone/acetone–ethanol mixture in presence of deionized water with three different polymers, i.e., hydroxypropyl cellulose (HPC), Soluplus, and Kollidon (VA64) with/without an anionic surfactant, sodium dodecyl sulfate (SDS), and fed to a spray dryer to produce ASD. The spray-dried powders were characterized via laser diffraction, X-ray diffraction (XRD), differential scanning calorimetry (DSC), and dissolution testing. XRD diffractograms confirmed that for all three polymers, spray drying of the drug solutions led to ASD. Dissolution test results show that all ASDs significantly improved the dissolution rate of GF at different drug:polymer ratios and doses, i.e., high (supersaturating condition) and low doses (non-saturating condition). At low dose, Soluplus–SDS outperformed HPC–SDS, and VA64–SDS, whereas in the absence of SDS, HPC outperformed other polymers in terms of GF dissolution enhancement. At high dose, Soluplus–SDS showed the best performance based on dissolution rate and extent of supersaturation, whereas in the absence of SDS the performance was altered and Soluplus showed very slow drug release. This study has demonstrated that i) overall, ASDs formulated with various polymers exhibited significant dissolution rate enhancement under both supersaturating and non-supersaturating conditions and ii) presence/absence of a surfactant could make a big impact on the drug dissolution rate.

Molecular Dynamics Simulations Study of Confinement Effects on Compressibility and Heat Capacity of Fluids

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Otto H. York Department of Chemical and Materials Engineering
New Jersey Institute of Technology

Confinement of fluids in nanoporous materials has been shown to affect the properties of the fluids versus those of the fluids in bulk. Through the use of ultrasonics, the compressibility of a confined fluid can be experimentally measured. However, ultrasonic experiments are only able to measure a network of pores, and are unable to measure single pore systems. Molecular dynamics simulations can be used to model fluid confined in a single pore.

The purpose of this study is to determine the confinement effects on the derivative properties of liquid argon through molecular dynamics simulations. The derivative properties were determined through two methods:

1. Statistical mechanics method: based on the fluctuations of thermodynamic properties
2. Thermodynamic method: based on running simulations at two different conditions and calculating the properties by numerical differentiation

We present results for the derivative properties of liquid argon in carbon slit pores. These results are compared with results from simulations of bulk argon, and from the properties calculated from the equation of state presented by Tegeler, Span, and Wagner.[1] These simulations provide a foundation for further research with the aim of simulating shale gas, which is confined in nanopores.

1. Tegeler, C., Span, R., & Wagner, W. (1999). A new equation of state for argon covering the fluid region for temperatures from the melting line to 700 K at pressures up to 1000 MPa. *Journal of Physical and Chemical Reference Data*, *28*(3), 779-850.

Identification of Frequency Modulation within Energetic and Informational Maskers

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Cochlear implants and hearing aids are effective at restoring hearing in quiet environments when there are no competing sound sources. However, both types of devices fail to restore speech intelligibility in crowded, high noise environments, where the listener must separate target sound from sounds in the background. Two types of background sound are commonly distinguished: *energetic* and *informational* masking. *Energetic masking* occurs when the background sound swamps the neural representation of the target sound at the level of the auditory nerve. *Informational masking* can interfere with performance when the competing sources are perceptually similar to each other. Animal models for studying detection and identification of target sound in the presence of energetic masking sound exist, but animal models studying informational masking are scant. Using a target identification task, this project seeks to establish an animal model of informational masking. As a first step towards this goal, animals are trained to discriminate between a target and a foil.

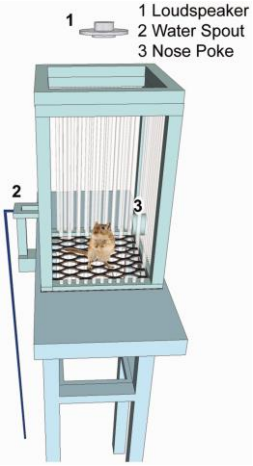

Figure 1: Setup of cage within soundproof booth

Mongolian gerbils, *Meriones unguiculatus,* were placed on water restriction and trained to associate a tone with the reward of water. *Figure 1* illustrates the apparatus where trials were run, within a sound-attenuating booth. Cage A (CMR08, n=3) was trained to associate an ascending frequency modulated tone with reward, and Cage Δ (CMR07, n=3) was trained to associate a descending frequency modulated tone with reward. Both ascending and descending targets were centered at 3500 Hz, with endpoints at 3000 Hz and 4000 Hz. Animals initiated trials by activating a sensor within the nose poke. Trials where a target was presented were called Go trials. Reward for a Go trial was given if the lick spout sensors were activated within a fixed response window after trial initiation. After running only Go trials for several sessions, NoGo trials were introduced. NoGo trials did not result in a reward, and were identified with the opposite tone pattern; Cage A having a NoGo tone of descending, and Cage Δ having a NoGo tone of an ascending tone. Results hint that animals are able to discriminate between target and foil in quiet. Thus, the current paradigm is promising for assessing target identification. My future work will extend this paradigm to examine this target identification task in a background with an informational masker.

Large-Scale Modeling of the Topological Properties of Microtubules

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Advisors: Dr. Camelia Prodan, Dr. David J. Apigo, Dr. Kyle Dobiszewski, Arooj Aslam
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The goal of this research project is to investigate the effect of structure on the resonant frequencies of microtubules (MTs) and Taxol MT dynamics. Finding the resonant frequencies of the MT can confirm if the material displays topological behavior; particularly an energy maximum at the edge of the structure known as edge modes.

We use the simplified parallelogram model (Figure 1) to test the MT topological properties. A spinner is positioned at each corner of the parallelogram and outfitted with magnet-bearing sleeves (Figure 2). The spinners' magnetic coupling occurs at about the same angle as MT subunits' coupling, as measured using molecular modeling software (CHIMERA). The outfitted spinners were positioned in a dimer arrangement and excited by a computer- controlled actuator. An accelerometer was used to measure the spinners' response at varying frequencies. This determines the system's resonance states and in turn, helps map the dimer phonon spectrum.

Our sleeve design allows for manipulation of the magnetic coupling angle while maintaining the spinner's large density and, in turn, moment of inertia. A large moment of inertia increases the quality factor (Q factor) of the mechanical spinner. A high Q factor reduces the forced oscillation of the system and minimizes damping effects. In future tests, we plan to expand the parallelogram pattern to investigate periodic interactions across a much larger three-dimensional model.

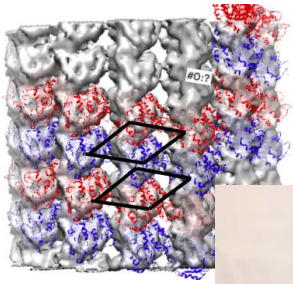

Fig. 1

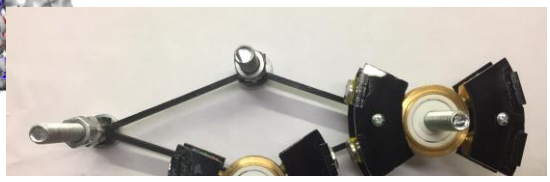

Fig. 2

Figure 1 shows a CHIMERA model of the microtubule with overlaid parallelograms.

Figure 2 shows two sleeve-fitted dimer-coupling spinners on a parallelogram mount.

Nanocrystalline Cellulose for Controlled Release Drug Delivery

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

Cellulose nanocrystals are an easily synthesized form of cellulose that have some very interesting properties such as high surface area and the ability to carry nanostructured drugs, which is important for nanomedicine. Cellulose nanocrystals are relatively inexpensive to manufacture because they're originally made from a plentiful product- cellulose. Some of it's notable qualities include inexpensive to manufacture, nontoxicity, and biocompatibility. CNCs have a large number of hydroxyl groups, and high surface-to-volume ratios, which make it suitable for many types of surface functionalization. CNC has a wide variety and range of uses, because by introducing any chemical functionality on their surface, the type of interactions that the material exhibits with its surroundings can be modified. Some commonly performed surface functionalization for CNCs are esterification, etherification, oxidation, amination, carbamation, nucleophilic substitution, silylation, and polymer grafting.

Nanocrystalline Cellulose (CNC) when combined with different drug particles may demonstrate controlled release dosage design. The physicochemical characteristics of the proposed nano composites would present the final determination of CNC's drug release capabilities. Cellulose is the most abundant and nearly inexhaustible natural polymer found on Earth. As a result, developing a drug delivery system from such a plentiful, and cheaply produced nanocomposite would be extremely beneficial in the world of drug nanotechnology and nano-medicine, allowing for more directed and sustainable drug delivery. (2)

Separating Maddox Components of Vergence Eye Movements: Normative Data

Sebastian Fine

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Convergence insufficiency (CI), a prevalent binocular vision disorder in adults and children, is characterized by greater exophoria at near than at far, reduced positive fusional convergence (PFV), and receded near point of convergence (NPC). CI is associated with double/blurred vision, eyestrain, and headaches when engaged in reading or other near work, thus impacting daily life and its activities. Individuals with CI have difficulty making convergence eye movements. In this study we collected and analyzed vergence eye movements of people with normal binocular vision before and after they received vision therapy. To better understand how individuals with normal binocular vision use Maddox components of vergence, these components were isolated. A haploscope was used to present individual images to each eye to remove disparity cues. A blurry Gabor patch was used to remove accommodative cues, and the sizes of stimuli were scaled to remove proximal cues.

Figures 1-3 and Table 1 show the mean final amplitudes, latencies, and peak velocities with standard deviations for each cue. In general, most binocular normal controls were able to make the 5-degree binocular convergence movements, and the 2.5-degree monocular movements. However, the amplitude for the condition with disparity cue only (Gabor patches) tended to have a smaller amplitude than the other binocular cues. The proximal cues also had smaller amplitudes than the other monocular cues. Monocular cues tended to have longer latencies than binocular counterparts. Peak velocities were faster for binocular cues. ANOVA tests indicated that the peak velocity ($F(3,22)=175.36$, $p<0.001$) and latency ($F(3,22)=17.113$, $p<0.001$) were significantly different between cues. Another ANOVA test indicated that the final amplitudes ($F(3,22)=15.631$, $p<0.001$) and peak velocity ($F(3,22)=8.83$, $p<0.001$) were significantly different after therapy. These results indicate that individulas with normal binocular vision can use disparity and accommodative cues to adequately converge to targets. However, they cannot use proximal cues to effectively make convergence eye movements.

Table 1. Mean and standard deviations (± 1 SD) for all experimental conditions.

Cue	Therapy	Mean Latency	Mean Velocity	Mean Amplitude
Accommodation	Active	0.3 ± .12	11.49 ± 5.54	2.71 ± .93
	Placebo	0.33 ± .11	14.4 ± 6.8	2.96 ± .92
All cues End	Active	0.21 ± .02	30.33 ± 10.67	5.06 ± .29
	Placebo	0.22 ± .04	30.23 ± 8.01	5.31 ± .37
All cues Start	Active	0.22 ± .02	31.02 ± 10.6	5.09 ± .21
	Placebo	0.22 ± .02	33.16 ± 7.62	5.1 ± .34
Disparity+Acc	Active	0.23 ± .03	29.22 ± 7.41	4.99 ± .3
	Placebo	0.22 ± .02	30.62 ± 7.1	5.19 ± .39
Disparity (central)	Active	0.23 ± .05	26.07 ± 10.22	4.4 ± 1.2
	Placebo	0.22 ± .03	22.35 ± 5.98	4.07 ± .99
Disparity (peripheral)	Active	0.2 ± .02	30.98 ± 12.92	4.88 ± .61
	Placebo	0.2 ± .02	28.6 ± 9.5	4.8 ± .55
Proximal	Active	0.2 ± .02	30.98 ± 12.74	4.88 ± .6
	Placebo	0.2 ± .02	28.6 ± 9.54	4.8 ± .55
Proximal+Acc	Active	0.27 ± .04	13.9 ± 9.96	2.9 ± .75
	Placebo	0.27 ± .07	13.66 ± 6.25	2.95 ± .88
Proximal+Disparity	Active	0.21 ± .02	27.57 ± 9.18	4.75 ± .92
	Placebo	0.2 ± .03	23.78 ± 5.9	4.48 ± .62

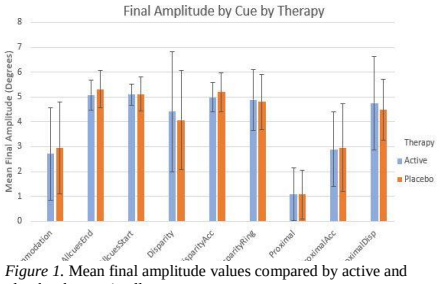

Figure 1. Mean final amplitude values compared by active and placebo therapy in all vergence cues.

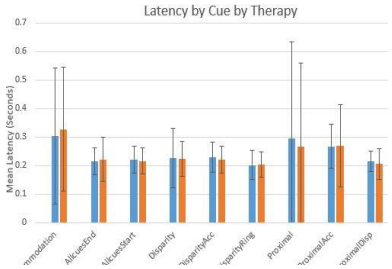

Figure 2. Mean latency values compared in active and placebo therapy in all vergence cues.

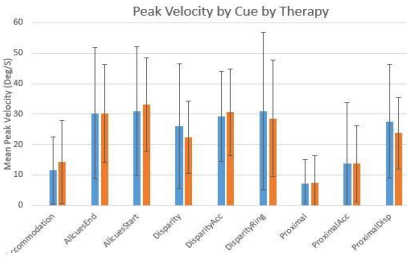

Figure 3. Mean peak velocity values compared in active and placebo therapy in all vergence cues.

Characterization of Microglial Activation After Blast Induced Traumatic Brain Injury

Ajay Gandhi and Geetasravya Vegunta
Faculty Mentors: Dr. Madhuvika Murugan and Dr. Namas Chandra
Center for Injury Biomechanics, Materials, and Medicine, NJIT

Many soldiers suffer traumatic brain injuries (TBI) from combat explosions. Typically, these soldiers are diagnosed and treated for visible injuries from shrapnel or from the impact of the blast. However, the initial blast pressure wave can also induce TBI that is often left untreated, causing an underestimation of the number of veterans suffering from TBI. The primary blast wave and subsequent injury in blast TBI is thought to activate microglial cells, the principal immune cells in the brain. This project seeks to confirm whether microglial cells are activated in the brain and to characterize the morphological and dynamic changes of the microglial cells. We hypothesize that there will be an increase in microglial activation at 4h, 1d, and 3d post-blast, with a decrease in activation at later time points. Activated microglial cells generally present in greater numbers with enlarged somas, shorter processes, and slower dynamic motility. Transgenic $Cx3cr1^{+/-}$ $GFP^{+/-}$: $CCr2^{+/-}$ $RFP^{+/-}$ mice were subjected to either sham or 180 kPa blasts in a shock tube. Samples were collected at various time points (sham, 4h, 1d, 3d, 7d, 30d) and were used for one of two experimental pathways - perfusion, cryosectioning, and immunostaining, or tissue collection, western blotting, and ELISA. Dynamic behavior was recorded with time-lapse two photon images of live brain slices collected at the same time points every 1 minute for 30 minutes to characterize the time-course of microglial activation. The preliminary data displayed in Figure 1 confirms that microglial cells are activated, and demonstrates that there is regional variability in activation. There was a notable increase in the number of microglia at 1d, 3d, and 7d (peak) after blast injury in the prefrontal cortex and CA1, a region of the hippocampus. The corpus callosum and CA3 regions show a slight, yet significant increase at 24 h and 7d after blast TBI. However, we observed a decrease in microglia population in the hilus at 7d after blast TBI. Regions with greater activation were investigated further with two-photon microscopy to monitor the dynamic activation of microglia.

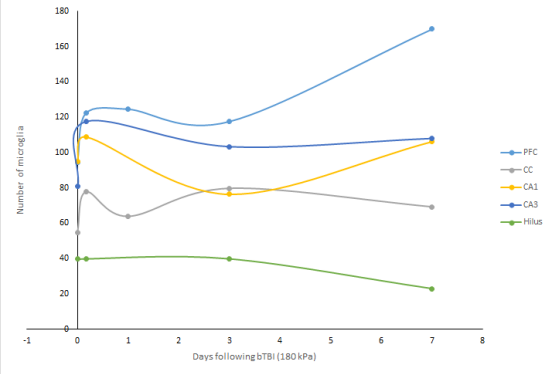

Figure 1: Number of microglial cells in various regions of the brain at various time points

Feedback Control of Social Behaviour

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Department of Biological Sciences

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Abstract: The objective of this project is to describe the neurophysiological mechanisms by which social signals are encoded in brain circuits to modulate locomotor behavior. This research is a continuation of my URI-supported project from 2017 that used behavioural experiments to identify changes in locomotor behavior in relation to social context. During this summer of 2018 I have began the translation of these behavioral observations into electrical signals that examine how information is encoded in neural circuits. Using information theoretic and other analytic approaches to understand how sensorimotor transformations are computed in the midbrain for locomotor control in these social environments, *Apteronotus* and *Eigenmannia* exhibited significant differences in their behaviours (e.g. linearity, location, velocity, acceleration, relative angles, etc).

Solitary *Apteronotus* spent a majority of their time in a refuge with near constant velocity while emitting a continuous and consistent frequency. In pairs of *Apteronotus*, it was common for the dominant fish to claim the refuge while the shy fish was moving along the sides of the tank (thigmotaxis). When in close proximity the fish tended to perform helical movements in parallel or antiparallel orientations in which the dominant fish would emit a burst of electrical signal called a chirp to possibly signal dominance.

Solitary *Eigenmannia* spent most of the time along the edges of the tank (thigmotaxis), rarely traveling across the center. In pairs of *Eigenmannia*, fish swam throughout the tank with far less preference for edges and even swam in synchorinzed movements at times. Fish also had aggressive interactions that included biting and chasing. The fish were routinely in physical contact with each other and interacted at mostly isopotential angles. These fish routinely changed frequency while in contact to prevent the jamming of their frequencies, a phenomenon called JAR (Jamming Avoidance Response).

We are performing two categories of data analysis. First, we are identifying and grouping behaviours and coupling them with their change in electrical frequency to normalize the data and find patterns of behaviour that directly translate into electrical signals. Second, we are conglomerating and comparing these data sets to the control solitary sets to ensure significance. Experiments to be conducted later this summer will include neurophysiological recordings in the midbrain of solitary fish as well as fish with other conspecifics. The neurophysiological data will be interpreted using information theoretic and other approaches to reveal the mechanisms for sensorimotor integration. This basic research may have impacts on our understanding of biological control systems and provide inspiration for new control strategies for robotic systems.

Analysis and Simulations of Vortex Beam Propagation and Polarization Properties

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Department of Physics

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ABSTRACT: A new vortex beam setup has been designed by Professor Sirenko's group at NJIT's Physics Department for use at the synchrotron radiation facility that produces coherent radiation in the far-infrared spectral range. This experimental setup is located at the MET beamline of NSLS-II, Brookhaven National Lab. The vortex beams will be used by Sirenko's group for spectroscopy of quantum materials at low temperatures and in strong external magnetic fields. New optics for conversion between conventional circularly or linearly polarized synchrotron light into a vortex beam with non-zero orbital angular momentum (OAM) will be integrated inside an existing NJIT-owned ellipsometer.

Some interest in optical vortices can be traced back to early work of Dirac and Nye & Berry. However, only the groundbreaking work by Allen in 1992 triggered the field explosion resulting in a multitude modern applications of optical vortices, such as optical tweezers and nanomachining due to a possibility to transfer of the OAM to mechanical rotation of nano-objects, image analysis and signal detection in astronomy, free-space telecommunication, and fiber-optic quantum communication based on entanglement of the OAM states of photons that is also promising for *m*-bit quantum computation.

The project utilizes the design of optical components, such as axicon retarders that are based on the Fresnel prism principle, design of a phase-shifting spiral mirror, and bull-eye and radial polarizers that will qualitatively enhance the existing experimental capabilities in producing beams with non-zero OAM. The main task of the research is to create a model for analysis of a critical focusing angles beyond which the OAM in the vortex beam may be destroyed as well as analyzing the degree of vorticity in the case of non-ideal circular polarization at the optical input.

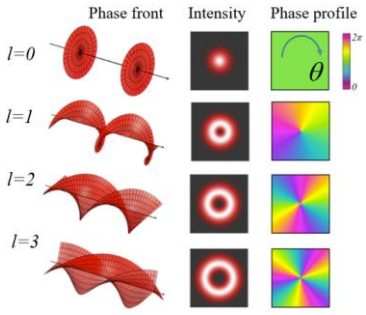

FIG. 1. Phase front, intensity, and phase profile for vortex beams with l = 0, 1, 2, and 3. Adopted from the website of Prof. G.-L. Oppo, U. Strathclyde, UK.

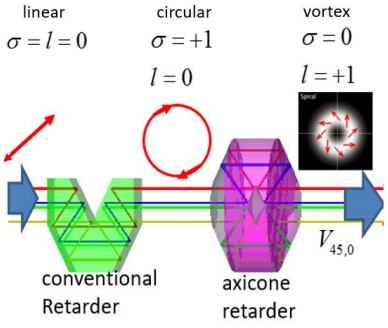

FIG. 2. Preliminary results for design of the optics setup for conversion of linearly polarized SR to a vortex beam with $l = \pm 1$ done in ZEMAX. Red arrow schematically represents linearly polarized light at the input. After passing through the axicon retarder, the beam acquires OAM $l = +1$, while losing its circular polarization. Distribution of the *E*-field in the beam after axicon retarder corresponds to a $V_{45.0}$ mode with $l = +1$.

Revealing Trade-offs in Sensory Organs and Morphological Traits of Formicidae

Chloe Jelley Advisor: Dr. Phil Barden

Sensory organs are vital to the survival of any organism and they determine how well an individual can receive and respond to stimuli within their environment. Based on the assumption that any given organism is evolutionarily optimized to be best suited for its environment, the reduction or loss of one sensory system may correspond with an increase in investment of another sensory organ. Do trade-offs occur between sensory organs of Formicidae, commonly known as ants, or does the variation that exists among different species represent 'spandrels' or incidental byproducts of evolution?[1] Using individual species as data points in order to quantify investment and assess variation is a unique advantage that comes with working with ants. Due to the high levels of variation among species (see *Fig 1*) collecting measurements that correlate with sensory investment as well as metrics of size can give a deeper understanding of evolution in regards to morphological patterns and ecological relationships. These metrics were obtained for over 100 different species from the lab on a Nikon SMZ25, which is a motorized auto montage stereoscope and allows for an extended focus. Images were also used from an online database in order to include a wider range of genera. Investment was calculated by using the approximate size of a trait and scaling it proportionally. The data were then compared using statistical as well as phylogenetic analyses in order to explore the relationships that exists between these sensory systems. Renormalization of the data collected is based on a molecular-based phylogeny from a previous study.[2] Results show a significant relationship between an increase in volume of the apex of the antennae and reduction of eye investment with most species. This may represent evolutionary optimization based trade-offs among visual, chemical, and tactile-based . It was also found that eye position and size is typically negatively correlated with interocular distance, meaning smaller eyes are generally located more towards the sides of the head. This research applies not only to ants; it reveals broad trends concerning trade-offs amongst any type of organism as well as inspiration for technological design.

Figure 1: (Genera from Left to Right) *Leptanilla* from Australia eyeless; *Cataulacus* from Malaysia, herbivore with relatively average eyes; *Myrmoteras* from Malaysia, predator with large eyes.

1. Gould, Stephen Jay, and Richard C. Lewontin. "The spandrels of San Marco and the Panglossian paradigm: a critique of the adaptationist programme." Proc. R. Soc. Lond. B 205, no. 1161 (1979): 581-598.
2. Moreau, C.S. and Bell, C.D., 2013. Testing the museum versus cradle tropical biological diversity hypothesis: phylogeny, diversification, and ancestral biogeographic range evolution of the ants. Evolution, 67(8), pp.2240-2257.

Design of Flow Reactors for Gas-Phase and Gas-Surface Mercury Experiments

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The major goal of this interdisciplinary project, which bridges architecture and chemistry, is to design flow reactors for studying the oxidation and removal of atmospheric mercury. Nearly half of atmospheric mercury, a highly toxic pollutant, comes from fossil fuel combustion and waste incineration. In the atmosphere, elemental mercury is converted to oxidized mercury whose chemical structures and formation pathways are currently largely unknown. The oxidized mercury is further converted to particle-bound mercury upon contact with the surfaces of Earth and atmospheric aerosols. Studying the reactions and finding the chemical mechanisms of mercury requires advanced instrumentation.

My project goals include designing three reactors that will be used to study the gas-surface uptake of gaseous oxidized mercury and the gas-phase oxidation of elemental mercury. I began with finding the flaws in the current setup for studying gas-surface uptake and designing a better more efficient solution along with Dr. Alexei Khalizov. I have found parts, prepared drawings, built, and tested two of the three reactors, fixing and finding solutions to problems that occurred throughout the design process, until the optimal solution was found.

The first reactor is the simplest: a "tube-coating device" in which the movable injector directs a flow of nitrogen to a salt-solution coated tube in order to dry out the water, leaving the tube internally coated with a uniform layer of salt. This tube is then inserted into the reaction chamber of the "small reactor" which tests gas-surface uptake of mercury-containing chemicals, such as mercury chloride, which are introduced in gas form through the movable injector into the reaction chamber. The final design, the "large reactor," will include a home-built microwave cavity, along with the movable injector, in order for studying gas-phase oxidation of mercury.

These new reactors will allow for more accurate measurements of the oxidation and removal of mercury, leading to a better understanding of atmospheric mercury cycling and deposition. This knowledge will help to better predict the fate of mercury in the environment and its impacts.

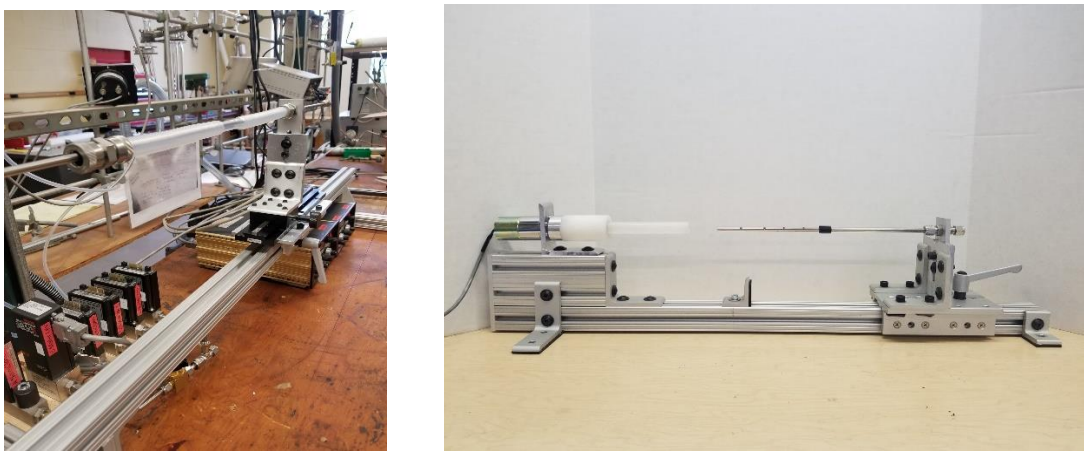

Figure 1. Photographs of the devices developed under this project. **Left**: tube coating device. **Right**: Small gas-surface reactor with movable injector

Assistive Device for Autistic People 2 (ADAP2)

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Autism spectrum disorder (ASD) is a developmental disorder that affects, nationally, 1 in 59 children by age 8 in 2014, a 15 percent increase over 2012. ASD rates in NJ is 1 in 34 with a 20 percent increase since 2012 as reported by CDC. ASD is characterized by a range of conditions that impairs the ability to socially interact and communicate. It is characterized by a range of conditions that impairs the ability to socially interact and communicate. Challenges include obsessive and repetitive behaviors, speech and nonverbal communications, inappropriate social interaction, compulsive behavior in addition to many other challenges and strengths caused by a combination of genetic and environmental factors. Currently, children and adults with autism require the presence of an aid to guide them with routines and provide direct verbal feedback towards their social interaction. Having an aid directly by their side reduces their confidence in their actions and discourages independence.

Our summer research focused on an Android app called Assistive Device for Autistic People 2 (ADAP2) that will encourage independence while still providing the feedback these children and adults with Autism need from a distance rather than direct proximity. ADAP2 will offer a subtle way of communicating as a means to enhance learning and behavior with augmented technology. ADAP2 is a phone application in combination with a smartwatch that will be used to give feedback to individuals with Autism. The phone will allow a subtler way for the aid to give feedback to the autistic person through the watch. The phone application can send emoticons, custom vibrations, and custom messages to the watch as well as store data of all messages sent to the watch. This way, the parent or instructors can encourage and reinforce acceptable behavior by positive feedback and discourage unacceptable behavior with messages, vibrations, and corrective feedback. This mean of subtle communications and prompts are crucial in public and classroom settings to avoid unwanted attention, chaos, and embarrassment that the students may feel if corrected verbally in public. The subtle communication builds confidence in their actions and encourages independence so they can thrive as adults in their communities.

We created a method of storing data for ADAP2 that will also allow instructors to quantitatively measure improvements in individuals by storing the number of messages and type of messages given throughout the day. A trend analysis of the autistic subject's behavior will prove beneficial for instructors as it will allow them to focus on particular weakness to build on and to promote strengths that transition the person into the workforce. ADAP2 will not only be beneficial for the students or autistic individuals in developing independence, but it will be a crucial teaching aid for their teachers to better tailor their lesson plans.

Behavioral and Histological Analysis of Moderate Traumatic Brain Injury

Julianna Kosty
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Center for Injury BioMechanics, Materials, and Medicine
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Traumatic brain injury (TBI) is defined as a "disruption in the normal function of the brain" that is caused by "a bump, blow, or jolt to the head, or penetrating head injury" [1]. From this, two types of impacts which may cause TBI can be differentiated: blast and blunt. The overall purpose of this study is to investigate the consequences of combined blast and blunt impacts, both of moderate severity, on cognitive and motor function, and explore the resulting behavioral effects. While there are ongoing investigations on the effects of blast and blunt TBI separately, this is the first effort to explore the combination of the two.

All experiments were performed using 10-week-old male Sprague-Dawley rats, divided into four testing groups: sham, blast, blunt, and blast+blunt (combination). In order to institute a moderate blunt injury of between 162-192.5 kPa, a craniectomy was performed to expose the injury site (-3mm bregma, 3.5mm from the sagittal suture) and a lateral fluid percussion injury (FPI) was subjected using a fluid percussion injury device. A moderate blast injury of 180 kPa was produced using a helium driven shock tube, mimicking an explosive blast. To analyze potential cognitive and motor deficits resulting from combined blast and blunt impacts, the Morris Water Maze and RotaRod tests have been performed, which assess working memory and vestibulo-motor function, respectively. Morris Water Maze and RotaRod results have indicated that the blast (MWM n=13 , RR n=4) and sham groups (n=14, n=4) show a trend of having no deficits, while the blunt (n=5, n=7) and combination (n=6, n=8) groups show deficits, with the combination group performing just as poorly or worse than the blunt group.

To support the findings of the behavior study, brain tissue from n=2 FPI injured animals and combination groups, sacrificed at 4 hours post-injury, were stained with fluorojade, a label for degenerating neurons. Preliminary cell counts using stereology indicate a greater amount of neurodegeneration in the hippocampus of the combination animals than in the blunt animals. In addition to fluorojade staining, cresyl violet staining and Map2+Synaptotagmin immunostaining will be used to analyze the tissue for neurodegeneration at the 4 hour and 34 day timepoints.

Lastly, a review paper is being developed which compiles the findings of other studies investigating the behavioral consequences of blast injury in an effort to propose the most effective behavioral tests and experimental setups for blast traumatic brain injury. In this paper, the animals used, anesthesia delivered, head and body constraint of the animal, animal position relative to the blast impact, shock wave delivery method, magnitude of pressure wave, neurological measures post-blast, mortality, behavioral tests and the results from these tests will be examined.

Real Time Analysis in Continuous Manufacturing of Orally Dissolving Films

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Abstract: The purpose of this project is to develop a real-time analysis technique for poorly water-soluble drug loaded strip films in a continuous manufacturing (CM) process which unlike the traditional batch process would minimize waste production, prevent sample destruction, and improve product quality monitoring. The proposal involves introducing in-line sensing with the Process Analytical Technology (PAT) tools, Near-Infrared Spectroscopy (NIRS) and Raman Spectroscopy, to analyze the critical quality attributes of the ODFs. The novelty of the proposed project is the use of engineered particles which result from surface modification of the drug particles with the help of hydrophilic silica used as a coating. Fenofibrate (FNB) was selected as the model BCS Class II (nearly insoluble) drug to be embedded in the films. The ODFs were cast onto a moving substrate and dried using a continuous casting and drying device. When the films were dried and while the substrate was moving, the NIR and Raman spectra were collected at various points and correlated to the film thickness and percent drug loading, respectively. **Figure 1** portrays the new method implementation. First, using the UV measurements of samples with five different drug loadings – 12 wt%, 18 wt%, 24 wt%, 36 wt%, and 42 wt% – along with micrometer film thickness measurements of the same samples, a calibrated model was created using the spectra of the film samples using Raman Spectroscopy or NIRS as predictors. Film casting thicknesses ranging from 0.2 to 0.9 with an interval of 0.1 were used to form the calibrated model for dry film thickness prediction. The calibrated model was then used to predict the drug loading or film thickness from the spectra taken of a new batch of film samples. For Raman Spectroscopy, these new film samples used for prediction were of 15 wt% and 30 wt% drug loadings taken within the range of the five drug loadings used for calibration. For NIRS, the samples used for prediction were casted at thicknesses of 0.35mm and 0.65mm taken within the range of the thicknesses used for calibration. **Figure 2** below shows one of the calibration curves created. The calibration curve was created using Partial Least Square Analysis (PLS) for the films loaded with as received form of the drug (AR-FNB). It showed an enhanced correlation between Raman spectra and assay values with the R^2 values of approximately 0.99 and the Root Mean Squared Error of approximately 0.65. Using the same approach, other calibration curves were also created from NIR and Raman spectra to predict drug loading or thickness for films loaded with the engineered particles, Coated-AR-FNB and Micronized Coated-FNB, which resulted in accurate prediction of the products' properties.

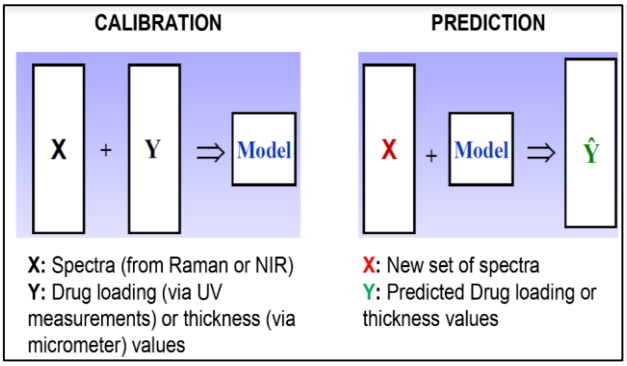

Figure 1

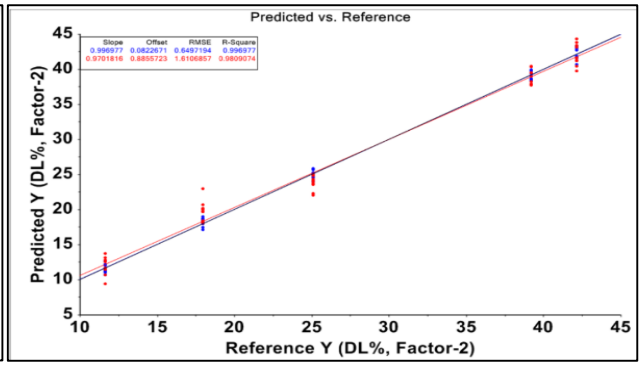

Figure 2

The Effects of Small Drugs on the Structure of Alzheimer's Disease Protein

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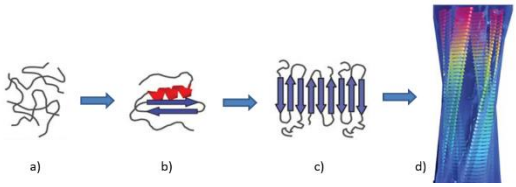
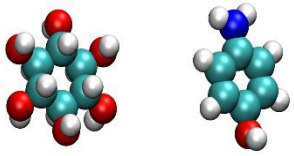
Alzheimer's disease (AD) is a progressive neurological disorder, which greatly impacts a person's cognitive functions. AD affects more than five million American people each year, and increasing age is the main risk factor. In the United States, AD is the sixth leading cause of death. There is currently no cure for this illness, but there are some existing treatments for slowing down progression of symptoms and ongoing research searching for potential methods of prevention.



Proposed idea of how disordered proteins (a) can form partially aggregated (b), β-structured aggregates (c), and finally lead to amyloid fibrils (d).

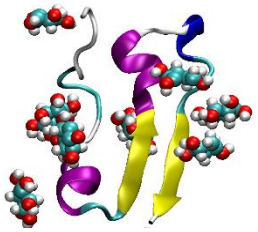
The causes of AD are not fully understood, but it is associated with plaques made up of insoluble aggregates of amyloid-β (Aβ) proteins. These aggregates were found to form fibril-like structures in the brains of patients suffering from AD. Understanding the molecular interactions leading to the formation of Aβ fibrils can help to design and produce effective drugs in order to inhibit their onset. Successful drugs may potentially prevent the formation of fibrils and plaques by altering the protein structure and stopping the protein from adopting fibril-prone conformations.

The specific aim of this project is to determine the impact of small compound/drug molecules, inositol and 4-aminophenol (4AP), on the structure of Aβ by performing computer simulations. Both drugs have been previously investigated for their effects on AD, but the molecular mechanisms behind their interactions are not yet clearly understood [1]. We hypothesize that each drug will target distinct parts of the Aβ42 protein, thus modifying its structure in different ways.



a) Inositol **b) 4AP**

Aβ42 is an intrinsically disordered protein, meaning that it does not have a native stable structure. It consists of 42 amino acids that can aggregate into ordered structures to form amyloid fibrils observed in the brains of AD patients. In this project, Aβ42 protein will be simulated using GROMACS, a molecular dynamics software designed for protein simulations. Due to high computational cost of molecular dynamics, these simulations are carried out on High Performance Computing clusters at NJIT (KONG).



Aβ42 monomer surrounded by inositol molecules

My role in this project is to calculate the molarities of the small compounds to be used in various simulations involving Aβ42. This is done by first solvating inositol in water molecules contained in a cubic box. This system is then energetically minimized to ensure that there is no unstable or inappropriate geometry of the molecules. Next, the system is equilibrated under constant temperature and pressure ensembles to achieve the desired stable conditions. The final conformations are used in a production run to increase the efficiency of the sampling. Once these processes are complete and the system is fully equilibrated, the approximate molarity of inositol may be determined using the box volume and number of inositol/water molecules of the final system. The calculated molarity will be used in further simulations involving the Aβ42 monomer to study its interactions with the compounds. This project is especially important because it will contribute to the rational design of new drugs to treat AD by providing fundamental insights on the structural changes of Aβ due to each of these small molecules.

[1] De Felice, F. G., Vieira, M. N., Saraiva, L. M., Figueroa-Villar, J. D., Garcia-Abreu, J., Liu, R. O. Y., ... & Ferreira, S. T. (2004). Targeting the neurotoxic species in Alzheimer's disease: inhibitors of Aβ oligomerization. *The FASEB journal*, *18*(12), 1366-1372.

Functional Connectivity in Stroke Subjects

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Stroke is a leading cause of death and long-term disability across the United States and across the world. Arterial ischemic stroke (AIS), a common form of stroke, is defined as a sudden death of brain cells due to lack of oxygen, resulting from reduced blood flow within an artery in the brain caused by narrowing of the artery or a blood clot formation[1,2]. About half of survivors face long-term disabilities, including impairment of motor function and loss of cognitive skills such as memory and language, while the remaining survivors are able to retain or regain their independence[1]. The aim of this study is to investigate the resting-state executive network in stroke subjects and the relationship between brain function and clinical measures following stroke.

Eighty four AIS patients with motor deficits were enrolled. Each patient having their first-ever ischemic stroke, no history of previous neurological insult or psychiatric disorder, and no abnormalities other than the infarction were found in conventional diagnostic magnetic resonance imaging (MRI). Structural brain image (MRI), resting-state functional MRI (fMRI) images, and arterial spin labeling (ASL) images were acquired for of each of the subjects.

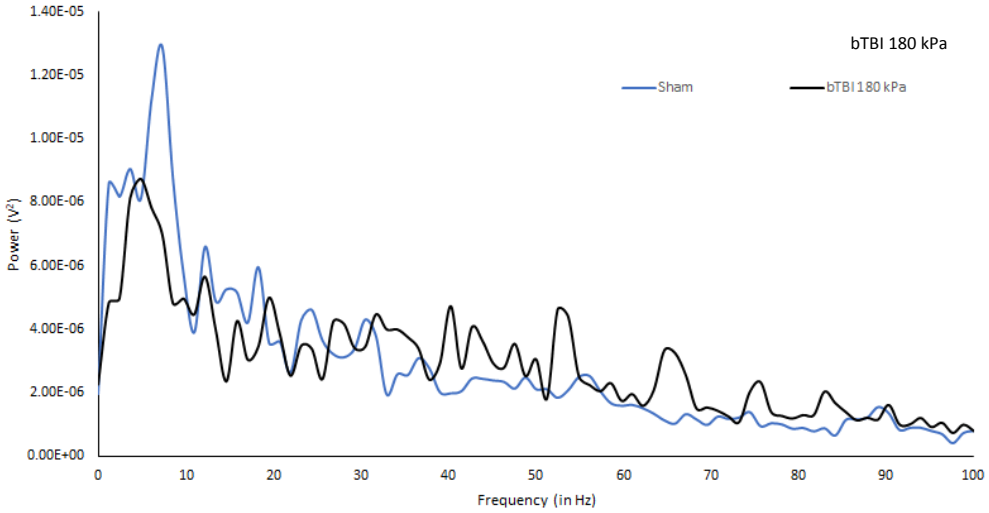
The project will analyze the relationship between the area of the stroke lesion and various brain networks, including some distant from the lesion. Independent Component Analysis (ICA) will be performed to determine brain networks. Using correlation matrices, functional connectivity will be determined. Decreased connection between brain networks, even those distant from the lesion, suggests altered interhemispheric interactions following stroke. This study will provide insight into the more complex underlying functional brain organization system, consisting of broad, dynamic functional networks. In addition, findings will deepen our understanding of association between higher-order executive function and brain networks after a stroke. It is among the first to show resting-state dynamic post-stroke processing in the BOLD signal are related to executive function.

1. Mair, G. and J. M. Wardlaw (2014). "Imaging of acute stroke prior to treatment: current practice and evolving techniques." Br J Radiol 87(1040): 20140216.
2. Zaharchuk, G. (2011). "Arterial spin label imaging of acute ischemic stroke and transient ischemic attack." Neuroimaging Clin N Am 21(2): 285-301, x.

Understanding changes in brain oscillations following blast induced traumatic brain injury

Waleed A Mujib, Advisor: Dr. Madhuvika Murugan and Dr. Namas Chandra

Epilepsy is a condition that negatively impacts the quality of life for those affected by it through abnormal electrical disturbances activity in the brain. The relationship between penetrating brain injury and epileptogenesis has been established. However, these injuries are far outnumbered by those of closed head injuries, particularly mild-moderate injuries from blast waves. The need for understanding the role of blast-induced traumatic brain injury (TBI) in epileptogenesis is increasing as the number of blast injuries and the strength of explosives continue to increase. The current research project investigated blast TBI induced brain electroencephalographic (EEG) changes and the subsequent development of epilepsy. Ten week old Sprague-dawley male rats were subjected to mild blast TBI (130 kPa) and sham conditions. Cortical surface electrodes were implanted 4 weeks after injury and the basal EEG changes was recorded for 30mins. For testing seizure susceptibility, kainic acid, an epileptogenic drug, was injected intraperitoneally and the development of seizure was monitored using continuous EEG and video recording. The data collected was analyzed in four different ways: seizure scoring, spectral density analysis, brain wave frequencies analysis, and a refined brain wave frequencies analysis. Current data, as shown in Figure 1, displays basal EEG changes that are consistent with that observed in epilepsy. Specifically, we noted a significant increase in gamma (30-90 Hz) and high frequency oscillations (90-200 Hz) and a significant decrease in theta (8-12 Hz) oscillations. Moreover, we observed increased susceptibility to evoked seizures in rats exposed to blast TBI compared to sham controls. Our data suggests that blast TBI is sufficient to cause changes in neuronal circuitry leading to epilepsy development. Future work is now focusing on understanding the cellular and molecular mechanisms that the changes in EEG oscillations and epileptic susceptibility following blast TBI.



Vanishing Viscoelasticity in Polymeric Gels

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

The purpose of this research is to investigate the mechanical behavioral differences of various elastomers when dry, partially swollen and fully swollen with a solvent. A polymeric gel is an elastomer when swollen by a solvent. The importance of these polymeric gels is that they are ubiquitous. They can be found foods and medicines, and have many useful applications including carriers for drug delivery, and synthetic cartilage-like biomaterials. The two materials investigated in this work are VHB and Polydimethylsiloxane which is commonly known as PDMS; swollen in Pentane or Xylene. Our previous preliminary data shows that VHB has the unique property of its viscoelasticity vanishing when fully swollen by a solvent and not yet characterized or the physical mechanism understood.

In order to gather our preliminary results, multiple tensile samples of VHB were cut from sheet using a cutting die, specifically an ASTM D638 Type 5. Four samples were left dry, four were placed in Pentane overnight, and four were placed in Xylene overnight. Leaving the samples in the solvent overnight allows the materials to reach a fully swollen equilibrium state. Each of the samples mass was measured before and after swelling, and the corresponding swelling stretch measured through image analysis using ImageJ software (see Fig. 1a). Each of the samples was then be placed into a universal tensile tester (see Fig. 1b). These samples were stretched at a specified rate to a desired maximum stretch, and then unloaded, to experimentally obtain the stretch stress behavior of the material in each of these conditions (see Fig. 1c).

The preliminary results show that viscoelasticity of the VHB disappears when the samples become fully swollen in the solvent.

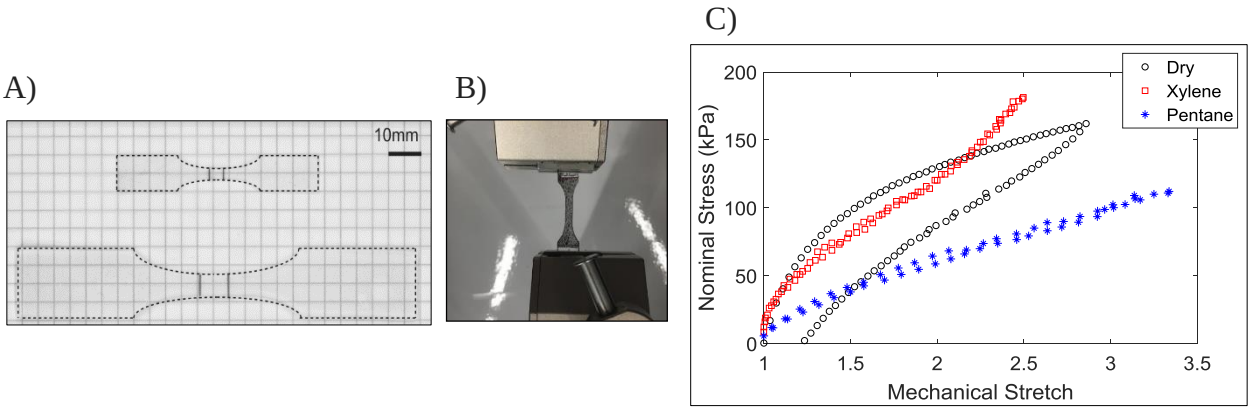

Figure 1: A) Comparison between a dry VHB sample and a Xylene swollen VHB sample. B) PDMS sample placed in the MTS. C) Stretch Stress curve of the dry and solvent swelled VHB samples.

Expediting the process of Food Waste Decomposition through Anaerobic Digestion

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Globally, more than one-third of the food produced is wasted including 33 billion pounds of food in the United States. The food waste is either landfilled or incinerated. The food waste in landfills produce methane which is 25 more damaging greenhouse gas than CO_2. However, at landfills, there is always risk of ground water contamination and not all landfills have the infrastructure to capture methane. In incinerator facilities, the energy from food waste is captured, but the nutrients are not recovered. Composting is a nice idea, but only the nutrients are recovered, not the energy. So, this research project aims at using anaerobic digestion, degrading of food waste in absence of oxygen, to capture both energy and nutrients from food waste sustainably. Moreover, this research also investigates ways to reduce the time of anaerobic biodegradation.

Anaerobic digestion involves four major processes: hydrolysis, acidogenesis, acetogensis and methanogenesis. In hydrolysis, insoluble molecules such as carbohydrates, proteins, and lipids are converted into soluble molecules by splitting of water component in the food waste. In the next stage, acidogenesis, the products of hydrolysis are converted to volatile fatty acids, ketones, alcohol, carbon dioxide and hydrogen gas. In acetogenesis, the products of acidogenesis are broken down further into hydrogen, acetate and other acetogens. In the last stage methanogenesis, acetate, hydrogen and other products are broken down into methane and carbon dioxide. The methanogenesis is the rate limiting step since the methanogenic bacteria take around 5 to 16 days to regenerate. Since the pH in the previous stage is 4.5-5.5, the methanogenic bacteria will not grow until the pH is above 6, preferably around 7. The oxidation-reduction potential must be around -330 mV, low enough for the reaction to be favorable thermodynamically, which happens when the partial pressure of hydrogen gas is low enough, around 1 atm.

Several tests were performed out to shorten the process of anaerobic biodegradation. The two types of substrate that were added to the food waste was deer manure and seed material. Methanogenic bacteria are present in the manure of many herbivores including deer. The seed material was obtained from a sewage treatment plant, which contains diverse population of bacteria. Before utilizing, the seed material was put in vacuum at 37 degrees Celsius in order to activate the sludge and have a higher population of methanogenic bacteria. In experiment A the deer manure was used, in experiment B both the seed material and deer manure were used at 1:1 ratio and in experiment C the seed material was used with vegetable waste. Tests showed that test C produced the best yield. Then another test is planned with vegetable waste with complex hydrocarbons and cellulose, pasta with complex hydrocarbons and sugar a simple hydrocarbons to explore the rate of methane generation.

Functionalization and Characterization of Peptide Hydrogels

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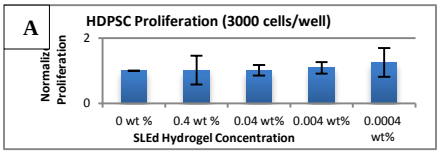
Self-assembling peptide hydrogels consisting of multi-domain peptides (MDP's) that can create a nanofibrous hydrogel have been shown to promote extracellular matrix deposition, re-epithelialization, vascularization, and innervation. Their sequence consists of amphiphilic crosslinked peptides with highly charged terminal ends and allows for modifications without the structure being disrupted. MDP hydrogels are useful in tissue engineering because they can be syringe aspirated in order to easily deliver small molecules/proteins and modified to control the rate of degradation in vivo. This project aims to assess functionalization and characterization of peptide hydrogels in four different areas -- dental pulp stem cell proliferation, mechanism reinforcement, biocompatibility, and mechanical characteristics of antibacterial peptides.

The standard procedure for treating infected dental pulp is the root canal. However, this procedure leaves a devitalized tooth. Through collaboration with Dr. Emi Shimizu at Rutgers School of Dental Medicine, an optimized construct of a previously published injectable hydrogel with an attachment of dentonin, termed SLEd, was tested for human dental pulp stem cell (HDPSC) proliferation using cell culture assays. HDPSC were seeded at 3000 cells/well and 5000 cells/well and 0.4wt%, 0.04wt%, 0.004wt%, and 0.0004wt% concentrations of SLEd were added to the cells. The plotted plate reader results, as shown in Fig.1A, suggests that low concentrations of SLEd seeded at 3000 cells/well promote an increasing trend in proliferation. The next step is conducting a HDPSC differentiation assay with 10,000 cells/well.



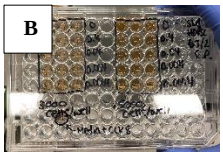


Fig. 1 (A) Plotted plate reader results for normalized proliferation of the HDPSC assays seeded at 3000 cells/well. (B) One of the 5 conducted assays that included both 3000cells/well and 5000cells/well with a

Mechanism reinforcement of peptide hydrogels was explored through collaboration with Dr. Somenath Mitra whose research focuses on carbon nanotubes (CNT). 50 ul of CNT dissolved in water at various concentrations was added to 50 ul of either two hydrogels termed K2 and E2. These samples were then used for rheological testing to assess for hydrogel reinforcement. Further steps include testing lower concentrations of CNT and lowering the CNT to gel ratio.

Antibacterial peptide hydrogels serve as a mechanism for mechanical disruption. Thus, rheological testing was conducted for four different antibacterial hydrogels with increasing lysines termed, K2, K4, K6, and K8. As shown in Fig. 2A and 2B, hydrogel strength decreased as the number of lysines increased with K2 being the strongest gel.

Biocompatibility of peptide hydrogels was assessed through data analysis of histological images of five different peptide hydrogels that were implanted in rats. The images were stained using H&E and trichrome. ImageJ was used to quantify the infiltration of cells into the implant, as shown in Fig.3A and blood vessel and neural fascicle regeneration. The cell counts were then averaged across the implants and an overall average was plotted as shown as in Fig. 3B.

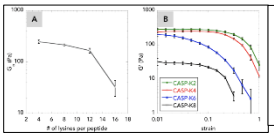


Fig. 2 (A) Plot of G^0 for the peptides hydrogels with increasing lysines. (B) Plot of G' against the strain from rheological testing

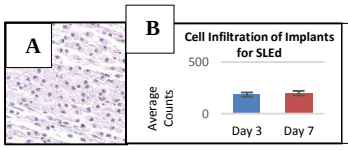


Fig. 3(A) A region from one of the SLEd 3 day implants stained with H&E and overlayed with the ImageJ cell count (B) Plot of the averaged cell counts for 3 day and 7 day SLEd implants.

Migration of Bacteria in Soil-less Aggregates for optimized VOC uptake

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Volatile organic carbon compounds or VOCs are organic compounds that are easily converted to gases or vapors. Thus, they are a part of the air we breathe and are continuously added to the atmosphere from sources like wall paint fumes and burnt fuel. Research shows that VOCs have health hazards ranging from eyes, ears, nose and throat infections to nausea and damage to the central nervous system. It is also seen that VOCs have been a significant factor in causing cancer in small animals like rats. The need of this research arises from these known adverse health hazards of VOCs. The aim of this research was to study the bacteria that is found in the root system of plants and can absorb VOCs. We are particularly interested in studying such bacteria in soil-less (that is, without natural soil) aggregates like claystone, charcoal, zeolite, perlite, vermiculite, and peat moss. We did a detailed study of the physical and chemical properties of these aggregates such as water retention, water absorption, pH, conductivity, and density. We also studied the migration patterns of the bacteria in these aggregates. Thus, by combing the physical properties and the migration patterns, we were able to find out how the physical properties affect the migration patterns. Our results show that bacterial migration happens only in wet aggregates while the migration in the dry set-up is negligible. Furthermore, in wet conditions Vermiculite, Claystone and Perlite had the best bacteria migration while Charcoal Chippings had moderate migration, Zeolite had low migration. We did not see any migration in Peat moss and Cylindrical Charcoal. We also tested the physical properties of the aggregates for water retention, density, pH, and conductivity. From these tests, we saw that neutral pH, low-medium conductivity, high water retention, and medium-low density (conditions found in Vermiculite, Claystone and Perlite) are best suited for bacteria migration. Moderate migration was seen with neutral pH, high conductivity, medium water retention, and medium density. For low migration, the pH was basic, conductivity was medium, water retention was low, and the density was high. For the aggregates in which we saw no migration, the physical properties included acidic pH, medium conductivity, med-high water retention, and high density.

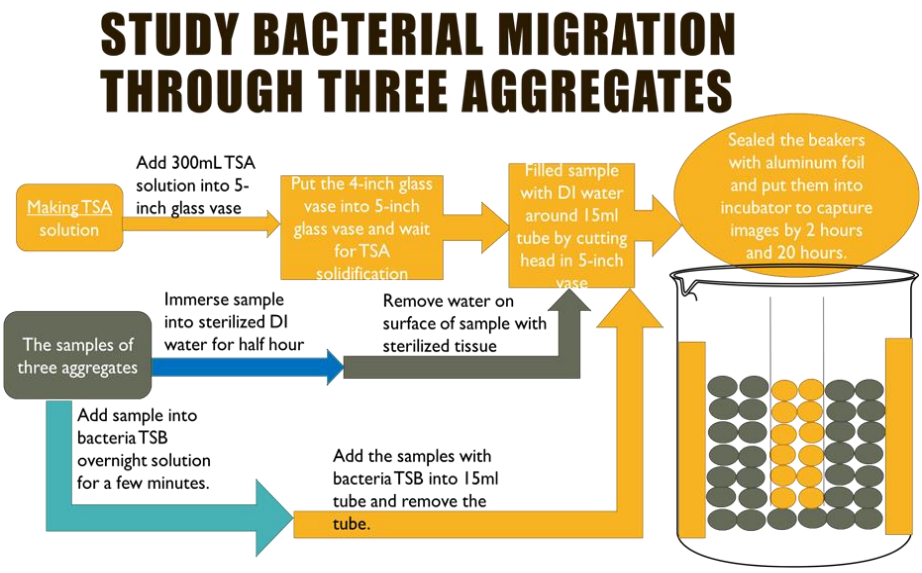

Figure: Protocol for studying bacterial migration in the aggregates

CNTs in Hollow Fiber Membranes for Protein Purification

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Abstract: In protein manufacturing, proteins are purified continuously in multiple process steps until they reach the desired purification levels. However, as the sample transitions through the different process steps, it leads to increased sample loss and contamination. Current purification strategies like filtration and chromatography also suffer from these issues. In addition, these techniques are costly, complex and require rigorous operator training prior to handling of the equipment. Other disadvantages unique to the process include, clogging in filtration or requiring multiple chromatographic techniques for the purification of a single protein.

Herein we have envisioned a device that not only reduces the number of steps in protein purification, but also is cost-effective, simple and has a high protein capture efficacy leading to significant increase in the yield. This device uses enhanced shear forces to increase the protein purification efficiency. The device consists of carbon nanotubes (CNTs) wherein the CNTs become the novel and upgraded support matrix that allows for substances to be better filtrated and does not require specific eluents. The inherent electrical properties of the material also allow for the scrutiny of the bound proteins, making it possible to perform real time protein characterization, a coveted feature that is not present in current chromatography methods. However, the device requires extensive characterization for it is unknown as to how the shear force will impact the protein structure; an important element that determines the efficacy of the protein in its bio-functionality. This summer, our main goal is to run experiments to correlate the shear force with the protein structure. The experiments will be run on a lab-on-a-chip device similar to Figure 1. The protocol for protein purification is described to Figure 2. Western Blot and ELISA will be used to measure the functionality of the purified proteins.

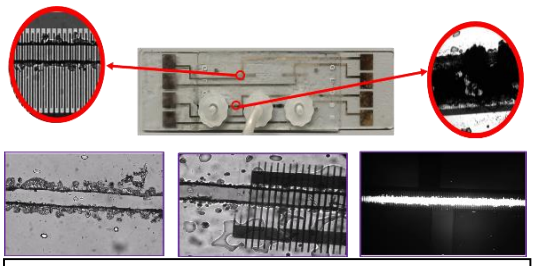

Figure 1: Images of the microfluidic chip. It is composed of two glass slides, each etched with a gold pattern. The device is put together with acrylic tape, introducing an empty channel to the device. This channel is packed with CNTs, trapped in between two non-planar, interdigitated gold electrodes. These electrodes allows for the real-time scrutiny of proteins through EIS. Fluid ports are attached to the device to allow for the passage of fluid. Further, using fluorescence we show the well-formed channel in the middle of the chip.

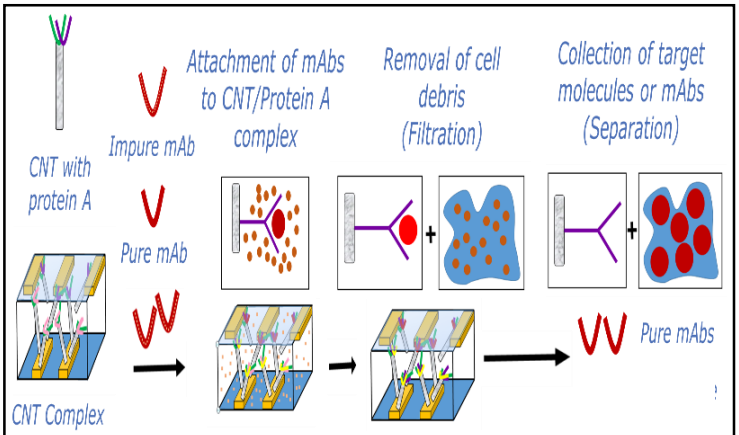

Figure 2: Protocol for running the experiments. CNT matrix will be functionalized and attached with protein of choice (Protein A). The structure is done on a lab-on-a-chip setting. Different flow rates are tested, utilizing shear force to elute the target molecule. Collected molecules can be analyzed through Western Blotting and ELISA.

Validation of Testing Protocol for Impact Energy Characterization in Ballistic Materials

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Impact energy, especially in the .5kHz - 1.5kHz range, can cause major disruptions in the cell-cell adhesions, effectively "loosening" structures such as cell surface and junctional proteins. By dissipating the high-frequency, low-amplitude wave components of blasts, the ballistic armor can prevent such devastating effects. To test this specific frequency range, a testing protocol was developed and validated.

The protocol utilized a custom sensor bed and commercial modal impact hammer. The sensor bed incorporated six piezoelectric (PVDF) coaxial cables within a flexible urethane matrix. The ballistic test specimen was placed on top of the sensor bed and secured via uniform compression on the edges. The modal impact hammer was used to strike the specimen and can sense the force applied.

We connected the sensors to an analog-to-digital converter (DAQ card) and developed a custom LabVIEW program to measure piezoelectric output during a five-second time frame. The differences between input and output signals at various frequencies was characterized via the MATLAB Signal Analyzer App.

To validate the sensor bed, we utilized a high-precision shear accelerometer and commercially-available body armor panels. Additional modeling and virtual prototyping was done through Autodesk CAD and COMSOL Multiphysics Modeling Software.

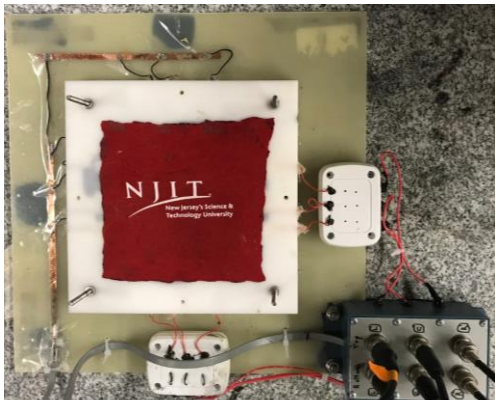

Figure A: Custom Piezoelectric Sensor Bed

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Figure B: Modal impact Hammer

Modeling the Distribution of Superparamagnetic Nanoparticles in the Bloodstream for Use in Magnetic Drug Targeting

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In traditional cancer treatments, anti-cancer drugs are injected directly into the bloodstream at a site near the targeted tumor, allowing for absorbance at the cancer site [1]. This process, however, leads to the distribution of the anti-cancer drugs throughout the body, which increases risk of potential side-effects as the drugs reach unintended sites. Additionally, this requires a significantly greater amount of the drugs to be administered, because only a fraction of the dosage actually reaches the cancer site. Magnetic drug targeting is a method that can be used to mitigate these issues. This method involves attaching anti-cancer drugs to superparamagnetic nanoparticles and guiding the particles to the site of the cancer with external magnets. In this study, a model will be developed for describing the distribution of clusters of superparamagnetic nanoparticles in the bloodstream near an applied external magnetic field. The model will include the effects of magnetic forces, hydrodynamic forces, gravitational forces, diffusion due to collision with blood cells, and the rheology of blood flow. In this study we solve the governing equations for the diffusion (including particle dispersion by collisions with blood cells), advection (due to flow, accounting for the rheology of the blood, such as shear thinning), and magnetic transport (magnetic drift) of nanoparticles in the blood, as well as considering the blood vessel branching and variation (vessel network). This model is expected to enhance the predictive capability of previously developed models that only consider the motion of single clusters [2,3], by analyzing the nanoparticle distribution instead. The model will be used to determine the capture rate of the clusters by the external magnet given different injection positions, strengths of the magnet, cluster sizes, cluster counts, blood flows, and diffusion effects.

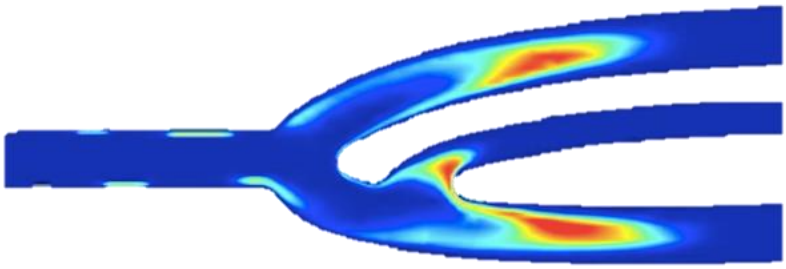

Figure 1. Concentration of passive tracers traveling through a self-generated geometry modeled after a popliteal leg artery.

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Influence of Skull Strength on Shock Wave Propagation in Rats

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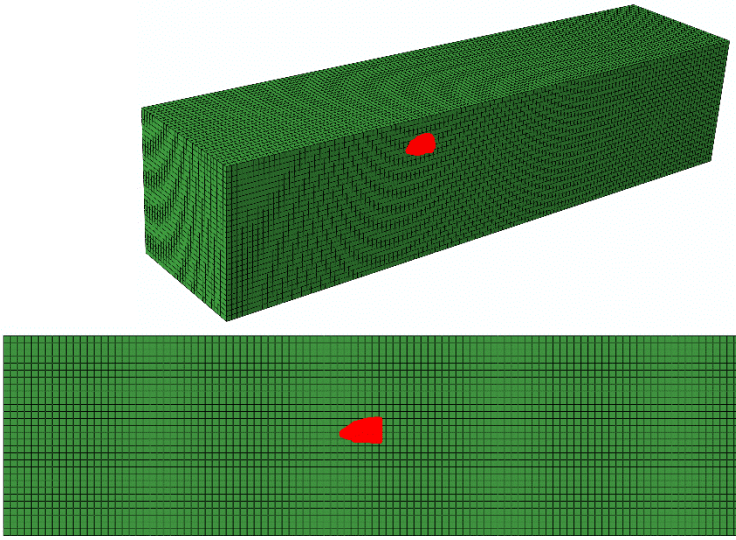
An ongoing international collaboration between the Institute of Nuclear Medicine and Allied Sciences (INMAS) in New Delhi, India and the Center for Injury Biomechanics, Materials, and Medicine (CIBM^3) in Newark, NJ has shown significant variability in the survival curves of 10-week old Sprague Dawley rats that were exposed to blunt impact-induced traumatic brain injury (TBI). Even by identical experimental methodologies and controlling for rat age and weight, this variability persists. This collaboration is expanding into investigating blast-induced TBI, and the variability in survival is expected to remain. It is hypothesized that skull strength and thickness will be found to largely contribute to this variability. This work will be the first systematic investigation on skull stiffness and shockwave propagation within the head.

To test the hypothesis, a rodent head model was created and fitted with skulls of varying cranial thicknesses (0.3 mm, 0.6 mm, and 0.9 mm) using the medical image segmentation and meshing software Simpleware (Synopsys). The rodent heads, based on radiographic scans of a 10-week old male Sprague Dawley rat, were segmented into the skin and soft tissues, skull, brain, and dura. Using finite element (FE) modeling, the skull strength was varied by increasing and decreasing the Young's moduli and Poisson's ratio of the skulls. The Young's modulus is varied in increments between 0.1 GPa and 20 GPa, maintaining a Poisson's ratio of 0.22 or 0.3. The rest of the biological tissues are represented with realistic material models derived from literature.

The completed head model was then placed in a model of a nine-inch shock tube. The rodent head then faced a shock wave analogous to that known to cause a mild TBI (130 kPa), which will allow for the examination of maximum intracranial pressures and intracranial pressure profiles. Skull flexure is expected to lead to higher loading on rodent brains in heads with more compliant skulls. This work will allow for future prediction of brain trauma on skulls of different strengths exposed to similar loading events.



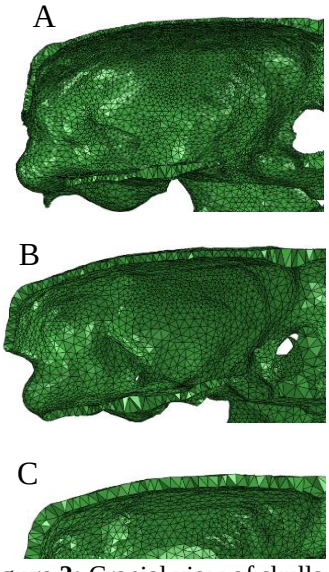


Figure 2: Cranial view of skulls with a mid-sagittal cut at thicknesses of (A) 0.3 mm, (B) 0.6 mm, and (C) 0.9 mm.

Automation of a Stem Cell Culturing System for Live Scale Microscopy using a Wago Controller

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When working with stem cells, it is crucial to ensure that the cells are kept in appropriate conditions. All biological phenomena are dynamic which means that understanding these phenomena requires constant observation under the microscope. Monitoring the conditions of the device under the microscope requires continuous observation which would require a researcher to constantly be next to the microscope. We currently are working on creating a way to automate this system so that a researcher would not have to constantly monitor it. By using a Wago Controller, we will be able to control the temperature of the device and the flow of the fluid travelling through the device. A Resistance Temperature Detector (RTD) will be used to measure the temperature the device and a pressure sensor will be used to measure the flow of the fluid. The temperature will be controlled by using an ITO coated glass that heats up when current is travelling through and the flow of the fluid will be controlled using a flow valve. All of this will be automated by using a MATLAB program.

The second part of the project requires automating the device which the stem cells are being stored in. The device will consist of two layers. The cells will be seated in the bottom layer and the user will be able to control where they would like to move the cells. By sending a chemoattractant to a specific location, the cells will gradually move towards that location. The top layer will consist of 16 chambers formed by a 4 by 4 grid. Chemoattractant will be flowing through the flow channels of the top layer. When a chamber is opened in the top layer, it will deliver the chemoattractant to a respective location on the bottom layer. Each row of the grid will be controlled by a flow channel which can be opened or closed depending on whether the chemoattractant needs to be send there. Each column of the grid will be controlled by a valve which would open and close the chambers in that column. By opening and closing various combinations of flow channels and valves, the researcher will be able to control which chamber to send the chemoattractant. All of this will be controlled using a the Wago Controller and a MATLAB program where the researcher will only have to select where to send the chemoattractant and the program will automate all the steps.

Figure 1: Wago Controller

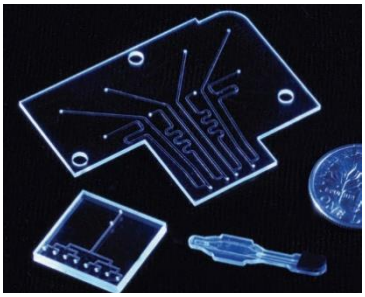

Figure 2: Microfluidic Device

The Piezoelectric Characterization of a Biodegradable ZnO Composite

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Piezoelectric materials can produce an electric charge when mechanically deformed[3]. Piezoelectricity also occurs in native tissue, such as bone and cartilage, and has gained interest as a tissue engineering strategy to promote tissue repair. Previous studies by our group have demonstrated the use of polyvinylidinefluoride-trifluoroethylene (PVDF-TrFE) as a piezoelectric scaffold that promoted mesenchymal stem cell differentiation and tissue growth[1] and nerve tissue regeneration[2] PVDF-TrFE is well characterized for its piezoelectric properties and proven biocompatibility. However, it is non-degradable, which limits its use for tissue engineering applications. We have developed a degradable piezoelectric material consisting of ZnO, which has known piezoelectic and insulin-mimetic properties. We have developed a composite consisting of ZnO nanoparticles embedded in slow-degrading polycaprolactone (PCL). The purpose of this study was to fabricate and characterize ZnO-PCL composite for its piezoelectric properties and compare to PVDF-TrFE.

Electrospinning was utilized to create the ZnO-PCL, PVDF-TrFE, and PCL alone scaffolds, which served as a non-piezoelecric control. Electospinning parameters consisted of 20 kV voltage, a collecting distance of 20 cm, needle gauge of 14, flow rate of 4 mL/hr, and a rotation speed of 3000 RPM for the collecting drum to create scaffolds consisting of aligned fibers. Each of the scaffolds was imaged using Scanning Electron Microscopy (SEM) and image analysis was performed using Image J (NIH) to measure fiber diameter, degree of fiber alignment, and interfiber spacing. In addition the piezoelectric coefficient, d_{33}, was determined for each material using d_{33} Piezometer System by Piezotest. We were able to successfully fabricate aligned fibers (Figure 1) and the ZnO-PCL had a measureable piezoelectric coefficient.

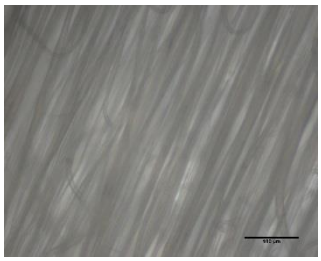

Figure 1. Aligned fibrous scaffold consisting of PCL + 10 wt.% ZnO

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Native pancreatic tissue matrix for insulin-producing cells for diabetes treatment

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Abstract: Diabetes is a disease that affects millions worldwide. Although treatments exist, the only cure currently available is pancreatic transplant, which often comes with a high risk of rejection and failure. While biological scaffolds may provide an alternative treatment for diabetes since they can be modified and processed to reduce the risk of implant failure, there have not been any studies examining the potential of native pancreatic tissue-derived scaffolds for supporting and improving insulin-producing cell survival and function.

In this study, we aimed to observe the viability of insulin producing islet cells within a scaffold created from decellularized porcine pancreatic tissue. We hypothesized that cells within a scaffold composed of native pancreatic tissue would be more viable than those not in pancreatic-tissue derived scaffolds. This hypothesis is based on the fact that pancreatic tissue may contain unique innate structural cues conducive to islet viability.

To test the hypothesis, we differentiated mouse embryonic stem cells into insulin-producing islet clusters, and manually implanted these clusters into either decellularized pancreatic-tissue scaffolds or collagen gels as a control. We examined the viability and function of islet cell clusters within these scaffolds using a live dead staining method and an insulin ELISA, respectively.

The live dead stain was done to observe the amount of cell death within the scaffolds. The more dead cells observed post stain, the less viable the environment for cell survival and function. The insulin ELISA test was performed to observe how the islet cell cluster-scaffold composites respond to the presence and lack of presence of glucose. A higher insulin secretion in response to higher concentration of glucose indicate normal cell function within the scaffold. We anticipate to see more insulin production and better survivability of stem cell derived islet cell clusters within the native pancreatic scaffold compared to in the collagen scaffold due to the scaffold providing a more native environment. Further experiments and analysis are currently being performed to achieve statistical significance between the native pancreatic tissue and collagen tissue.

Machine Learning to further earlier studies on Alzheimer's Disease

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Alzheimer's disease (AD), a progressive disease that affects regular brain functioning and diminishes memory, is one of the leading causes of death in the US. Currently there is no single non-invasive test that can be used as a biomarker for Alzheimer's. As baby boomers age into their later decades, there is an urgent need to early diagnosis of the disease to ensure early treatment and, consequently, a better chance at surviving. Even with detectable amyloid deposits (seen in PET), one out of five elderly people have normal cognitive functioning. An early diagnosis and trend of the progression of the disease can delay progression.

This study aims to use machine learning to optimize the findings in the earlier paper, which aimed to predict the diagnosis of AD using a model using a number of different clinical and imaging measures. Improvement in computational power in conjunction with advanced algorithms, it has become easier to train Neural Networks. We will select subjects from the Alzheimer's Disease Neuroimaging Initiative Database. ADNI Database was used to collect data. Alzheimer's Disease Neuroimaging Initiative researchers collect data of the patients in the form of Resting State fMRI, ASL Perfusion (Arterial Spin Labeling Perfusion), and MPRAGE (Magnetization Prepared Rapid Acquisition Gradient-Echo). This study employed data from ADNI 2 databases. The different cohort includes 155 elderly controls, 93 AD, 68 early Mild Cognitive Impairment (MCI) subjects and late MCI subjects.

Convolutional Neural Networks (CNN, or ConvNet) is a class of deep artificial neural network used to analyze visual imagery. They are a hybrid of Kernel Convolutions and Neural Networks. Kernel Convolutions is a technique that processes an image using filters to recognize and segment images based on attributes. Neural Networks consist of neurons which are loosely based on human brain's neuron which analyzes example images to identify a particular image. By using Convolutional Neural Networks, the problem of accurate detection can be solved with minimal error rate. The libraries used in this project will be taken from TensorFlow, an open-source software library for dataflow programming across a range of tasks. The findings will shed a light on the link between preclinical AD status and indicative onset and can be applied to accurately identify progressive AD graph

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Modeling Filtering Process Using Stochastic Simulations of Monte-Carlo Type

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Filtration media has changed over the years to address a multitude of problems resulting from environmental, pharmaceutical, or other industrial processes. Membranes are used in nature and are now being used commonly in industrial processes to filter out undesired solute from suspensions. Some major applications where membrane filtration plays a crucial role includes food/beverage processing, drinking water and wastewater treatment, seawater desalination, and wastewater recycling in which water sources that were previously unfit for human use are transformed into clean water that can be used for recharging drinking water aquifers, irrigation, and boiler feed water for power generation. These membranes typically lose efficiency over a period of time because of plugging and degradation which is generally referred to as membrane fouling. Microfiltration processes which use solutions containing particles tend to foul the membranes despite their small size compared to the pore cross-section. With a better prediction for an efficient membrane filter design, the membrane filtration industry would grow and further develop ways to optimize the ability of filters to purify water for everyday use.

The focus of this research was to develop specifications for the optimal pore orientation in the membrane media that resists fouling. As part of this study, a mathematical model was developed to simulate fouling such as adsorption and used to study the effect of various parameters on the performance of the pore. Such parameters that were studied include the probabilities of particles sticking to each other and to the pore walls as well as the effect of a solution containing particles with a cross-flow. This was then used to investigate the performance of a membrane given multiple pores positioned along side each other. In this model, the parameters studied included the effect of the cross-flow along with the varying widths of the pores. From the results, it can be seen that the higher probabilities of sticking to other particles and to the pore walls, in particular a probability of 0.75, causes the pores to perform the best, letting through less than 5% of particles and a horizontal combination of pores perform better with varying widths.

Development of Hydrogel Drug Delivery Systems for Heart Regeneration

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Abstract: Hydrogels are three-dimensional networks of polymers that have tunable mechanical properties and excellent biocompatibility. This material has gained much attention in the biomedical field due to its many unique and advantageous properties. Hydrogels are characterized by their ability to encapsulate and protect fragile therapeutics, be injected through minimally-invasive procedures, achieve sustained release through biodegradation, and act as biocompatible three-dimensional scaffolds to fill irregularly-shaped defects[1]. These features make hydrogels the material of choice for many biomedical applications in the fields of drug delivery, tissue engineering, and regenerative medicine.

Cardiovascular disease continues to be the number one cause of death world-wide, accounting for almost one in four deaths[2]. Due to the heart's limited regenerative capacity, myocardial infarction causes severe, irreversible scarring and remodeling of the cardiac tissue. Many studies have shown promising regenerative effects of new therapeutic materials, including stem cells, exosomes, microRNA, and growth factors. Delivery of these materials continues to be a challenge due to low retention in the heart, poor targeting and circulation times, adverse immune reactions, and invasive delivery techniques[1]. Hydrogels represent an innovative drug delivery system capable of overcoming these limitations by protecting encapsulated therapeutics and releasing regenerative drugs through sustained, targeted, and non-toxic means.

The objective of this proposed research is to develop a novel biodegradable polymeric hydrogel for minimally invasive delivery and sustained-release of heart regenerative therapeutics to the infarcted area of the heart. The material we employed is a polymer that has many desirable biomedical properties including its excellent biocompatibility and favorable mechanical properties. We have synthesized a library of hydrogels by varying the concentration of reactants, and we characterized the drug loading and release profiles of each. We will continue this work by evaluating the therapeutic efficiency of this new approach in vitro and in vivo. If successful, this approach has the potential to be translated to clinical applications that will save lives and improve the life quality of heart disease patients. Additionally, this novel method has the potential to be applied to a wide range of other disease treatments.

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An Efficient Visual Learning System Based on a Bio-mimetic Camera

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The human brain is the most power efficient computing system known, consuming a mere 20 Watts of power to perform the various computationally intensive tasks that underlie cognition. A popular research goal has been to understand the computational principles employed by biology and reverse-engineer the human brain to develop intelligent computing systems. As opposed to neural networks used for deep learning today, SNNs (spiked neural networks) naturally incorporate the time-based information encoding and processing aspects of the human brain, transmitting data through the network as a sparse binary signal (spike). In this project, we aimed to design an end to end neuromorphic handwritten digit recognition system using a Dynamic Vision Sensor (DVS) camera and a 3-layer biology-inspired and trained SNN).

The DVS camera works similarly to the human retina, only capturing the changes in pixel intensity over time, in comparison to a conventional camera which captures the entire frame at one time point. Each pixel responds to changes in contrast with precisely-timed events, giving a spatio-temporally encoded output that lies in the native processing domain of an SNN. All events are asynchronously generated using Address-Event Representation (AER) protocol through Java Address-Event Representation (jAER) software to create an Address Event Data (AEDAT) file which stores both the event data and corresponding timestamp information. Uniformly formatted AEDAT images of the MNIST handwritten digit database are collected. The images undergo compression and preprocessing to derive a 28x28 pixel binary spike stream from the event data. An SNN trained using the Normalized Approximate Descent (NormAD) learning algorithm that achieves 98% accuracy on computer generated spiking inputs is used to classify the new native spike domain MNIST data. The main deliverable of this project is to develop a working prototype of a brain inspired GPU based learning system for real-time classification on handwritten digit images in the spike domain for encoding and processing information.

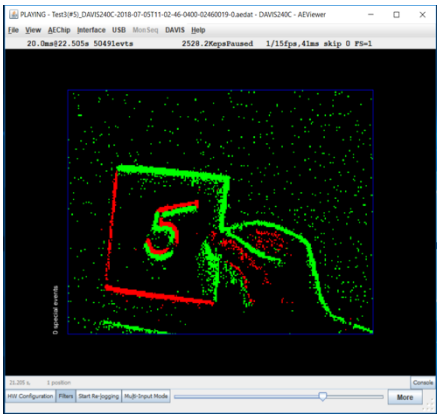

Figure 1: Photo of the AEDAT output from the DVS240c camera using jAER

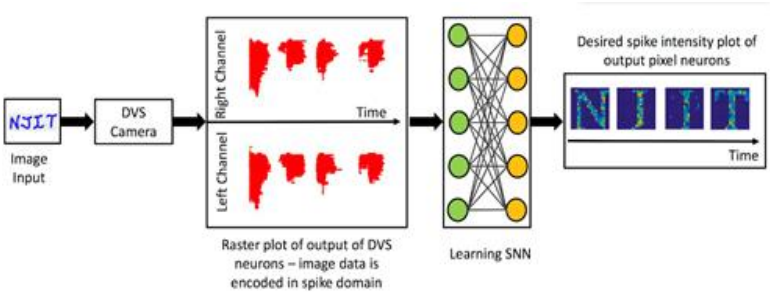

Figure 2: Overview of the end-to end neuromorphic signal processing system.

Religiosity and Wealth in the Eternal City

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While a general trend toward secularization has been largely accepted for Italy, the only measure used to support this conclusion has been self-reported church-attendance. Economic growth is often cited as a cause of secularization. Using devotion at the *edicole sacre* (street shrines) as an indication for religiosity, this project examines the link between economic growth and secularization in various neighborhoods of Rome. The goal of this project is to use multiple economic measures in many neighborhoods to establish a trend independent of self-reported data of church attendance.

The level of religiosity of each region was determined by using the number of active shrines in each neighborhood. A shrine is considered active when it has flowers, candles, or votive plaques in its vicinity. To normalize the data, a formula for a standardized shrine score was used. Here, a higher score indicates higher religiosity. The formula is as follows:

$$Normalized\ Shrine\ Score = Area * 1000 * (\frac{\#\ of\ Active\ Shrines}{Population})$$

The Normalized Shrine Score takes account of the size of a neighborhood and its population. This allows for a more unbiased comparison of the religiosity of different neighborhoods. After being grouped and averaged, the shrine scores for 13 neighborhoods of Rome was plotted on the vertical axis against their respective rates of employment plotted on the horizontal axis.

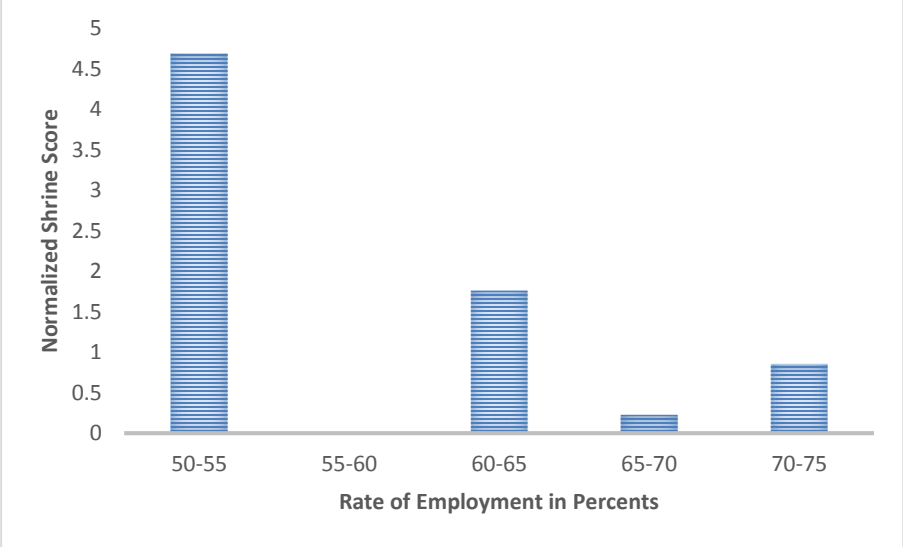

Figure 1: Religiosity vs. Employment Rates

In general, higher economic status in a neighborhood correlates to lower religiosity. However, in neighborhoods with the highest levels of employment (70%-75%), there is more religiosity than in neighborhoods with employment levels of 65%-70%. This implies a more nuanced reality than that which is generally accepted. By using more measures of economic status (real estate value, rates of unemployment, etc.,) this trend will be further examined. The completion of this project will provide a more in-depth and nuanced perspective on the relationship between wealth and secularization.

Development and Validation of a Computational Model of the Interactions of a Primary Shock Wave with a Human Head Surrogate

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Exposure to a blast wave is the leading injury observed in military personnel during wartime and during trainings with heavy weapons and explosives. The injuries exhibited by mild, blast-induced traumatic brain injury (mbTBI) are diffuse, difficult to identify, and manifest themselves in concerning neurocognitive and behavioral changes. Although high fidelity representations of the brain are necessary to fully understand the mechanisms for injury, current experimentation is constrained to the use of animal models and human surrogates.

Therefore, this work closes this gap with a validated computational model. Previously, a RED head form surrogate was mounted to a Hybrid III neck and exposed to shock waves within a field-validated shock tube. The surrogate was exposed to shock waves of varying intensities (70, 140, and 210 kPa) at three orientations with the blast (a 0°, 90°, and 180° rotation about the superior-inferior axis). Surface pressures were recorded at ten regions of interest on the head surface.

By leveraging numerical modeling techniques and knowledge of hydrodynamics, a computer simulation of this system was created to better understand how the human head interacts with a shock wave. The twenty-eight-inch shock tube was modeled using a hydrodynamics model via a meshed (finite element modeling) approach. The human head surrogate was considered a rigid body for model simplicity and further work will be conducted to include the effect of surface deformation on surface reflected pressures. The input, loading, and boundary conditions of the computational model were selected to match the experimental test setup. Nine validation simulations were conducted, with three blast overpressures and three test subject orientations.

The experimentally-measured surface reflected pressures were used as validation criteria for the hydrodynamics model. Surface reflected pressures were compared between the experimental measurements and the computational predictions at the sensor locations, comparing the rise times, peak blast overpressures, durations, frequency content, and impulses in all test cases. These comparisons validate the simulation inputs or inform changes to be implemented in the computational simulation, eventually enabling for the investigation of pressure and impulse contours on the simulated RED head.

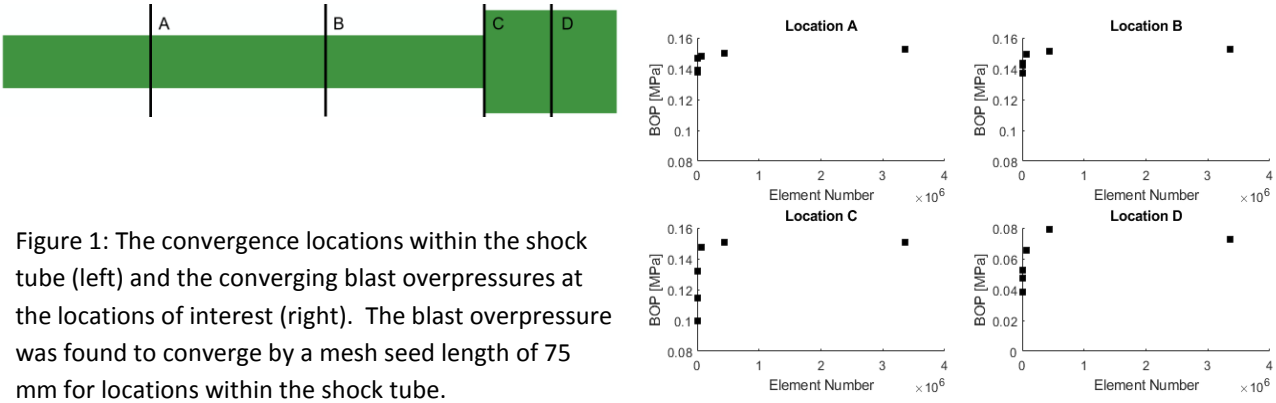

Figure 1: The convergence locations within the shock tube (left) and the converging blast overpressures at the locations of interest (right). The blast overpressure was found to converge by a mesh seed length of 75 mm for locations within the shock tube.

3D Printing of PCL/HA Composite Scaffolds for Bone Tissue Regeneration

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Abstract:

Osteoporosis is a progressive condition in which bone tissue loses its density and becomes brittle leading to severe pain and discomfort for the patients. Current treatment methods used to address this problem are non-restorative, which means that they do not restore function to the tissue; rather they focus on alleviating the pain temporarily. Tissue engineering approaches attempt to rebuild the damaged tissues from scratch by combining biodegradable scaffolds with biological factors and cells. The specific aim of this research is to use the Additive Manufacturing technology to develop bio-ceramic (hydroxyapatite, HA/ biodegradable polymer (polycaprolactone, PCL) composite scaffolds that will regenerate bone tissue. The engineered scaffold will enable i) stem cell differentiation to osteogenic lineage (bone) and ii) surgical implantation into the bone defect region to promote tissue formation.

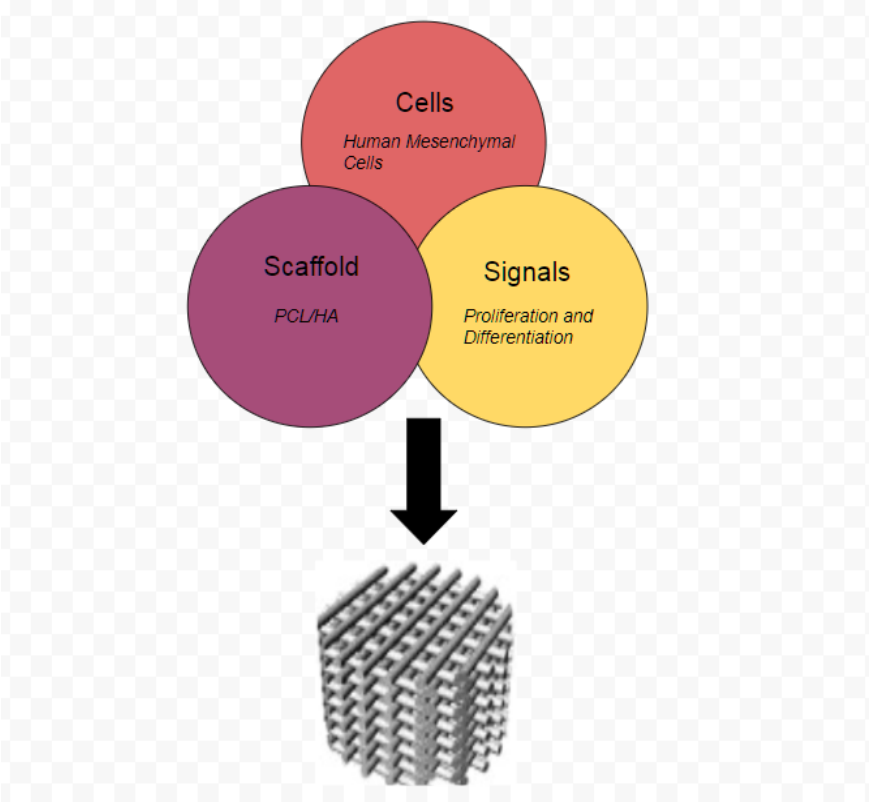

Figure 1: This figure shows the overall model for the project

Oral Nanoparticle-based GLP-1 Formulation for Treatment of Diabetes

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While insulin offers the benefit of lowering the blood glucose levels of diabetic patients, it can also cause weight gain and hypoglycemia, thus decreasing its clinical efficacy [1]. On the other hand, the incretin glucagon-like peptide-1 (GLP-1) secreted by intestinal L-cells has been associated with weight loss and a reduced risk for hypoglycemia [1]. Furthermore, GLP-1 stimulates insulin secretion strictly upon glucose intake and therefore prevents the exhaustion of pancreatic beta-cells responsible for insulin production, storage, and release [1]. GLP-1 is, however, rapidly inactivated by the enzyme dipeptidyl peptidase-4 (DPP-4) [1], which is ubiquitously expressed on intestinal epithelial cells. Consequently, GLP-1 receptor agonists (RAs), or incretin mimetics, with greater stability toward DPP-4 than native GLP-1 have been developed and used for the treatment of diabetes. Although there are already several GLP-1 RAs available commercially and others in development, like insulin, they are currently administered by injection.

Here, we developed an oral GLP-1 formulation using polymeric nanoparticles (NPs). Briefly, the polymeric NPs were synthesized from poly(lactic co-glycolic acid)-poly(ethylene glycol) (PLGA-PEG), a biocompatible, biodegradable, proteolysis-resistant di-block polymer composed of hydrophobic and hydrophilic segments, through nanoprecipitation. Dynamic light scattering (DLS) instrumentation was used to determine the size, charge, and polydispersity index (PDI) of the NPs. Varied concentration of GLP-1 were encapsulated within the NPs. The NPs were purified using centrifugal filter units. High performance liquid chromatography (HPLC) was used to study the kinetics of GLP-1 release from the NPs at variable pH. The formulation that had the greatest encapsulation efficiency and release profile was determined once each formulation and subsequent release kinetics were analyzed. Next, we plan to study the intestinal permeability, cellular uptake, toxicity, and efficacy of the NPs through *in vitro* and *in vivo* experimentation, using Caco-2 cell lines as a model of the intestinal barrier and db/db mice as a model of Type 2 diabetes.

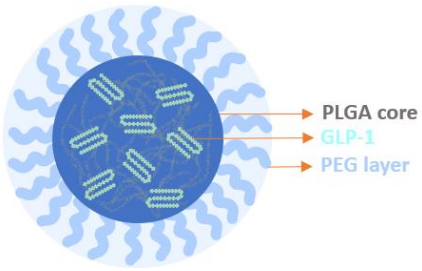

Figure 3. Structure of GLP-1-loaded PEG-PLGA NPs.

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RONALD E. MCNAIR POSTBACCALAUREATE ACHIEVEMENT PROGRAM

Exploring a role for Rac1 in *Xenopus* neurulation using optogenetics

Naira Abou-Ghali, Advisor: Dr. Gregory Weber
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Cell migration of tissues has important contributions to cell and developmental biology in both normal and abnormal circumstances, such as wound healing and cancer metastasis. In early stages of embryonic development, a unicellular zygote divides to become multicellular. Subsequent cell and tissue movements promote shaping of the embryo, so-called morphogenesis. Gastrulation is characterized by the formation of three primitive germ layers- mesoderm, endoderm, and ectoderm. Cells emerging from these germ layers form tissues integral to specific structures, and dynamically change shape to facilitate motility. As a result, physical changes in individual cells will reflect tissue morphology. Neurulation is characterized by dramatic shape changes in individual cells that facilitate bending of the neuroepithelium into raised neural folds, fold migration to the medial axis, and neural fold fusion to form a hollow neural tube[1]. Cellular shape change and motility are facilitated by a large network of fibrous filaments known as the cytoskeleton, which is composed of actin microfilaments[2]. Regulation of this actin network on the cellular level allows for morphogenesis of embryonic tissue. A main regulator of actin cytoskeleton is the Rho family of small GTPases, one of them being Rac1. Rac1 facilitates membrane protrusions called *lamellipodia*. Formation of lamellipodia allows a cell to protrude forward[2]. The consequences of manipulating actin cytoskeleton by inducing Rac1 expression have been observed *in vitro*, but not *in vivo*. Using *Xenopus laevis* frog embryos as a model for the effects of Rac1 during development is advantageous due to the ease with which they are cultured outside the maternal environment, and their rapid and robust development. Injecting *Xenopus* embryos with mRNA encoding constitutively active Rac1 protein is known to impair gastrulation; however, effects of Rac1 on stages past gastrula are not known[3]. New innovations in genetically-encoded light-inducible fusion proteins now allow the examination of Rac1 during specific stages of development[4]. The LOV (light, oxygen, voltage) protein domain is native to *Avena sativa* phototropin-1, a photoreceptor sensitive to blue and UV wavelengths, and is responsible for its light sensitivity[5].Fusion of the LOV domain to constitutively active Rac1 protein produces a Photoactivatable-Rac1 (PA-Rac1) that is light sensitive, yet sterically blocks the effector binding site, rendering Rac1 inactive when maintained in the dark[4]. Upon exposure to blue light, LOV domain undergoes structural changes that expose the effector binding site of Rac1, inducing activation of downstream effector pathways[4]. Early stage *Xenopus* embryos will be injected with PA-Rac1 and exposed to blue light at the start of neurulation (neurula stage) for various periods of time. Embryos will be examined for developmental problems in neural tube closure and neural crest cell related structures such as pharyngeal arches, eyes, and pigment cells. Given the known role of Rac1 in cell migration, we anticipate that perturbing cell migration with this inducible system will manifest in disruption of neurulation events.

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Clearance of Waste Metabolites in the Paravenous space

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Clearance of waste metabolites inside the brain is essential for tissue homeostasis. The brain consists of one basic clearance pathway known as the cerebrospinal fluid (CSF). Additionally, there are other systems that are responsible for clearance known as the glymphatic and the meningeal lymphatic systems inside the brain. However, these systems were not adequate forms of clearance due to their anatomical locations (eg. meningeal lymphatic vessels) as well as preference for water soluble, small size molecules (eg. glymphatic system). Our research has found that large size, water-insoluble waste metabolites produced in brain parenchyma were rapidly (~30 min) collected and aggregated at perivascular space (PVS). This process was mediated by cerebral vascular reactivity, particularly through dilation of smooth muscle cell covered vasculatures. Once accumulated at PVS, waste metabolites were found to travel along vasculatures and ultimately gain access to systematic circulation (~ 2 hrs), providing a new route for large size waste metabolites that were neglected by previous described pathways.

However, though waste metabolites movement and clearance were identified to follow PVS – circulation route, a connection that links these two elements was still missing: whether waste metabolites from PVS entered systematic circulation at arterial, capillary or venous level was still unknown. Thus, the primary objective of the project is to identify the exact entrance of waste metabolites from PVS to systematic circulation at vasculature levels. Fluorescently labeled tracer (2000 KD) will be used to mimic large size waste metabolites. Bio-distribution of tracer in brain will be evaluated on tissue slices. Arterial and venous vasculatures will be distinguished based on tissue specific bio-markers while capillary will be identified based on diameters. Co-localization assay will be conducted to explore the location of tracers in relationship with different vasculature structures. The goal of this project assumes high clinical relevance because large size waste metabolites, including tau-phosphorylated neuropathy and amyloid plaque proteins, were widely seen in neurodegenerative diseases, such as Alzheimer's disease. Uncovering the mysterious clearance mechanism will definitely shed lights on its clinical treatments.

Establishing Temperature Control Through the Cell Environment Using a Raspberry Pi

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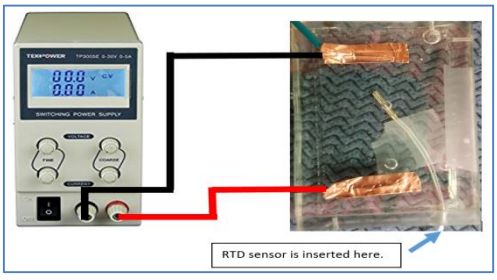
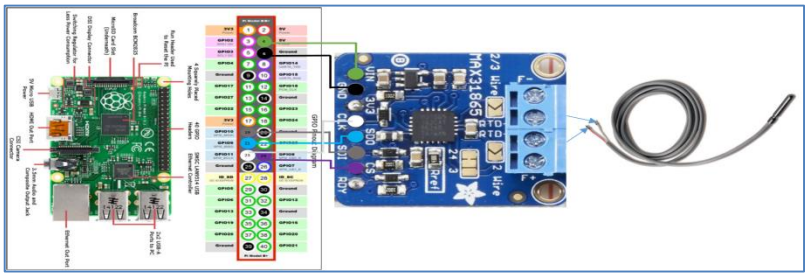
Live cell microscopy experiments require precise equipment and can be very expensive. The significance of this project lies with integrating new technologies into the scientific mindset thereby reducing reliance on over-engineered, expensive, dedicated systems. For example, the original system, WAGO controller, is a modular system that can be programmed to work with different sensors and specifications. The efficiency of using this controller is pretty good; however, it is pretty expensive since not all the tasks can be done using only one module. Therefore, the Raspberry Pi is used to perform requisite tasks. We chose the RPi3b simply for its flexibility, processing power, connectivity options, and extremely low cost. The RPi3b receives an input from a user specifying the parameters of the experiment to be run. The RPi3b then runs a script that initializes the heating element to heat the environment via ITO coated glass and controls the pressure valves by increasing or decreasing the flow rate of each channel. And once the environment has reached the requisite temperature and pressure the cell migration experiment can begin. In order to keep the cells from drastically changing, it is important to maintain a temperature of 37° C. The temperature is constantly measured by a Resistance Temperature Detector (RTD) sensor embedded in the environment and provides feedback for correction via a proportional–integral–derivative (PID) controller script run by the RPi3b. Right now, a non-programmable power supply and temperature probe are doing the job in reading and monitoring the temperature in the cell environment. So, the research is how we can integrate both the power supply and temperature probe on the RPi. Currently, we were able to utilize the temperature sensor on the RPi using the GPIO pins and an MAX31865 amplifier which is attached to the RTD shown below. Now the idea is to build a switch mode power supply and a PID controller through the use of a Raspberry Pi. So, the RPi performs PID to regulate Pulse Width Modulation (PWM) that heats up glass through the switch mode power supply that outputs 5V. Then the amplifier circuit allows RPi to read next step and the analog to digital convertor (ADC) is used to convert the input voltage so that the RPi could read it. Future research will concentrate on exactly how we will experimentally perform the heating control network.





DATABASE OF MECHANISM ANIMATIONS

www.designwell.me

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In many assemblies, there are integral mechanisms found within the machine. Many of these concepts can be exploited in diverse applications. For example, the Geneva mechanism which is found in an analog watch, used for transferring motion between the hour and minute hands, can be also found in a CNC machine for indexing tool changers; or the movement of an eccentric mechanism commonly found in locomotive engines is a vital mechanism in an electric toothbrush. It is critical for a design engineer to understand these concepts to develop a novel and efficient device. To utilize these concepts in an efficient manner, it is critical in understanding which mechanism can be used for a particular machine. Many of these simple mechanisms have been published in textbooks; however, most are outdated, incomplete, and not explored thoroughly. To understand the functionality of the mechanisms, engineers must see them in action to grasp the practicality of them. Our research aims to show 3D animations to demonstrate the intended motions of the mechanisms. As Albert Einstein said, "The only source of knowledge is experience." Through this database, DesignWell™, users can enhance their knowledge by bringing the experience to them at their fingertips. The user will see how each mechanism works and a brief description on what it can be applied to. The mechanisms are modeled using the 3D modeling software Creo Parametric 4.0. After completing the individual components constituting the mechanism, the parts are then combined into an assembly. After adding motors and constrains, the assembly would be converting into a movie file and the motion movie file is archived into the DesignWell™ database. Users will be able to find specific mechanisms through keyword search and related categories. The ideas presented in the database will serve as a resource for product designers and idea-seeking entrepreneurs. In addition, it can serve as a source of knowledge and inspiration to the interested students and motivate them around Mechanical Engineering. After studying various mechanisms and modeling them, it was found that eccentric and planetary gear mechanisms are used efficiently in electric toothbrushes. Figure 1 shows the entire assembly. The motor provides a rotary motion for the planetary gear to rotate around the main gear. Then the eccentric mechanism that is attached to the planetary gear is converting the rotating motion to an oscillatory motion for the toothbrush head. Another, application for this same mechanism, is a floss head attachment. By understanding simple mechanisms, it helps ignite ideas on creating new devices.

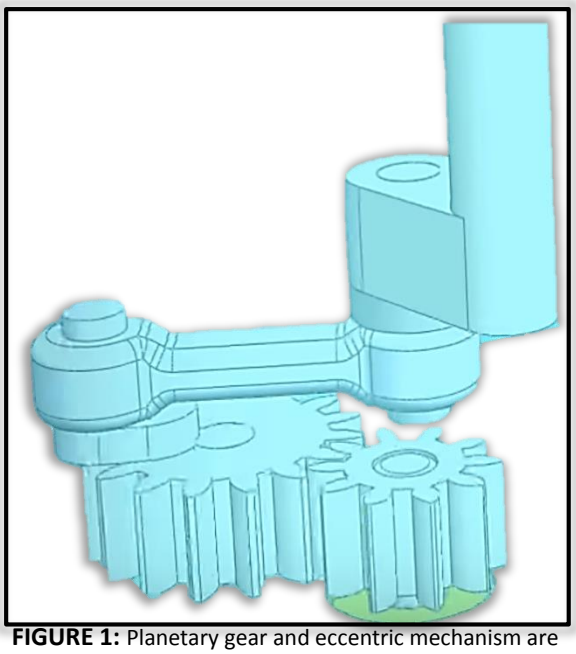

FIGURE 1: Planetary gear and eccentric mechanism are combined to provide oscillatory movement

Social Systems/Network Application for Recovering Opioid Addicts Customer Discovery

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Ying Wu College of Computing, Department of Information Systems
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Currently, the United States of America is experiencing an opioid epidemic. Addiction fatalities with prescribed pharmaceutical opioid medication, Heroin, and other narcotics contribute to this steady increase. Large New Jersey populations are especially problematic without the reciprocating treatment resources for rehabilitation and recovery. A large inner-city community does not have the needed community networking and literacy towards addiction preventions. The problem being that recovering opioid addicts are isolated without socially supportive environments. The isolation also prevents helpful information to be utilized by: 1.) by other former opioid users seeking recovery maintenance, 2.) the paraprofessionals that facilitate centers, 3.) the medical professionals alongside clinicians, and 4.) supportive family, significant others and friends. A possible solution for this specific problem within the research project proposes the development of a social systems or social network application for the specific groups. For the application to be developed, a surveying interview was tested with twenty participants. The participants ranged from medical professionals at the 2018 International Conference on Opioids at the Harvard Medical School in Boston, Massachusetts to licensed emergency medical technicians. Subsequently, this critical information would lead to the recommended application utilities. The survey information that was collected was valuable to the research on its themes of suggested features for the application. Primarily, the ultimate goal of developing the application will be to assist the recovering opioid addict with available, online information on recovery resources.

Boiling of HFE-7100 on a microheater

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Miniaturization of electronic and photonic systems is challenged by a dramatic increase in the power dissipation per unit volume with the occurrence of hot spots where the heat flux is much higher than the average. Force-flow cooling by gas or liquid appears insufficient to remove local high heat fluxes. Boiling that involves evaporation of liquid in a hot spot and condensation of vapor in a cold region can remove a significantly larger amount of heat through the latent heat of vaporization. It is therefore considered as the most promising cooling technology for future space applications. As cooling implies immediate contact between the liquid and the heated electronic component, the liquid must be dielectric. 3M Novec HFE-7100 (3M, St. Paul, MN) with the saturation temperature 60°C at a normal pressure is agrees well with data reported on similar dielectric liquids in the literature. Our experiments focus on measuring the dependence of the heat flux on the heater temperature for nucleate boiling heat transfer of HFE-7100 on a microheater. Boiling on small heaters and/or low gravity is dominated by capillary forces and thermocapillary convection around a heater. As a liquid in a cooling system utilized over a long period of time usually accumulates dissolved air, experiments are carried out with the cuvette lid that is not airtight to maintain atmospheric pressure inside the cuvette (Fig. 1). A heating DC voltage is varied from 5.6V to 12.01V to heat the liquid in the cuvette in a temperature range of 32°- 58°C. The experimental results agree well with data on similar dielectric liquids. Since electric fields are widely used to enhance boiling heat transfer, it is planned to study the effects of high-voltage pulses on the boiling heat transfer.

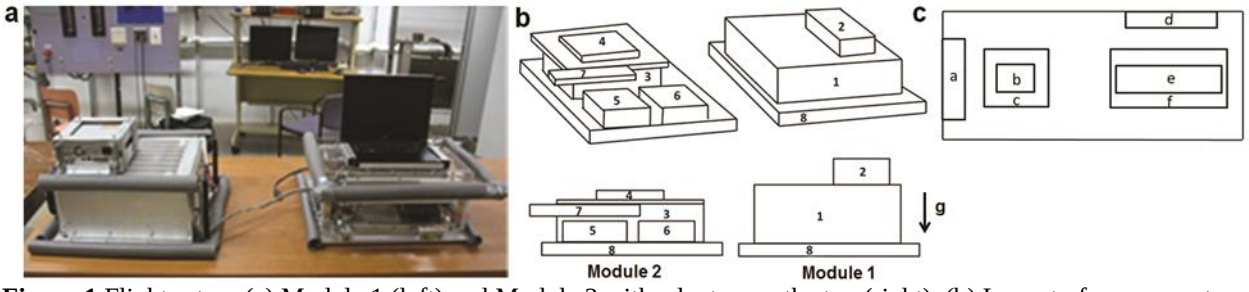

Figure 1 Flight setup: (a) Module 1 (left) and Module 2 with a laptop on the top (right), (b) Layout of components of Modules 1 and 2, (c) Layout of components within the enclosure in Module 2.

Observing Morphological and Ecological Evolution over 20 million years through ants and amber

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Ants play an important role within terrestrial ecosystems, significantly impact the ecology of many environments, and they comprise a large percentage of total biomass on Earth. There are over 13,000 species of ants alive today and over 700 fossil ant species are currently described, and a good number of them are preserved in amber. Fossil amber from the Dominican Republic preserves a large quantity of ancient ants that provide a window into ecology and morphology 20 million years ago. Compared to existing species, were ants morphologically and ecologically distinct in the Caribbean 20 million years ago? Using an internet database and lab samples 177 extant species (383 specimens) and 85 (110 specimens) fossil species were measured and seven unique measurements were recorded to quantify morphological variation. Principal component analyses were performed to understand the degree of morphological change and create a picture of how evolution works over time. The objective of this project is to understand whether or not the ecological community represented within 20 million-year-old Dominican amber is distinct by observing and comparing this assemblage to living species. The result will inform us how evolution works over time and the pattern of evolution. These pilot data will lead into other projects and publication related to evolutionary change and stasis over millions of years.

Figure :(left to right) Odontomachus bradleyi, Thaumatomyrmex mandibularis, Octostruma balzani, Cephalotes serratus(fossil)

Optimizing Hand Rehabilitation Post-Stroke Using Interactive Virtual Environments

Pablo Tejada Jr. Advisors: Dr. Sergei Adamovich, Ashley Mont Ph.D. Candidate
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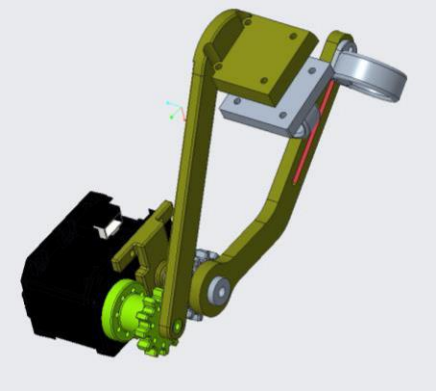
New Jersey Institute of Technology, Newark NJ 07102

Stroke, also known as cerebrovascular accident, is a condition that damages the brain caused by interruption of blood supply. A stroke occurs when a blood vessel feeding the brain gets clogged or bursts. Although pre-stroke (transient ischemic attack) symptoms are early signs that help physicians take countermeasures to prevent a stroke, stroke is the leading cause of serious long-term disability in the United States. Disabilities include difficulties walking, speaking as well as paralysis and lack of muscular strength and coordination. Post-Stroke rehabilitation has been developed to help patients recover through the use of exercises and machine therapy to stimulate the brain. Several research studies on post-stroke rehabilitation has shown that the importance in relearning motor skills depends on the quantity, duration, and intensity of training sessions. However, when therapy is provided in rehabilitation center, the patient has a half-hour session once or twice a day. This consistency decrease further when the patient is sent home. Virtual reality (VR) technology has and it's still being used in several areas of rehabilitation alongside with robots and machines. By combining a robot-assisted sensorimotor activity in a virtual environment subjects were able to not only strengthen but also relearn movements. VR technology can provide the ability to increase the duration, frequency and intensity of exercise when being used with a semiautomated program. Low-cost pc-based Virtual Reality devices are available to the average consumer which could allow rehabilitation stations to be placed in the patient's home besides the hospital. As a result, the patient would be able to continue rehabilitation and maintain consistent training sessions.This research focuses on implementing the use of virtual reality and physical therapy to optimize and decrease recovery time and allow patients to continue their rehabilitation in their home. Unity is the game engine used to create the virtual environment. It will be navigated with the use of a Leap Motion sensor together with a hand wearable device (**Figure 1**) that houses a force sensor and Dynamixel MX 28 servo actuator which has the ability to track its speed, temperature, shaft position, voltage, and load. Several different virtual environments were created to provide a variety of exercises to recover different muscle groups. The wearable devices were printed on a Flashforge Creator Pro using ABS filament with an 85% infill.



HONORS SUMMER RESEARCH FELLOWSHIP

Compensatory Neuronal Plasticity Mechanisms in Response to Insertion of Exogenous Genes

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Abstract: In order to function properly, an animal's nervous system must maintain relatively stable properties while adapting to changes in the environment, a concept known as homeostatic plasticity. The goal of this project is to test the hypothesis that neurons express compensatory mechanisms that allow them to maintain the relative levels of gene products (ionic channels) while allowing individual levels to vary. The model system we are studying is the neurons in the stomatogastric ganglion of the crab *Cancer Borealis*. It is well suited for the experimental design because these neurons are easily accessible, identifiable, and robust (able to survive impalement). The compensatory mechanisms are probed by tampering with the expression levels of individual ion channels by upregulation with messenger ribonucleic acid (mRNA) injected directly into the neurons to boost the expression of specific channels. Alternatively, double stranded RNA (dsRNA) is injected to depress (downregulate) the expression of channels. The unperturbed ion channels will be studied to see how they react to these manipulations.

In order to insure that the neurons I am working with can express exogenous mRNA, I developed a method to inject into individual cells mRNA that codes for a protein that can easily be tracked and quantified due to its fluorescent properties. This protein is known as GFP (Green Fluorescent Protein). Figure 1 shows that these neurons do express exogenous mRNA over the course of days. Preliminary analysis of the data indicates that the expression of channels is not affected significantly over the course of days by simply injecting GFP. Once I finish acquiring control data, I will start injecting mRNA and dsRNA to alter specific channel levels and analyze the affect this produces on the other channels.

In addition to probing mechanisms of homeostatic plasticity in these neurons, the development of a new method of altering the expression levels of target proteins (and a cell's properties) will be a valuable outcome of this project as it will enable precise and effective alteration of specific molecules for a number of future studies, thus overcoming the notorious lack of specificity of drugs normally developed for vertebrate use.

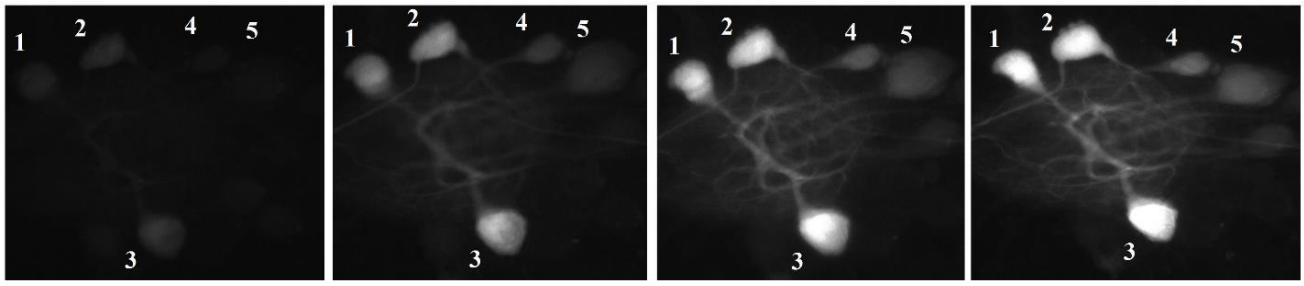

Figure 1: Progression of fluorescence in cells after injecting mRNA that codes for GFP. Numbers identify the individual neurons over time. The fluorescing lines that can be seen between the cells are the axons and dendrites of the cells.

Research on the Edicole Sparita of Sant'Angelo, Rome

Katherine DeMottie, Advisor: Louis I. Hamilton

In Rome, religious shrines on the streets have served as a form of public devotion since antiquity, but they first emerged within Christianity in the thirteenth century.[1] Termed *edicole sacre*, these well-studied shrines usually take the form of an image (most commonly of the Madonna) under a small roof or protective frame along with a shelf below. As pedestrians pass, they stop to pray and sometimes leave behind flowers, candles, and/or messages in the form of votive plaques. In addition to their complex historiography, the "virgins on the street corner" represent the prevalence of faith in Roman communities as well as its strength.[3]

The focus of this project is the *edicole sacre* of Rome's eleventh Rione, Sant'Angelo, in the nineteenth century. Demographically, this rione, or region, has been home to the Rome's Jewish community, one of the oldest in Europe, dating back to the second century BCE. As Christianity gained prominence over the next centuries, especially under the Roman Emperor Constantine, the Jews were subjected to varying religious pressure. In the sixteenth century CE, a new level of antipathy towards the Jews emerged in Europe. In 1555, Pope Paul IV issued papal bull, *Cum nimis absurdum*, that ultimately instituted the creation of the Roman Jewish Ghetto: a wall enclosing eight acres in one of the worst parts of Rome, overcrowded and prone to flooding from the Tiber, and subject to few but inadequate expansions over the next centuries.[4] In addition to physical restrictions, compulsory sermons were held at regular weekly intervals in front of Christian images (*edicole* or similar images) erected just beyond the gates of the Ghetto.[5] The Roman Ghetto was the last of its kind in Europe to be torn down, with the termination of Ghettoization policies during the unification of Italy in 1878. Ghettoization, of course, returned and escalated in the wake of Nazi Germany. The Roman Ghetto is an important link in the broader history of anti-Semitism in Europe. As the only precursor to the infamous Nazi ghettoization policies, one would assume a connection between the two, but the forty-year gap in the historical record of anti-Semitism calls into question the legacy of the Roman Ghetto and its effects on the cultural and political development of Europe.

My hypothesis is that the purpose of the creation of the shrines in and around the Ghetto is a stark contrast to the usual benevolent advocation of faith. Instead, they may have served as a means for the papacy to aggressively enforce Christianity on an unwilling community. A database and location map of 20 historical images of the Roman Ghetto from its creation to its demolition prove the existence of these shrines directly outside the Ghetto gates. Even as the Ghetto expanded into the later centuries, the *edicole* continued to surround and punctuate the Jewish community. Primary source evidence from papal decrees and publications suggest a hostile attitude towards the Jews of Rome, even as late as 1870 when the European liberalism movement peaked with the unification of Italy and widespread religious toleration. The papacy made no attempts to rectify their mistreatment of the Jewish community despite the sentiments of many of its constituents. Catholic Romans supported the liberation of their Jewish peers throughout the 19th century, thus leaving only the Papacy guilty of anti-Semitism towards the end of the Ghetto period and possibly into the 20th century. The conversionary practice of compulsory sermons from the 16th and 17th centuries was revived by Pope Leo XII in 1832, suggesting a futile attempt by the papacy to maintain control over a population that was gradually shifting from a position of inferiority to one of equality.

Optimization of 3D Printed Hybrid Scaffolds

Caroline D'Souza; Advisor: Dr. Murat Guvendiren, and Mentor: Dr. ChyaYan Liaw

Otto H York Department of Chemical, Biological, and Pharmaceutical Engineering

New Jersey Institute of Technology, Newark, NJ 07102

3D printing allows fabrication of scaffolds for tissue regeneration and repair, yet the resolution does not allow nano-scale fibrous structures mimicking the native extracellular matrix. In this work, we create large-scale hybrid scaffolds combining 3D printing and airbrushing. Polycaprolactone (PCL) is used as the 3D printed material, and PCL and gelatin are used as the airbrushed polymer. This approach allows us to create micro-scale printed structures combined with nano-scale fibrous network. We will investigate the effect of sequential airbrushing on fiber density. We will fabricate multi layered hybrid scaffolds and determine the uniformity of the fiber density with depth. We will also examine the fiber stability in an aqueous solution.

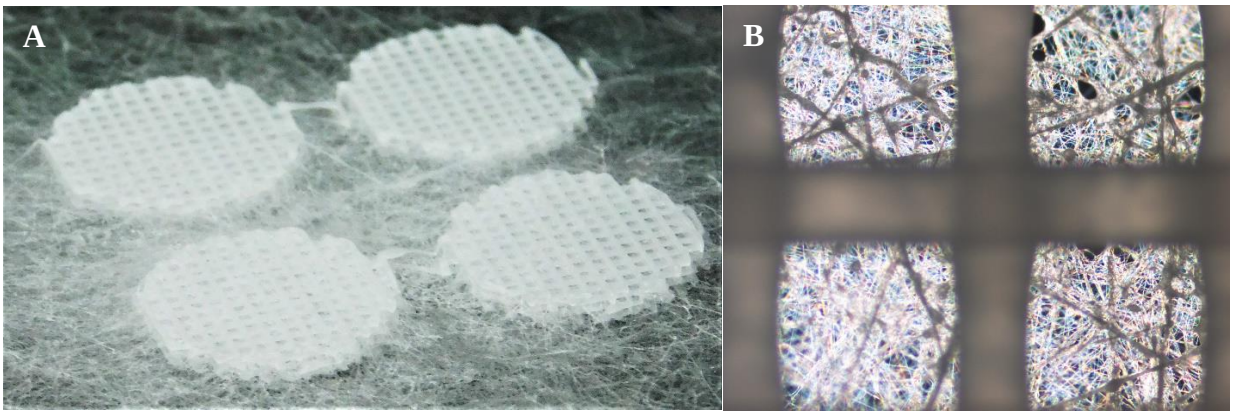

Figure 1: (A) Multi layered hybrid scaffolds with airbrushed PCL fibers. (B) Optical microscope image of airbrushed PCL fibers on a 3D printed PCL grid.

Correlation Between Architecture and Human Cognition and Behavior

Laura Dawn Gould and Mentor: Dr. Louis I Hamilton

Many architects and experts on building design have argued that it is possible to control behavior through architecture. Michael Desanctis remarked that while a building is a reflection of its occupants, buildings themselves "[e]xert a subtle but real influence on those who inhabit them." (Lurie 2014). However, little research has been done in this field to quantify these ideas. Quantifying how a space changes human cognition and behavior means that we can make more effective architecture, from offices to churches, to prisons. Spaces of relaxation would be scientifically designed to be relaxing, and work spaces could be designed to promote the greatest productivity.

This research project seeks to prove whether physical spaces affect human cognition and behavior by looking at the physical infrastructure around shrines to the Madonna in Rome, Italy and comparing that data to amount of apparent devotion. This research is done through studying rates of devotion at shrines to the Madonna (mother of God in Christian theology). These shrines are often attached to walls and look like small houses with images of Mary, Jesus, and or Christian saints in them. Since their appearance in the thirteenth century, these *madonelle*, or "little Madonnas", were placed on street corners or outside of people's homes as a form of protection and a reminder to be holy (Muir 1989). Many of these attract active devotion of their own in the form of brief prayers or small physical offerings, including candles, flowers, and cards (Hamilton forthcoming).

The research is done primarily through adding information to the largest existing GIS database of *madonelle* in Rome. The initial study is limited to two *rione,* or sections, of the city of Rome – one in its historic center, with little new infrastructure in the last few centuries, and one with lots of new urban infrastructure in the last century – which allows for a representative sample of preliminary results. Using Google Street View images of Rome, the presence or absence of devotion at each shrine is confirmed using inclusion criteria such as fresh flowers, cards, plaques, candles, or recent restoration. Simultaneously, the physical characteristics of the urban infrastructure around the shrine are measured, including street width, use of building that the shrine is placed on, the presence of a shelf, the original purpose of the shrine, and its age. Finally, the data is analyzed to track possible correlations between physical elements of Rome and the way its residents show religious devotion. This will allow me to determine whether there is a correlation between architecture and religious activity. Future studies will try to quantify how exactly physical space does affect human behavior and cognition to develop better architecture.

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In Situ Decontamination of Sediments Using High Intensity Ultrasound

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Over half of the world's population lives in urban centers with this number projected to increase in coming years. As these cities are usually concentrated along major rivers, dangers associated with pollutants released from major industries are an increasing concern. Often, these pollutants accumulate in sediments at the bottom of the river which limit the river's usage. Therefore, it is necessary to solve the problem of contaminated sediments. In situ remediation can prevent the risks involved with the resuspension of the contaminants during dredging and high costs associated with the disposal of dredged, contaminated sediments.

The goal of this research is to determine the viability of on-site cleaning of contaminated sediments. It will focus on the developing technology of ultrasound to provide a cheaper and more environmentally-sustainable on-site treatment technology with a lower total cost over a shorter time span compared with dredging. Ultrasound is already a commonly used technology and has applications in industrial cleaning. However, its uses in wastewater treatment and soil washing are still in development. The process proposed in this study will begin initially with high frequency ultrasound transducers providing agitation and creating a suspension of soil and pollutants. Later, lower frequency ultrasound plates cause cavitation, or the formation of bubbles within the water. The rapid collapse of these bubbles creates high temperatures and pressures where hydroxyl radicals are split from water molecules and react with pollutants in a process known as sonochemistry. This study will identify and optimize parameters, including frequency, power input, and geometry, that will affect the removal efficiency of contaminated sediments.

Topologically Protected Domain Boundary Modes in Meta Materials

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Abstract: This decade saw an immense development in the field of topology and it has entered the stage for practical application. One of the interesting phenomena in the field of topology is topological insulators, which are insulators in the bulk but are conductors on the edges. More importantly, they are topically boundary protected: the conductive property is conserved under continuous deformations. Dr Ahn Keun, recently described a model in which the properties of topological insulators depend on the lattice distortion. The premises of this research, is to propose a topological pattern which can validate the model and realize Dr. Ahn's model for topological materials in meta-materials. The proposed topological pattern in shown in Fig. 1, where each cross showing a particle coupled with the neighboring particles, with varying force of interacting as color coded in the Fig. 1. Currently we are developing the mathematical and computational model for the pattern so that in the future the pattern could be constructed in the lab and the theoretical data along with practical data can be utilized to validify the pattern and realize the model in meta materials.

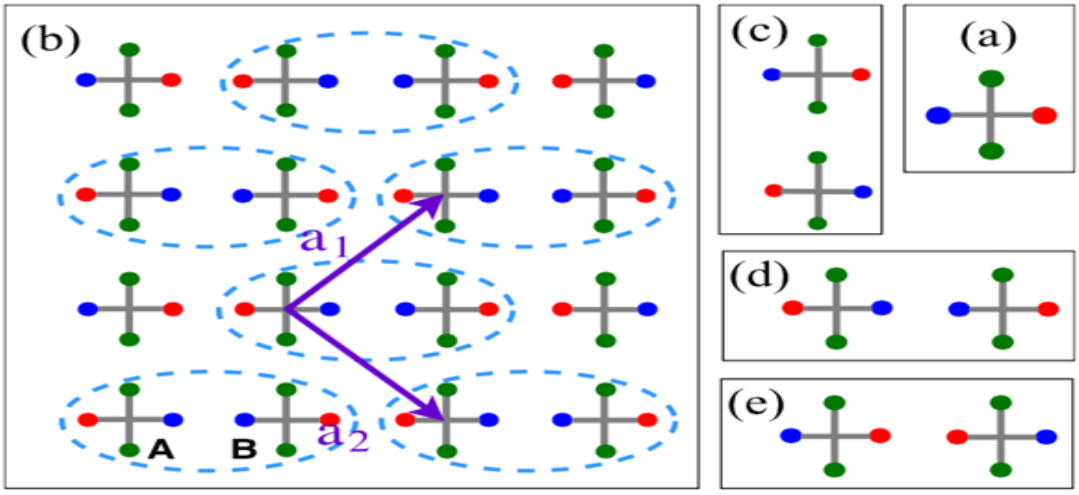

Figure 1 (a) The four-armed spinners; (b) A pattern made by the four-armed spinners; (c) Spinners interacting with green pairs; (d) Spinners interacting with blue pairs; (e) Spinners interacting with red pairs.

The Effect of Breeding on Thoroughbred Racehorse Durability

Beatrice Rejouis, Advisors: Dr. Louis Hamilton
Department of Biology; New Jersey Institute of Technology, Newark, NJ 07102 USA

The purpose of this study is to test whether there is a correlation between a Thoroughbred horse's breeding and its durability. Thoroughbred horses possess several qualities which make them valuable race horses, such as their speed and agility. To preserve these highly sought-after qualities, Thoroughbreds have been bred within their own small genetic pool. At the same time, there has been a growing concern over the frequency of fatal injuries in Thoroughbreds. Some years the rate of fatal injuries increases and other years it decreases, all with no clear pattern, although in the last several years recent studies have suggested a decline in fatal injuries per 1000 starts. Some believe the inbreeding of Thoroughbreds causes increases in fatal injuries, however, a wide range of factors are also involved including the track the horse races on, and the trainers and jockeys who handle the horse. This study aims to assess the impact of breeding on a horse's durability by first testing whether there is correlation between the two.

Specific records on horse injuries are not readily available, therefore a lack of durability will be marked by the presence of DNFs, or "did not finishes", in the horses' racing record. A DNF can occur in the event the horse cannot physically finish a race, or the jockey deems the horse unfit to finish the race, either because it has sustained an injury or is at risk of sustaining an injury should it continue. We considered less durable horses to have one or more DNFs in their career and more durable horses to have long careers with no DNFs. We hypothesize less durable horses will have more instances of inbreeding in their pedigrees while more durable horses will have little to no instances of inbreeding in their pedigrees. In the event the correlation between durability and genetics relies on inheritance rather than inbreeding, a separate hypothesis was formed suggesting horses with similar durability should be more closely related if genetics does indeed influence durability.

Preliminary data of 869 horses suggests there is no correlation between inbreeding and durability. Horses for this data set were selected from a singular track and a select number of years to help control for some of the factors involved. Information about each of the horses was recorded including the amount of inbreeding in their pedigree and the amount of DNFs in their career. When their number of DNFs was plotted against each horse's amount of inbreeding, no accurate trendline could be made, no matter which set of variables were designated as the dependent value. Even in a data set containing only the least durable horses, finding a correlation proved very difficult. In addition, most horses on either end of the durability scale trace their ancestry back to two major lines of horses, suggesting genetics has no significant effect on durability. Further research will be directed toward assessing the statistical significance of the data collected on inbreeding and durability as well as measuring the individual soundness of the two most influential lines of horses.

No one is certain of the major cause of breakdowns in Thoroughbreds. If there should be a sharp or sudden increase in fatal injuries, there would be no way of knowing how exactly to address it. This could potentially lead to the unintentional harm of the Thoroughbred breed. Though this project deals with DNFs as opposed to solely fatal injuries, the principle of durability remains the same. Our research seeks to lay the foundation for finding a solution to a very real and pertinent problem. The results of this research would benefit Thoroughbred Jockeys, Trainers, Breeders, and essentially anyone else invested in the Thoroughbred racing industry. Most importantly, it could help improve the safety of the equine athlete.

NSF REU – EXTREEMS-QED

Computer Simulation of a Biophysical Pallidostriatal Network Model

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Parkinson's disease is marked by the death of dopaminergic neurons responsible for the creation of dopamine, leading to low dopamine levels in the brain [1]. In this dopamine depleted state, the basal ganglia of the brain develops synchronous, rhythmic activity in the ß frequency range (13-30 Hz) [2]. The mechanistic origin of these oscillations remains unknown; however, their reduction is correlated with symptomatic improvement [2]. It is therefore important to understand the mechanism responsible for these oscillations, as it could be of therapeutic significance [2]. Multiple models have been proposed to explain the origin of these oscillations, one of which is a pallidostriatal pathway involving the globus pallidus externa (GPe) and the striatum of the basal ganglia [2]. This pathway is composed of GPe neurons, present in the globus pallidus externus, and fast-spiking interneurons (FSI) and medium spiny neurons (MSN) of the striatum. The connective organization of this pathway is shown in **Figure 1** below. In this project, we attempt to model this biophysical pallidostriatal network using different software packages: XPP, MatLab, and Brian2. Base code for XPP of the network simulations was provided as a means to verify the results we received ourselves. MatLab produced accurate simulations that ran in moderate time, whilst being difficult to scale to larger cell networks. Brian2 was efficient and easily scalable, while being less accurate than the MatLab simulations.

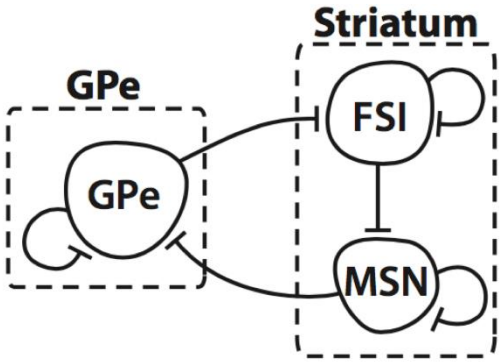

Fig. 1. "Schematic of the conductance based network model connected synaptically with experimentally observed values for connection probabilities and strengths" [2].

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The Journal of Neuroscience, 18 May 2016, pp 5556-70.

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

Observing the properties of CsPb Halide Quantum Dots

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In recent years, $CsPbX_3$ halide Quantum Dots (QD) have been attracting research in the field of optoelectronics due to its many unique properties. CsPb halide QD's exhibit properties such as size and band gap tunability which have been optimized in the research of photovoltaics and LEDs. The ability to tune its band gap and size allows for the absorption of wavelengths across the entire visible light spectrum. The band gap tunability can be achieved by means of the Hot Injection method (HI) which allows for the synthesis of mixed halides such as $CsPb(Cl/Br)_3$ and $CsPb(I/Br)_3$ which covers the absorption of wavelengths from 390-700 nm. The HI method also allows for the size tunability of the QDs by adjusting the temperature from 140- 200 ◦C.

The objective of this research is to produce a variety of CsPb Halide QDs and observe their wavelength and size tunability properties. The mixed halides synthesized were $CsPb(Br/Cl)_3$ which were synthesized in different ratios. $CsPbBr_3$ was also synthesized via Hot Injection and Emulsion synthesis to compare the emission and photoluminescence properties with the mixed Halides. The size tunability of properties were also observed by synthesizing the QDs at different temperatures via HI method and comparing its emission and photoluminescence with other samples.

Figure 1: $CsPbBr_3$,$CsPbBr_2Cl$, $CsPbBrCl_2$ under UV light

Synthesis of Metallic Nanoparticles in Lab-on-a-Chip Devices

Joseph Griesel
Advisor: Dr. Sagnik Basuray

An issue facing contemporary wastewater management is contamination from small molecules. These are typically from medicine or from plastic that are used regularly in our life. These pollutants have significant adverse effects on aquatic life, and can lead to ecological disaster. It is worthwhile to note that traditional detection methodologies like mass spectroscopy are too bulky to implement at the waste site. Hence there is a serious need for sensors that can used on the field. The unique physical and chemical characteristic of silver nanoparticles could pave the way to build handheld sensors that allow sensitive and selective detection of the small molecules using optical strategies.

Here we have developed protocols to synthesize gold and silver nanoparticles. Lab scale batch and continuous flow synthesis at a microscale are performed to observe and analyze the differences in resulting size distribution of nanoparticles. To explain the difference, fundamental chemical engineering principles have been utilized. Further, such principles were used to enhance particle monodispersity by altering various conditions such as concentration, flow rates, reaction temperature.

The continuous flow reactions occur within the confines of a lab-on-a-chip device fashioned out of glass slides and with an acrylic tape channel. The channel design was cut into double-sided acrylic tape with a Cricut Explore® smart printer. The channel has a height of 25 μm, follows a serpentine pattern, and retains 1.98 μL of fluid. UV-Vis and DLS are used to characterize the products and determine properties. Gold nanoparticles were obtained by the reduction of tetrachloroauric acid with sodium citrate. For silver nanoparticles, the reduction of silver nitrate with sodium borohydride with the additions of surfactants and complexants was performed along with the reduction of silver nitrate with ascorbic acid. Future work in this project will contain a more thorough examination of the parameter space to enhance size-tunability of metallic nanoparticles and the use of alternative green reducing agents in reaction chemistry, such as tannic acid or garlic extract instead of sodium borohydride.

Figure 1. A device in the middle of gold nanoparticle synthesis.

Real Time VLC Indoor Positioning System for Electronic-Free IoT Devices

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Abstract: The growing presence of the Internet of Things (IoT) has created the need for very accurate indoor real time locating systems (RTLS) for applications in indoor navigation, process automation, and asset tracking. Visible light communication (VLC) is ideal for indoor RTLS channels because of the widespread availability of already-existing light sources, the lack of interference with radio frequency (RF)-based systems, and the high accuracy provided with inexpensive sensing equipment. However, existing indoor VLC-based RTLS are unsuitable for small IoT device tracking due to the lack of an efficient server backchannel, creating the need for bulky sensing/computational hardware on the device. Therefore, we propose and evaluate a retroreflector-based VLC positioning system that modulates light's polarization to create a completely passive server backchannel, allowing for the trilateration of electronic-free IoT devices based on received signal strength and thus greatly reducing device size and cost. We first demonstrate the feasibility of polarization-based modulation and developing multiple channels using wavelength division multiplexing, which is shown in Figure 1. We then evaluate the single-channel accuracy of our system, which is depicted in Figure 2, and lastly, we evaluate multiple channel interference and accuracy. Future research can help determine optimal bandpass-filter range and disperser thickness to maximize the number of channels, as well as explore ways to develop more communications channels within same range.

Figure 1

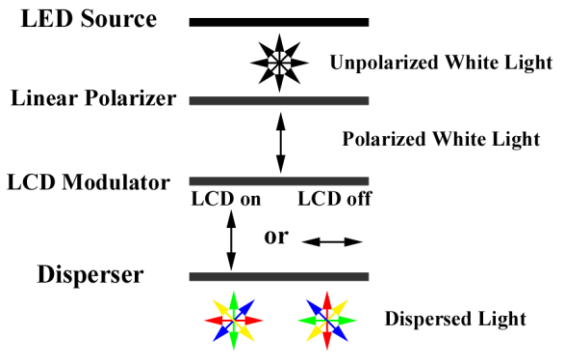

Figure 2

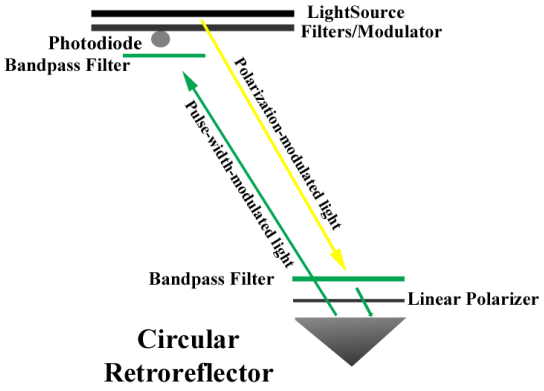

Image Registration in Optical Coherence Tomography

Henil Patel, Advisor: Dr. Xuan Liu

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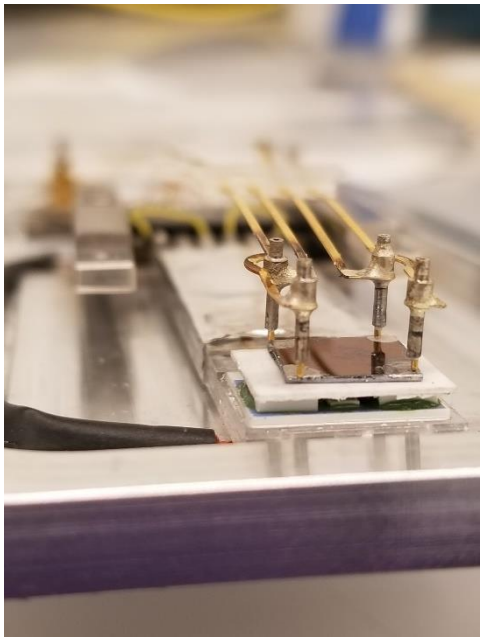
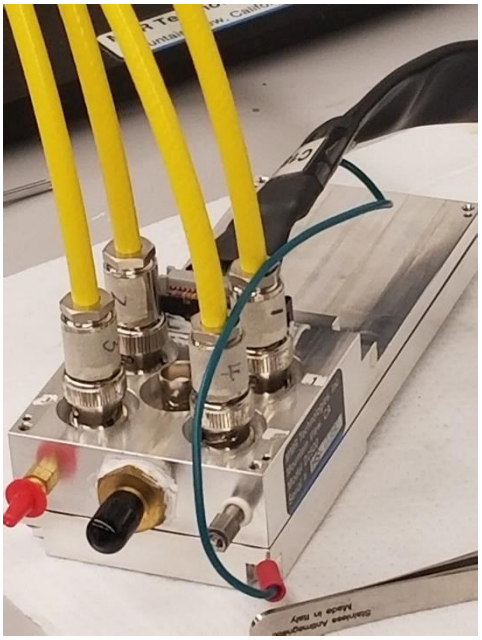
ABSTRACT: Overlaying image data retrieved from the non-invasive optical coherence tomography imaging system with other modalities is instrumental for spatial alignment of biological tissues in the 2D space. A robust computational technique developed through the coupling of Speeded Up Robust Features (SURF) and M-Estimator Sampling Consensus (MSAC) was employed for image registration from raw data obtained through imaging systems. SURF uses corner detection to identify and match significant points of interest and in turn, MSAC utilizes the maximum likelihood method to estimate the geometric transformation by filtering outliers generated from SURF between two or more sets of points of interest. Furthermore, this algorithm has been successfully demonstrated to work on binary images. Therefore various filtering techniques in addition to the algorithm will be used to extract useful information from noise and background information in the raw microscopic and OCT images to accurately overlay multimodal images. The implications of these findings may give new direction to the fields of medical imaging and computer vision paving way to more interdisciplinary approaches to locating and aligning defects in biological structures.

Hall Effect Characterization of Silver Selenide Colloidal Quantum Dots

Aradhya Rajanala
Graduate Advisor: Shihab Hafiz
Advisor: Professor Dongkyun Ko

The newly discovered silver selenide colloidal quantum dots (QDs) have tunable optical absorption in the mid-wavelength infrared (MWIR = 3-5 μm), which is known to have high penetration through airborne obscurants such as fog and mists, making them optimal for long-distance sensing and enhanced night vision applications. These semiconductor QDs are synthesized into a new thermodynamically stable crystal phase (tetragonal) not accessible in bulk, and have a bandgap of 0.07 eV, which is among the narrowest of all known binary compound semiconductors. As a new generation of infrared QD nanomaterial, their fundamental physical properties have not been investigated to date and are critical to estimating the impact that this new material could bring to mid-infrared optoelectronics. The primary goal of this project is to characterize thin-films made of close-packed silver selenide QDs using the Hall effect to estimate three key semiconductor parameters: (1) sheet resistance, (2) carrier concentration, and (3) carrier mobility. This data will be compared with previously reported literature values obtained from current state-of-the-art mercury chalcogenide QDs. The outcome of this study will help establish the groundwork for advancing silver selenide QDs toward MWIR sensing and imaging device applications.





Design, Fabrication, and Characterization of AlGaN-Based Ultraviolet Nanowire Light Emitting Diodes

Maria Ramirez, Advisor: Dr. Hieu Nguyen, Mentor: Moab Rajan Philip

Department of Electrical and Computer Engineering

New Jersey Institute of Technology, Newark, NJ 07102

Abstract: The recent development of deep ultraviolet light emitting diodes (LEDs) with emission wavelengths ranging from 200 nm to 280 nm requires much improvement to increase light extraction efficiency (LEE) in order to increase overall efficiency for UV emission. Deep ultraviolet LEDs have many important applications including the purification of water, disinfection, and polymer curing. However, current deep ultraviolet LEDs suffer from low light extraction efficiency. This is partly due to absorption of ultraviolet light by the p-GaN layer, which is required to increase the current injection efficiency into the active region. Low LEE can also be attributed to the lateral propagation of transverse-magnetic or TM-polarized light, which is dominant when the Al content of the AlGaN active region is higher than ~25%. Furthermore, the polymers currently being used to fabricate LEDs absorb ultraviolet light, hence decreasing LEE. We use finite-difference time-domain simulations to examine the nanowire spacing and diameter to obtain the greatest LEE. We also consider the thickness of the p-GaN layer and the active region, as well as a filling material with higher ultraviolet transmission to increase LEE. Our results show an LEE of ~26% is possible for deep ultraviolet LEDs with emission at 265 nm. With further optimization, we anticipate reaching a higher LEE.

Application and Comparison of Noise Reduction Methods in Functional Near-Infrared Spectroscopy

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Functional near-infrared spectroscopy (fNIRS) is a neuroimaging method that operates on the principle of neurovascular coupling: changes in hemoglobin concentrations (i.e. an increase in oxygenated hemoglobin and a decrease in deoxygenated hemoglobin) are indicative of changes in neural activity. Oxygenated and deoxygenated hemoglobin absorption spectra are the primary contributors in the absorption of near-infrared (NIR) light, making them suitable chromophores in measuring absorption changes. By emitting NIR light into the brain, measuring its transmitted intensity, and applying the Modified Beer-Lambert Law to convert from signal intensity to changes in hemoglobin concentrations, brain activity can be measured with good temporal resolution.

This versatile neuroimaging method may have numerous applications in medical diagnostics and treatment in the future, as well as offering novel experimental paradigms in research. An essential step before analyzing the data, however, is the effective reduction of noise and pre-processing of raw signals. Numerous methodologies for attenuating motion artifacts and underlying physiological noise have been discovered and compared individually, but no experiments analyze the effect of multiple methods being applied consecutively in different orders. Because certain methods operate relying on differing assumptions and each attenuate unique sources of noise, their effects can be assumed to be non-commutative. Thus, altering the order of application of these methods will result in varying outcomes of the noise-reduction processing.

In this experiment, three different noise reduction methods commonly applied to fNIRS data will be evaluated: targeted principal component analysis (tPCA), kurtosis-based wavelet filtering (kbWF), and independent component analysis (ICA). In each series, bandpass filtering will be applied as the final step. Sample data was gathered from prior fNIRS research using a five-minute, block-design visual sustained attention test. To assess efficacy of noise reduction methods, three different statistical evaluations will be implemented: signal-to-noise ratio (SNR), contrast-to-noise ratio (CNR), and mean-squared error, each applied between every step in processing. All data processing will be done in the MATLAB coding environment.

The ultimate goals of this research are to (1) confirm the hypothesis that these noise reduction methods do not behave commutatively; (2) determine which order of noise reduction methods, if any, performs consistently the best across all sample datasets; and (3) if multiple combination orders perform similarly, determine if the most effective order of noise reduction methods is dependent on the initial noise of the unprocessed dataset, e.g. the quantity of motion artifacts.

Investigating the Effects of Light Soaking on ZMO/CdTe Solar Cells

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In cadmium telluride (CdTe) solar cells, CdTe typically forms a heterojunction with cadmium sulfide (CdS). CdS/CdTe has been the standard for over forty years and has achieved the current CdTe record efficiency of 22.1%. However, one major challenge remains with using CdS as the emitter: CdS has a bandgap of 2.42eV, resulting in strong blue absorption and, by extension, reduced cell performance. Thin CdS layers can mitigate absorption losses, but the open circuit voltage V_{OC} begins to deteriorate if the layer is too thin. Thus, new wider bandgap materials are being sought to replace CdS. One such material is zinc magnesium oxide (ZMO). Pure zinc oxide has a bandgap of 3.24eV, and this bandgap can be increased by alloying with magnesium. ZMO/CdTe cells show promising performance, having reached 18.3% efficiency.

Light soaking is the extended illumination of a solar cell. All solar cell technologies experience performance changes under extended illumination, to varying degrees. CdS/CdTe cells will typically exhibit single-digit percentage performance changes over hours. By comparison, previous work at NJIT has revealed that ZMO/CdTe cells can exhibit relatively large changes in performance within only a single hour. In this research, changes in V_{OC} during and after light soaking are observed for CdS/CdTe and ZMO/CdTe solar cells (Fig. 1(a)). The I-V characteristics of ZMO cells were characterized and hysteresis was observed under illumination (Fig. 1(b)), whereas no such behavior was observed for CdS cells. The possible presence of excess defects in the space charge region of the cell can contribute to the hysteresis in ZMO cells and can further explain the difference in light soaking behavior.

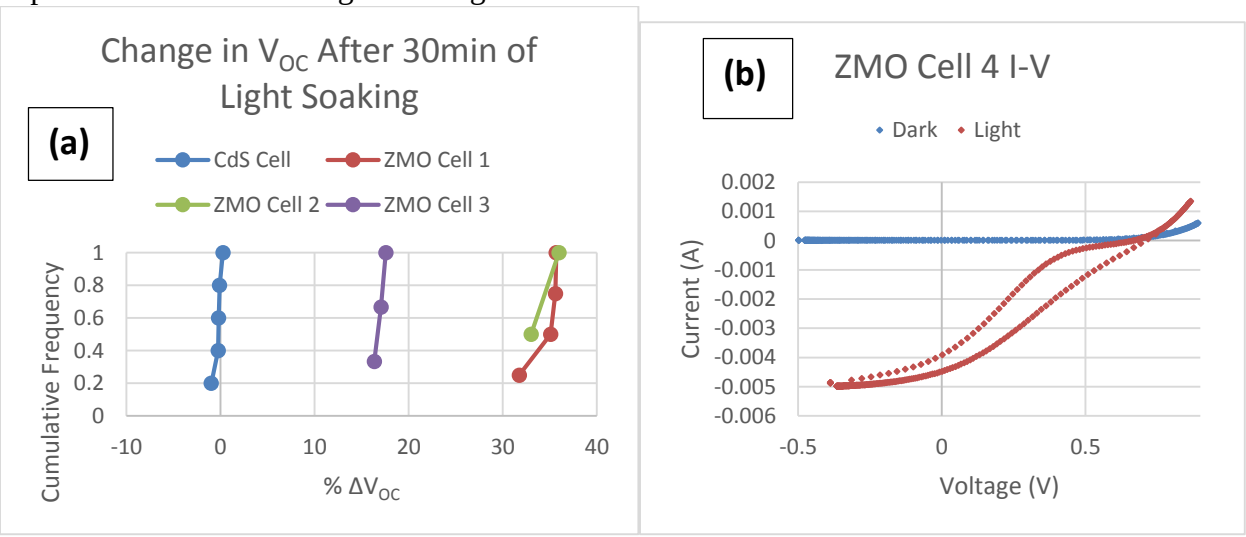

Figure 4 – (a) A cumulative frequency graph showing the percentage change in V_{OC} after the cell has been soaking for 30 minutes. 0% is denoted as the voltage of the cell when illumination first begins; (b) I-V hysteresis of ZMO/CdTe solar cells under illumination.

Multi-Platform Optics and Photonics Educational App

Louis Yepez

Advisors: John Carpinelli and Abdallah Khreishah

Abstract: Students taking physics courses may be introduced to topics such as refraction and optical lenses. The Multi-Platform Optics and Photonics Educational App was created to target student interactivity within these topics in order to enhance their learning environment. Optics is a subject which requires visualization techniques in order to understand the changes of properties that light undergoes when encountering optical lenses. Instead of relying on textbooks and outdated websites for these visual aids, the app focuses on demonstrating how paraxial ray tracing works by introducing short lessons and interactive quizzes to test the student's understanding of the subject at hand. The lessons give a guided approach of paraxial ray tracing with common optical elements while integrating the mathematical equations at various stages to tie together the visual techniques and the math behind it. Students are taught the fundamental laws that form refraction and are given several equations such as the Lens Maker's formula to interact with. Students will also be able to experiment on their own with access to various optical lenses and the ability to customize these objects in an unguided environment, which allows them to apply and confirm what they have learned in the previous lessons. Feedback can be collected directly from the students from within the app to improve features and to develop a better approach on how to present the material. Future development will be based on the feedback gathered from its pilot run in physics courses.

NSF - Community College Biomathematical Research Initiation Program (C2BRIP)

Predicting Apneas in Preterm Infants from Physiological Time Series Data

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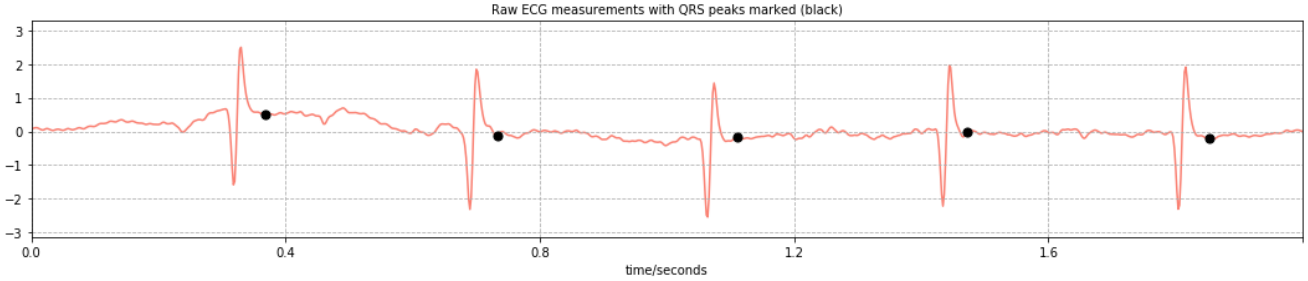
In the United States, one out of eight infants are classified as a preterm birth, in which they are born less than 37 weeks after conception. Episodes of apnea are more common in premature infants as opposed to full-term infants, and are also associated with hypoxia (lack of oxygen reaching tissues) and bradycardia (slowing of heart rate, heart rate slower than 100 BPM). Apnea of prematurity, which is one of the most common diagnoses in neonatal intensive care units (NICU), has detrimental long term effects as it increases the risk of organ damage, especially to the developing brain. Automated algorithms that accurately predict the onset of apneas in preterm infants before they occur would help prevent these effects. In this project, we use simultaneous ECG and respiration signals recorded for 20-70 hours from ten preterm infants taken from the Preterm Infant Cardiorespiratory Signals database (PICSDB) on PhysioNet (Gee *et al.*). We utilized the Python waveform-database (WFDB) package, a library of tools used to read, write, and process WFDB signals from PhysioNet. To analyze the ECG data, we used a modified Pan-Tompkins algorithm to find peaks of the QRS complex. The QRS complex is a series of voltage deflections that occurs in the ECG signal every time there is a heartbeat. By finding the time between peaks, we were able to calculate an infant's heart rate and designate when that infant was experiencing bradycardia. Our next step is to use machine learning algorithms to explore the relationship between bradycardia and the respiratory signal.



A. Gee *et al.*, "Predicting Bradycardia in Preterm Infants Using Point Process Analysis of Heart Rate", *IEEE Transactions on Biomedical Engineering*, vol. 64, no.9, 2017

NSF and Other REUs

Creating Reversible Surface Topography on 3D-Printed Elastomers

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Abstract: The dynamic alignment of cells and extracellular matrix plays a vital role in cellular development, which is not rendered by most of the static in vitro model. Also, to better mimic the cellular environment, 3-D scaffolds are more preferred in recent research. Here, we examined the printability of different ink formulations (PDMS sylgard-184 and SE-1700) to print well-defined, high-quality soft scaffolds. The following 1-axial or biaxial stretch-release process under uv-ozone creates the strain-responsive wrinkle patterns on the scaffold surface (shown as Figure 1). We believe this engineered soft scaffold is a potent tool to prepare 3D dynamic in vitro models for further studies such as drug screening, regenerate medicine, and fundamental researches.

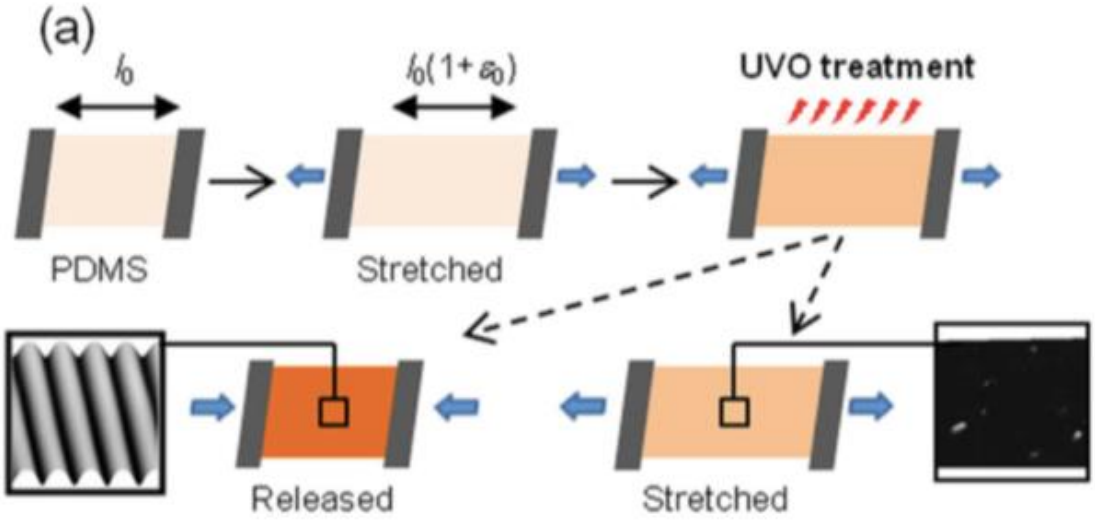

Figure 1: Production of PDMS with reversible surface topography.

Optimization of Soft Lithography using 3D molds for micron-sized PDMS channels

Name: Alahna Diaz

Major: Biological Sciences

Faculty Advisor: Dr. Sagnik Basuray

Department: Chemical Engineering

Microfluidic devices have gained significance as platforms for diagnostic sensors, lab-on-chip devices, and *in-vitro* organ-on-chip systems due to several advantages like lower reagent consumption, rapid manufacturing, portability, ease-of-use, and increased surface area to volume ratio. The devices are constructed from PDMS, due to its biocompatibility, fabrication ease, well-established protocols, and simplicity. PDMS based microfluidic devices are constructed by (i) applying liquid PDMS to a negative mold (usually a silicon mold) and (ii) curing the PDMS with heat exposure over a set time-period. Mostly the PDMS channels in these devices are of the order of a couple of 100 microns. This process becomes more sensitive to the processing once the channels are of the order of a few microns. We have carried out the optimization of the PDMS to make PDMS devices (~ a few microns) on both glass coverslips and slides. Here we have extended the process to make PDMS molds from 3D printed substrates. We have optimized the protocol for the 3D printed PDMS molds. Further, to validate the findings we have manufactured a microfluidic tree wherein we have shown the different mixing regimes that can be obtained. Finally, we have made PDMS based devices to look at worms (C. Elegans) to carefully understand the locomotion of the worms through the channel.

The Comorbid Effect of Alcohol and HIV-1 Tat Neurodegeneration: Increased Infiltration Across Impaired Blood Brain Barrier Model

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Background: The brain is a highly sensitive organ that needs a constant supply of nutrients via the blood brain barrier (BBB). The BBB is a highly specialized vascular system that is responsible for maintaining homeostasis of the brain space and regulating the passive and active transport of both molecules and leukocytes into the surrounding microenvironment. The BBB is able to perform this task due to the highly specialized endothelial cells and the specified tight junction proteins that control the permeability of this membrane. Under normal physiological conditions, a particular subset of molecules and cells are able to permeate this barrier. In the case of HIV infection, this scope can broaden to include neurotoxic viral proteins (Tat and Gp120) and infected leukocytes that exist in the circulation and brain space. Under impaired conditions, infected immune cells and viral proteins can invade the brain space at a much higher rate. These proteins and cells are able to establish latent reservoirs within the brain, that can enable a resurgence of the virus. One common method of barrier impairment is alcohol (EtOH). Surprisingly, the consumption of alcohol in HIV patients is both highly prevalent and alarming. In the United States, chronic alcohol abuse remains one of the highest and most costly forms of drug abuse. In a prospective cohort study as many as 41% of HIV-patients met the qualifications for alcoholism. The use of alcohol coupled with HIV has a comorbid effect on the cells within the BBB and the brain due to the adverse effects of increased trafficking across the impaired barrier. The adverse effects of alcohol on HIV patients has been linked to a number of HIV associated neurological disorders (HAND). Here, we investigate the comorbid effects of alcohol and HIV Tat protein on macrophage trafficking across the BBB as indicator of neuroinflammation and subsequent neurodegeneration.

Methods: Brain microvascular endothelial cells ($2 \cdot 10^4$ cell/insert) were seeded onto the top side of Transwell culture insert (3um pore size). The same insert is inverted and seeded on the underside with astrocytes ($1 \cdot 10^5$ cell/insert). Once allowed three days to coculture, these Transwell is introduced to a culture well with primary cortical neurons. The barriers are impaired with varying concentrations of alcohol (10mmol/mL, 50mmol/mL, and 20mmol/mL) for a 24-hour time period. The transmigration is analyzed by introducing macrophage ($3 \cdot 10^5$ cell/insert) pretreated with flou-3, to the top compartment of the transwells. After 30min, 2hr, and 24hr time points, the Transwells are removed and the wells are analyzed for the fluorescence of flou-3, corresponding to the abundance of macrophage allowed to permeate the barrier. This corresponding increase in macrophage abundance shows an increase in the damage done to the barrier due to treatment with alcohol. The coverslips with neurons and macrophage are then stained for NueN, Dapi, and Neurofilament in conjunction with the flou-3 labeled macrophage in culture.

Discussion and Results: Alcohol increases permeability of the membrane to large macromolecules and macrophage in which under normal physiological conditions would not appear in such quantities. In the condition of HIV-1 infection, the passage of macrophage and viral proteins will increase the opportunistic effect of neurodegeneration. The impact of alcohol needs continued research in order to treat these adverse effects and spread awareness to those suffering from HIV infection.

Scraping Kickstarter and predicting the success of campaigns

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Faculty advisor: Dr. Zhi Wei, New Jersey Institute of Technology, zhi.wei@njit.edu
Mentor: Fei Tan, New Jersey Institute of Technology, ft54@njit.edu

In the internet era crowdfunding continues to gain popularity as the preferred financing tool, as it presents great opportunities for startup companies whose funding options otherwise would be limited. Countless online crowdfunding platforms allow the entrepreneurs connect to potential investors directly, allowing them to pitch and fund even the most extravagant ideas with minimal cost and complexity. Kickstarter.com is one of the most prominent crowdfunding platforms famous for its low-risk environment and a massive network of investors: since its launch in 2009, 15 million people have backed a campaign, $3.8 billion has been pledged and 146,973 campaigns have been successfully funded[1]. The purpose of this project is to build a deep learning model that would predict if a certain campaign will be successful based on textual data (title of the campaign and its description), numerical data (pledged amount and goal amount), image data (cover image) and metadata (category and subcategory). Such multityped, interconnected data is known as heterogeneous data and it is much more semantically rich than homogeneous data which makes it more valuable for prediction models. So, the primary technological novelty of this project would be to apply the concept of heterogeneous data fusion to machine learning.

The first part of this project involved gathering the data from Kickstarter campaign pages. First, a crawler was created to gather the links from the "Explore" section of the website in each category (Art, Comics, Dance, Design, Fashion, Film & Video, Food, Games, Music, Photography, Publishing, Technology, Theater) by crawling through different filters (goal amount, pledged amount, percent raised) and subcategories. Then, a scraper was designed utilizing Selenium Python package to gather the information from individual campaign pages. To speed up the process, scraping scripts with multithreading were implemented on three different machines. The data was then stored in the database and pre-processed. In total, the cleaned-up dataset consists of about 130K entries. Preliminary analysis shows that only 41.1% of the campaigns are successful in the sample, so it would benefit the startup creators greatly to find out what factors determine the success of a campaign.

Once the data is ready for processing, the second part of this project will be to generate a model and to train it on the existing dataset utilizing TensorFlow and Keras deep learning tools. N-gram approach and tf-idf will be used for natural language processing and convolutional neural network will be used for image processing. Once the model is successfully trained to predict the success of a campaign, it can be used as foundation to create even more powerful AI that would be able to generate content based on an optimal funding rate. So, this project has a potential to make a great impact on the crowdfunding segment of the market and digital marketing in general, as well as on exploring new aspects of Artificial Intelligence applications.

[1] Kickstarter, "Kickstarter About," [Online]. Available: https://www.kickstarter.com/about?ref=nav. [Accessed 10 July 2018].

Controllable Delivery power Grid -CDG

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Abstract:

For over a century, the distribution of electrical energy is akin to a single wire continuously transmitting energy to consumers. One can plug into any outlet providing energy, and receive it at any moment's notice. However, power lines are permanently energized and lead to a loss of power during transmission and distribution. Any energy unused is therefore wasted. As such, our current method of energy distribution is suboptimal.

The Controllable Delivery power Grid (CDG) discretizes electrical energy in the form of packets sent to the requester. This is done by a web of data networks as well as capacitive power banks used for controlling grants and requests for energy. The CDG proactively sends energy as they are requested by the consumer. As such, the distribution of electrical energy is improved upon, thereby relieving stress from transmission lines and minimizing energy loss.

However, the system is bottlenecked by the propagation delay of the servers. Under unfavorable conditions, this delay between request and grant lay under a fraction of a second. Under continuous use, heavy loads, and an overwhelming consumer base, the CDG will strike a wall where the energy supplied no longers meets the energy demanded by the consumers.

Thus, through simulation, we find the inherent capacity of the CDG based on the number of consumers connected to the system and the volatility of energy requested by said consumers. Propagation delay, high consumer loads, and large consumer sizes are kept in mind.

Note: The simulation is approached in the relatively ideal case where parasitic resistance and inductance, leakage, and hardware specifications are not included.

Desalination of Water Through The Use of Carbon Nanotubes

Jordan Sheft-Ason, Adviser: Dr. Somenath Mitra

Recent climatic change with fairly widespread drought along with depleting ground water levels due to extensive water use is drawing us into a state of water scarcity. This increases the global demand for water purification and sea water desalination. Conventional methods for desalination include Reverse Osmosis, Multi Stage Flash, and Multiple Effect Desalination, which are expensive and energy intensive. Membrane distillation (MD) is an alternative to these traditional methods due to its lower energy requirements. The objective of this research was to determine the impact different nanoparticle immobilization in desalination membranes. Different approaches included the use of carbon nanotube and graphene oxide and modification of both the feed and permeate sides are being studied. The membrane enhancement is studied as an increase in flux as well as the reduction in fouling.

U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING CENTER, PICATINNY ARSENAL

Interdisciplinary Summer Research - Collaborative Robotic Fleet:

Funded By: ARDEC, NJ Space Grant Consortium

Roy Baker, Oliver Budd, Luke Connell, Austin Hall, Preston Konopka, Jonathan Martinez, Nicolas Ramirez-Diaz, Nicholas Warholak, Matthew Van't Slot, Anthony Yacoub.
Mentors: *Dr. John Federici, Martina Decker, Sam Gatley*

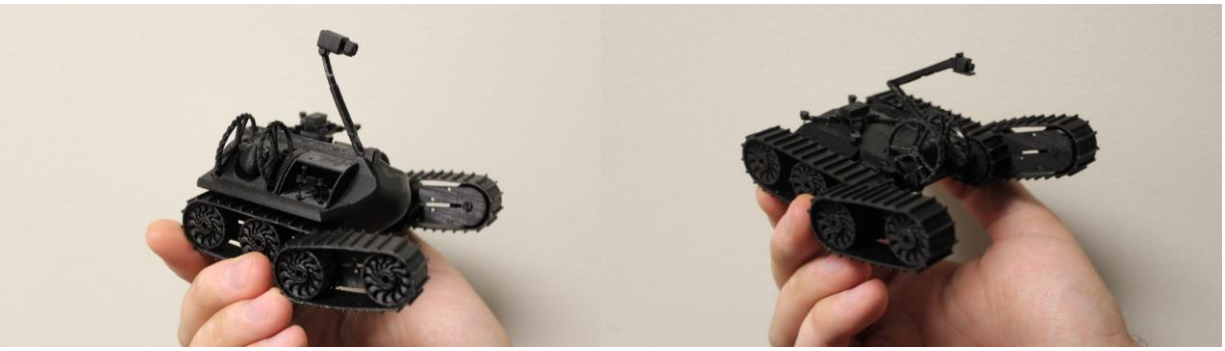

Figure 1. 3D prints (15% Scale) of carrier concept iterations. Image credit, Oliver Budd.

The goal of this interdisciplinary summer research internship was to design and manufacture a low cost collaborative robotic fleet capable of cave exploration, urban rescue, or disaster relief. The team was tasked to create a carrier robot with reduced SWaP (size, weight, and power), and a suite of smaller deployable robots. This system of collaborative robots is capable of surveying a larger environment, while constantly communicating with each other and relaying sensor data back to the users. Each distributed robot, as well as the carrier, has a suite of various sensing capabilities, from air pressure to radioactive materials. The distributed fleet has a mix of "intelligent" and "non-intelligent" robotic elements. The "intelligent" robots have way-finding capabilities to navigate and map the environment. The "non-intelligent" robots are set off in one direction with no way-finding capabilities and collect data.

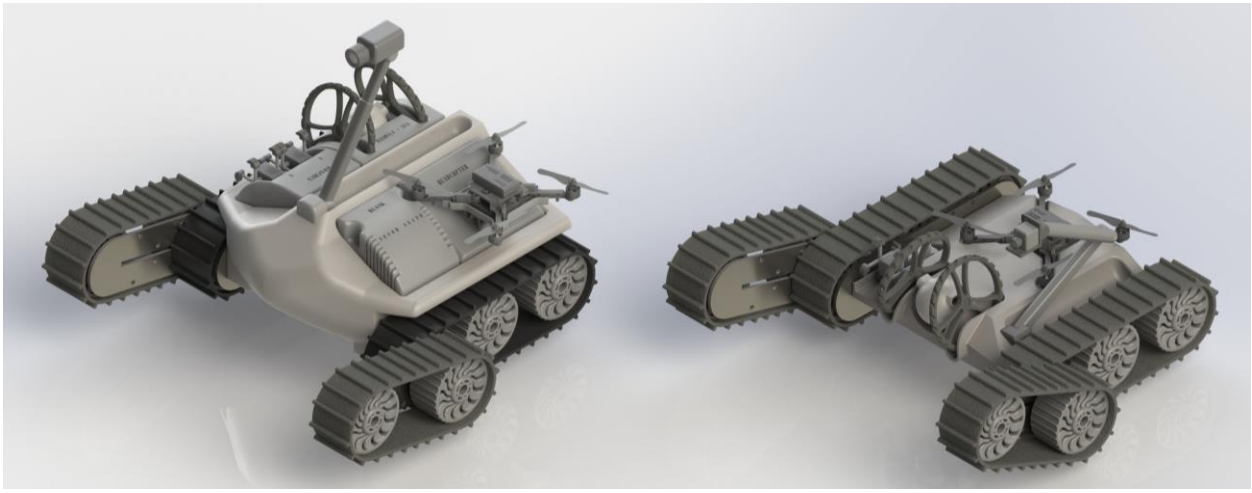

Figure 2. Iteration models of the carrier robot designs with distributive fleet. Image credit, Oliver Budd

Interdisciplinary Summer Research - Design Process:

Funded By: ARDEC, NJ Space Grant Consortium

Roy Baker, Oliver Budd, Luke Connell, Austin Hall, Preston Konopka, Jonathan Martinez, Nicolas Ramirez-Diaz, Nicholas Warholak, Matthew Van't Slot, Anthony Yacoub.
Mentors: *Dr. John Federici, Martina Decker, Sam Gatley*

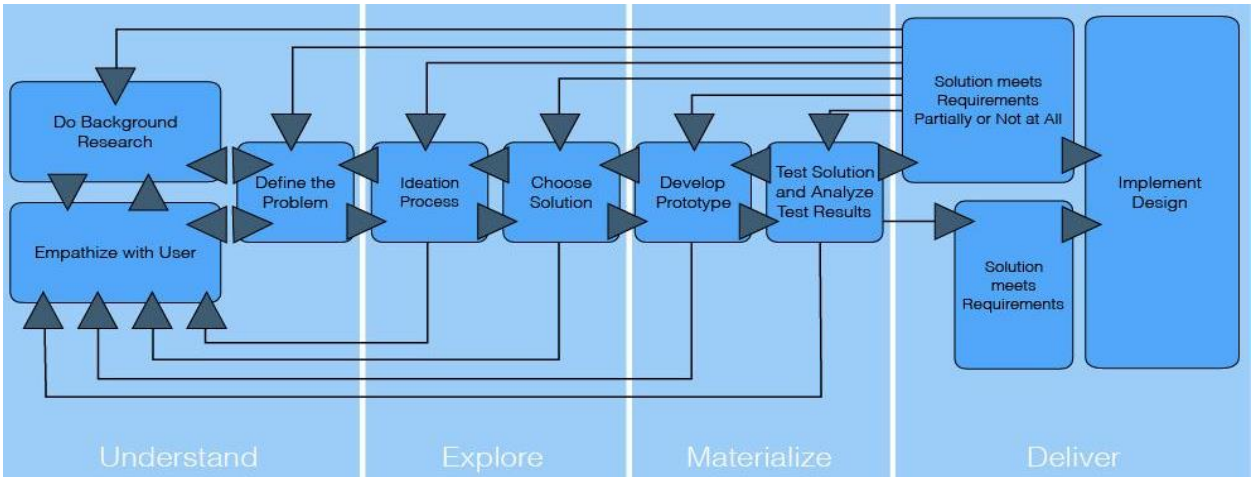

Figure 1. Collaborative Design Process. Image Credit, Material Dynamics Lab

This summer research internship focused on interdisciplinary collaboration. The group worked together using an interdisciplinary methodology that integrates elements of the scientific, the engineering, and the design thinking method to meet the user's needs. The project used to implement this approach is a robotic fleet that explores uncertain, GPS denied environments, such as cave systems, urban environments, or disaster sites.

The collaborative approach started with background research to understand the user. It was followed by a phase that explores the design challenges. The group worked with a highly iterative design process that produced solutions and prototypes that were analyzed, tested and then redeveloped based on what was discovered. The team learned how to work in interdisciplinary groups and to communicate complex technical details to each other.

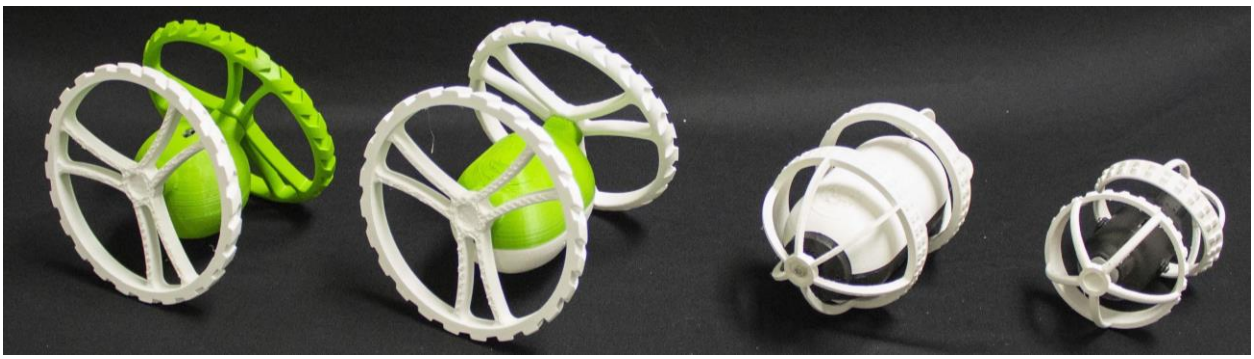

Figure 2. Iterations of Distributed Drone Design. Image Credit, Preston Konopka; Material Dynamics Lab

Interdisciplinary Summer Research - Distributed Robotics:

Funded By: ARDEC, NJ Space Grant Consortium

Roy Baker, Oliver Budd, Luke Connell, Austin Hall, Preston Konopka, Jonathan Martinez, Nicolas Ramirez-Diaz, Nicholas Warholak, Matthew Van't Slot, Anthony Yacoub.
Mentors: *Dr. John Federici, Martina Decker, Sam Gatley*

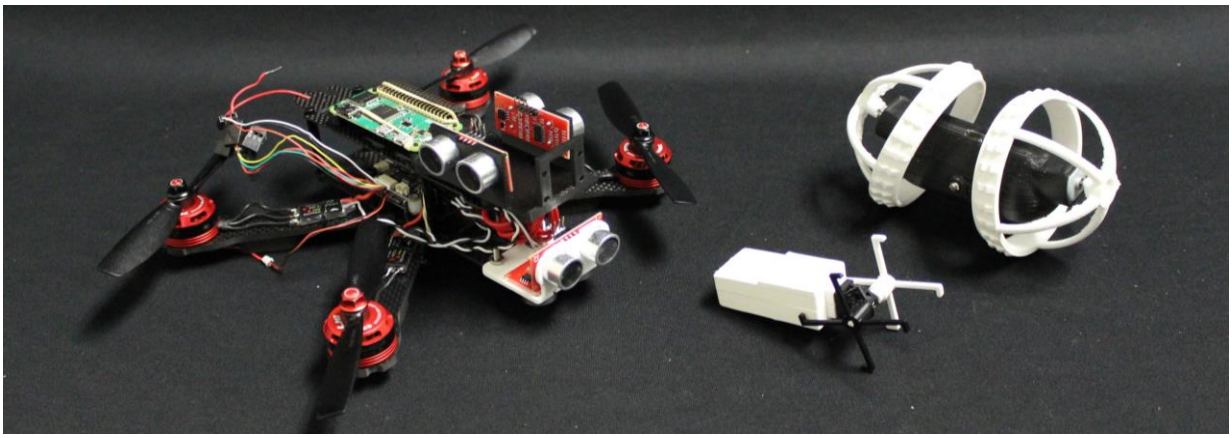

Figure 1. Prototypes of Distributed Robots. Image Credit - Material Dynamics Lab

Our interdisciplinary team assessed the viability of using distributed robots in tandem with a main carrier robot. The smaller robots, which are able to specialize in distinct locomotive tasks, can navigate certain environments more adeptly. Loss or damage is less of a concern with the low cost distributed robots compared to the carrier. Three different environments were explored: air, ground, and water. The team designed a series of robots, varying in terms of locomotion, intelligence, autonomy, and sensing capabilities. Multiple prototypes were developed and tested for each style of locomotion through an iterative design process. The final prototypes include a hybrid land/water navigating robot, a fleet of purely land based robots, as well as an aerial robot. Each design features its own set sensing capabilities, data recovery, and navigation. This allows for a highly flexible and resilient system.

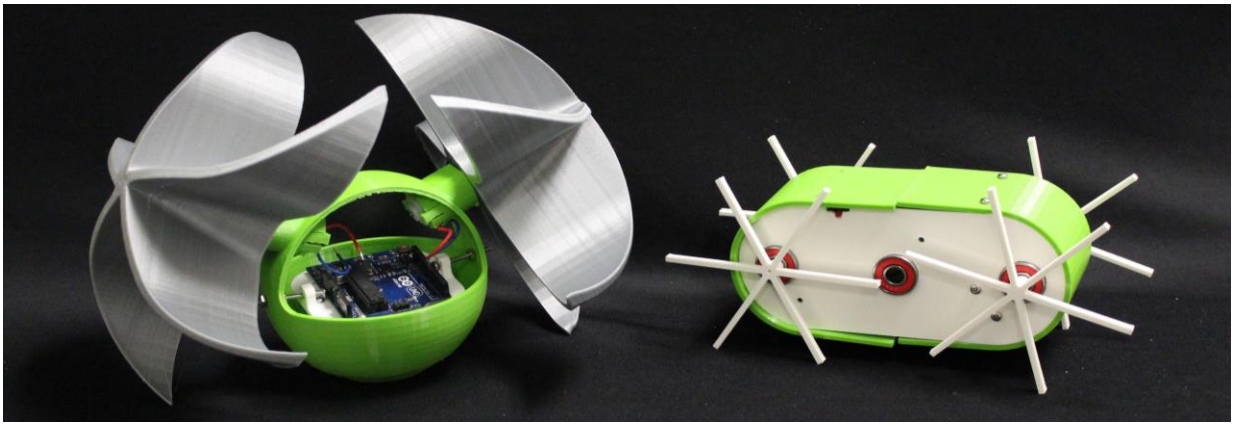

Figure 2. Past Iterations of Distributed Robots. Image Credit - Material Dynamics Lab

NJ SPACE GRANT CORSORTIUM SUMMER RESEARCH PROGRAM

Octahedral Compression and Rotations in Halide Perovskites Under Pressure

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Halide perovskites are a group of crystalline solids that have the potential to be used in a variety of energy capture, storage and utilization applications. In particular, hybrid organic-inorganic tin and lead-halide based solar cells are some of most promising classes of materials for next-generation photovoltaic technologies. An efficiency of over 20% has been reported in these solar cells, and they have a band gap near 1.4 eV, the ideal optical gap for solar absorption. However, there are still significant challenges hindering the widespread adoption of these materials. Namely, there is concern over their lead content and their tendency to degrade quickly at ambient environmental conditions. In order to further understand and implement halide perovskite technologies, a method for manipulating the electronic properties of these materials must be developed.

The crystal structure of ABX_3 perovskites is comprised of corner-connected BX_6 octahedra that surround large A cations. The versatility of these materials stems from the fact that the size, shape and arrangement of these octahedra greatly influences their electrical, magnetic and optical properties. These include their electronic bandgaps, thermal conductivity, magnetic properties, transition temperatures for superconductivity and metal-insulator transitions. The soft crystalline structure of halide perovskites makes the application of hydrostatic pressure an effective method for inducing octahedral compression and rotations and, in turn, tuning the electronic properties of these materials. While the most successful of materials used in photovoltaic technologies include an organic molecule as the A cation as seen in $[CH_3NH_3]PbI_3$, we first explore all-inorganic compounds with Cs replacing the organic molecule at the A-site, which are simpler to treat computationally.

Here, the effects of hydrostatic pressure on the relative stability and structure of several all-inorganic halide perovskites were investigated using density functional theory (DFT), as implemented in the Vienna *ab initio* Simulation Package (VASP). Specifically, we investigated the ground state structure as well as several metastable structural phases of $CsPbBr_3$, $CsSnBr_3$, $CsPbI_3$ and $CsSnI_3$. We find that at zero applied pressure, the most stable phase of all of these materials has *Pnma* symmetry, while other structural phases with different symmetries become lower energy above 2 GPa. The rapid decrease in the stability of the *Pnma* phase is attributed to greater compression and rotations of the its BX_6 octahedra at higher pressures in comparison to the other phases.

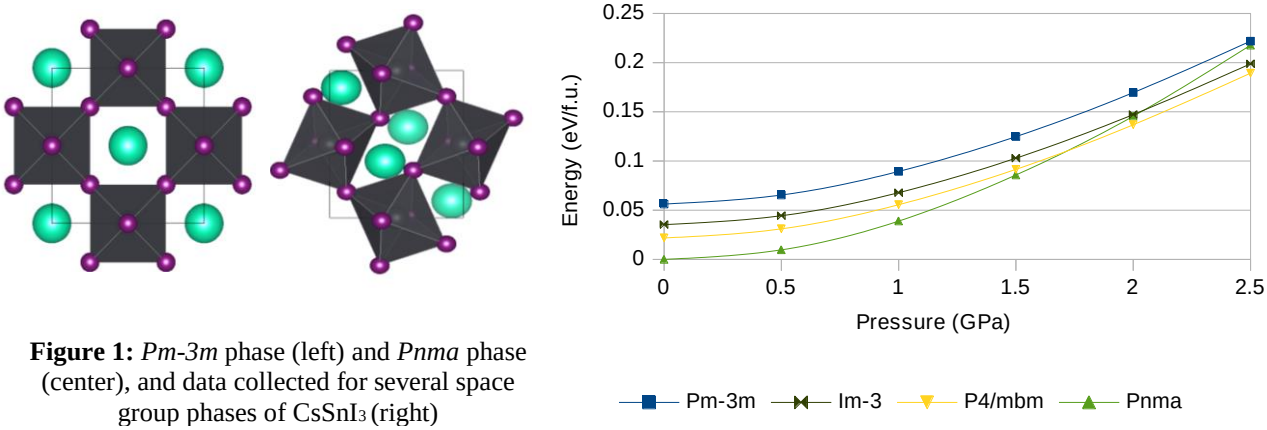

Figure 1: *Pm-3m* phase (left) and *Pnma* phase (center), and data collected for several space group phases of $CsSnI_3$ (right)

Laser Phase-Shift Range Finder for Entomological Lidars

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New Jersey Institute of Technology, Newark NJ

Mosquitoes, by their number and diversity, play a fundamental role in ecosystems with major consequences on human health. They play a role as vectors of infectious diseases such as malaria, yellow fever, dengue fever, or Zika virus. As a result, nearly 700 million people get a mosquito borne illness each year resulting in greater than one million deaths, rendering it by far the deadliest animal in the world. Current methods to monitor mosquito populations are presently very limited. They rely mostly on physical traps, which are tedious to set up, and require long laboratory analysis. In addition, there are many biases regarding species, age, and sex groups. This project aims to develop a new laser-based methodology (lidar) to remotely identify mosquito species and gender in real time and directly in their natural habitat.

The work presented here seeks to evaluate the ability of entomological lidars to retrieve the distance at which an insect transited through the beam. The ability for a device to determine distance between two points with minimal error is something that is useful and sought after in many practices. Range finding for lidars commonly use a short pulse of electromagnetic radiation that scatters off a target and travels back toward the device. A detector collects the backscattered light and calculates the time of flight of the laser pulse. With knowledge of speed of light and time of flight, the distance can be calculated. However, in this experiment, a continuous laser is used to retrieve the wing beat frequency and optical properties of different species of mosquitoes. Continuous laser range finding cannot rely on time of flight, but will instead rely on amplitude modulation to find the phase shift difference between the laser output and received signal. From the phase shift, the distance between the source and the insect can be calculated. A numerical simulation has been performed to evaluate the accuracy of this methodology, and to assess the influence of various parameters, such as the modulation frequency, the amplitude of the modulation and the signal to noise ratio. In addition, preliminary measurements obtained using a laboratory prototype are presented. A hard target is used to test the methodology on actual signals from an infrared CW laser. Results show that the accuracy increases as the modulation amplitude and modulating frequency increases. Therefore, the limitations for accuracy are dependent on the output capabilities of the device.

HERITAGE INSTITUTE OF TECHNOLOGY - NJIT SUMMER RESEARCH

Detecting Bad Hubs in High Dimensional Data using Local Laplacian Score

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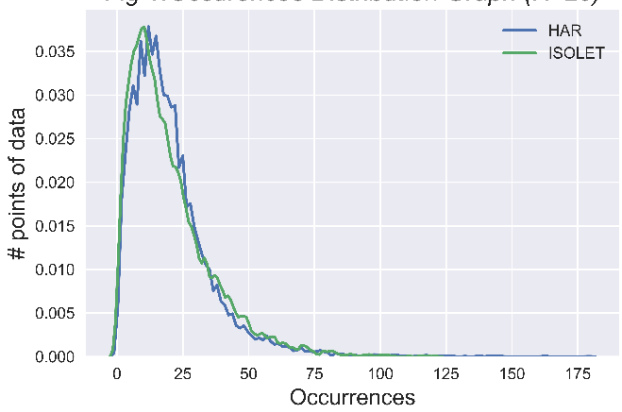
When applying data mining and machine learning algorithms on high-dimensional data, a critical issue is known as the curse of dimensionality. Well-known consequences of the curse of dimensionality like hubness have regularly presented a great challenge for various machine-learning methods and tasks, both in terms of effectiveness and efficiency. In real-world problems it is not always clear what features if any will help you model the problem you are attempting to solve. Along with this issue, there is also a lot of issues with data sometimes being redundant or not being very relevant. Feature selection helps alleviate this issue by picking out important features. Feature selection techniques computes a subset of features from the original feature sets. However, the traditional feature selection method neglects the possibility that a feature that is relevant for one data point may be irrelevant for another.

Hubs are data points with very high k-occurrences (the number of times a point appears among the k-nearest neighbors of other points in a data set) making them "popular" nearest neighbors. Figure 1 shows the distribution of k-occurrences of two datasets and the hubs are data points that appear are part of tail (60 or more in Fig. 1). These hubs can be good or bad depending on the neighborhoods. The more dimensions you work with, the less effective standard computational and statistical techniques that rely on K-NN become. Hubness affects the performance of the Information Retrieval systems and the experience of their users, who may consistently observe the appearance of the same irrelevant results even for very different queries.

The aim of this project is to detect bad hubs from query results and remove them. We first get a list of hubs from the distribution of k-occurrences (the points in the tail). We can use the occurrences distribution graph to detect the hub occurrences, i.e. the tail of the graph. For each point in the dataset we compute its subjective feature set (the most stable features). Using the Local Laplacian Score we then re-rank the query result using the subjective feature set. The rationale is that after the local feature selection, the nearest neighbors of the query points which are of the query point class will be closer to the query points. Since the bad hubs are not within the same classes of query points, they will be pushed further away from the query points. In all, we examined three real data sets from different domains: HAR ISOLET and RLCT. We conducted experiments to show the effectiveness of the proposed method. In particular, we would like to study the influence of the three parameters: the number of noise features removed, the neighborhood size K (number of nearest neighbors) and the big neighborhood size K' (size of the query expansion set) on the results.

Fig 1:Occurences Distribution Graph (K=20)



Detecting Bad Hubs in High Dimensional Data using Local Laplacian Score

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[2]Department of Computer Sc. & Engineering, Heritage Institute of Technology, Kolkata, India

Abstract: Hubs are few instances in the dataset that appear surprisingly frequently as k-nearest neighbours in k-NN searches in high dimensional spaces. As the dimensionality increases, the discriminative ability of similarity measures diminishes to the point where methods such as search and clustering that depend on them lose their effectiveness. This phenomenon is known as "curse of dimensionality" and hubness is one of its manifestations.

Hubs may be good or bad depending on the neighbourhood in which it appears. *X* is said to be a good hub for a point *Y* if it is of the same class as *Y*. *X* is said to be a bad hub of *Y* it is of different class than *Y*.

Figure 1

Figure 1 represents a k-NN graph with 10 nodes and k=1. Here node 1 is a good hub for node 2, however node 6 is a bad hub for node 9. Bad hubs affect machine learning methods in several negative ways.

Thus to decrease hubness we use feature selection. One of the methods includes the usage of Laplacian Score (LS). In the computation of LS, each feature receives one score computed over all the instances of the dataset. This, however, neglects the possibility that a feature that is important for one data point may be irrelevant for another. Thus the Local Laplacian Score (LLS) was proposed in an effort to select subsets of features tailored to each data point. In this paper the authors combine the Laplacian Score (LS) and the Local Laplacian Score (LLS) to produce the Generalized Laplacian Score (GLS) for each of the features of the query points.
The aim of this project is to detect bad hubs from query results using the GLS as feature selection. So we first compute a list of hubs from the values of k-occurrences of the dataset. The query points having bad hubs are identified using the class labels. Then the GLS score for each feature is used to identify the top noisy features for each query point. These noisy features are sparsified and only the subjective features of the query points are used to re-calculate the Euclidean distance between the query point and its neighbours. Using this distance the query result is then re-ranked to show that the ranks of bad hubs have increased as they were initially (without the use of feature selection.)

The rationale is that after feature selection, the nearest neighbours of the query points which are in the same classes of the query points will be closer to the query points. Since bad hubs are of different classes than query point, they will move further away.

The effectiveness of the above algorithm has been experimentally tested on the three datasets- HAR, ISOLET and RLCT.

Dimension Reduction for Compressing HPC data

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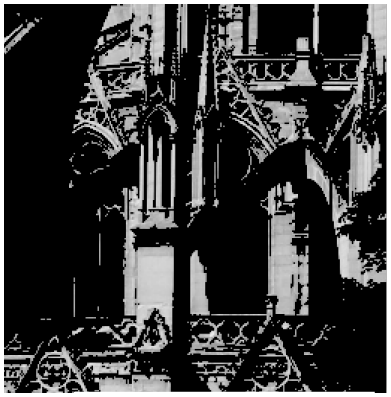
With the increasing growth of technology in the modern age we have to deal with huge amount of data which must be stored and retrieved in an effective manner. Unless we are able to store this large amount of data in some efficient way we cannot put them into any practical use. High-performance computing (HPC) applications generate large amounts of floating-point data that need to be stored and analysed effectively. Recently data compression has been seen as a major step to reduce these large volumes of data through lossy or lossless compression.

In this paper three techniques of existing image compression have been discussed – Haar wavelet, Singular Values Decomposition (SVD) and Principal Components Analysis (PCA). Haar wavelet compression is an efficient way in performing both lossy as well as lossless compression. In Haar wavelet transformation we start with an initial matrix representing the original image, and then we compute the transformed matrix by averaging and differencing each row and column. Finally in case of lossy compression we choose a threshold and apply it to the new matrix from which we can reconstruct back our image. SVD is a dimension reduction technique, we use it for lossy compression; it involves splitting the input image into RGB channels and decomposing each unit. A rank is selected which must be optimum so that there is minimum damage to image quality and at the same time the storage space required is reduced. PCA technique allows the identification of characteristics in data such that the similarities and differences are emphasized. Optimal system of axes is obtained using PCA and the reduced dimension structure is selected so that relevant data characteristics are identified with little loss.

Preliminary results: We have implemented wavelet lossy compression with python codes. With a threshold of 300, we obtain the following image with a compression ratio of 14.31.
It is observed that with increase in the compression ratio, the quality of the image degrades
For the following work, we will apply the same procedures on HPC data.

Original Image



Compressed Image

FABRICATION OF AN ASSISTIVE ROBOT ARM AND VOICE CONTROL

Oindrila Ghosh, Advisor - Professor Lu Lu, Mentor-Jiawei Li
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New Jersey Institute of Technology, Newark, NJ 07102, USA

This study depicts a fabrication process of a Three Degrees of Freedom (DOF) robot manipulator which includes 3-D modelling, 3-D printing, electro circuit connecting as well as software programming. The control methods involve forward kinematics and inverse kinematics.

A robotic arm is a type of mechanical arm, usually programmable with similar functions to a human arm. The arm is the sum total of a mechanism or part of a more complex robot. It consists of parts linked together in the same way as that of a human arm, mounted on a stand. The goal of my research is to fabricate a robotic arm which assists a human being via voice control.
In robotics the forward and inverse kinematics methods are used to find a relationship between the end effector and the joint angles. In forward kinematics the joint angles are the inputs given by the user while the coordinates of the end effector are the outputs. Whereas, in inverse kinematics the coordinates of the end effector are the inputs and the corresponding joint angles are the output. However, inverse kinematics is prefered over forward kinematics here because it gives a more definite result.

For making this robotic arm we used Creo Parametric 4.0 software in order to design its parts in details. Then we used Ultimaker Cura 3.4.0 to 3-D print the respective parts and then assembled the different parts. The hardware involves four servo motors each capable of producing different torques. We used arduino pulse width modulation control and serial monitor input.

To ensure stability of the robotic arm we are fixing its base and also made a load estimation, which is about 0.9 kg.

Future scopes: Robot arms are already in use in industrial as well as medical fields. So in future maybe a robot arm can be used by a disabled person for assistance in their daily life.

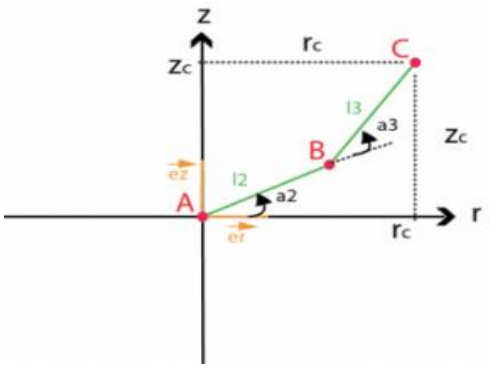

Fig.1 – Trigonometric Model

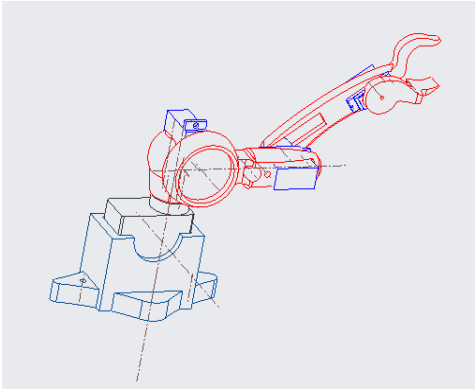

Fig.2- Robotic arm Design

Investigating the role of interfacial dielectric in $Ge/Al_2O_3/ZrO_2/TiN$ gate stacks

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Scaling beyond sub-10nm technology limits the silicon devices to achieve high-speed and low power performance. Germanium can be used as a replacement substrate as it has higher hole and electron mobilities compared to silicon. The interface state density at the Ge and high-k interface has to be reduced so that Ge/high-k gate stacks can be used. Studies are going on to improve the Ge dielectric interface quality by different deposition techniques and post processing methods. It has been reported that slot plane antenna plasma oxidation(SPAO) improves the oxide and interface quality which helps to enhance the device performance by reducing leakage current, interface state density, equivalent oxide thickness (EOT) and it also improves the oxide and interface quality.

This project studies the p-Ge/Al_2O_3(1nm)/ZrO_2 (3.5nm),p-Ge/ Al_2O_3 (1nm)/ $TiAlO_2$(3.5nm) and p-$Ge/TiAlO_2$(1.2nm)/ZrO_2(3.5nm) gate stacks. The devices were subjected to chemical oxide removal (COR) process to clean the substrate prior to deposition of high-k layers. Post high-k deposition, all the devices were exposed to slot plane antenna oxidation (SPAO) condition. Several parameters like equivalent oxide thickness (EOT), flat band voltage (V_{fb}), interface defects density (D_{it}), C-V hysteresis and leakage current (I-V) are being analysed by capacitance voltage (C-V), conductance-voltage (G-V) and current-voltage (I-V) measurements. The devices are also being subjected to a stress of 3.5V to understand the reliability of these devices. The EOT and flat band voltage are being obtained from CVC program and D_{it} is being calculated. The C-V characteristics at 100Khz of the three different samples have been shown in Fig 1. It is seen that Al_2O_3/ZrO_2 dielectric stack shows lowest EOT values.

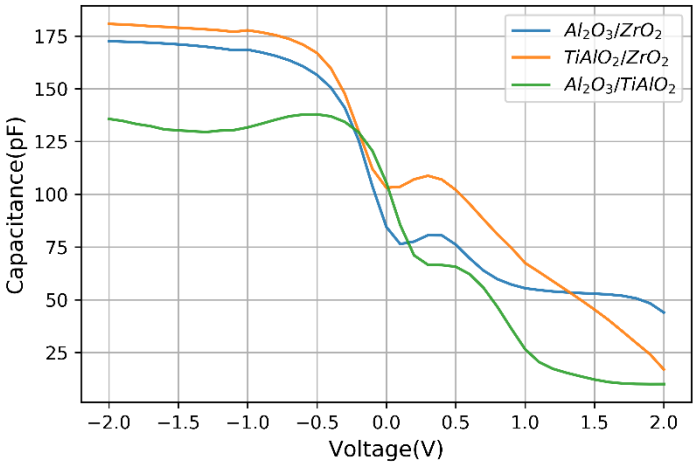

Fig 1: C-V Characteristics of all three devices

References:

1.Kolla, Lakshmi Ganapathi, et al. "Interface states reduction in atomic layer deposited $TiN/ZrO_2/Al_2O_3/Ge$ gate stacks." *Journal of Vacuum Science & Technology B, Nanotechnology and Microelectronics: Materials, Processing, Measurement, and Phenomena* 36.2 (2018): 021201.

2.Ding, Y. M., et al. "Electrical characterization of dry and wet processed interface layer in Ge/High-K devices." *Journal of Vacuum Science & Technology B, Nanotechnology and Microelectronics: Materials, Processing, Measurement, and Phenomena* 34.2 (2016): 021203.

Capturing the Metadata in Continuous Integration Workflows

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Abstract

Software plays an integral role in today's age of widespread technological development and consumption. It is the interface between the user and the hardware. Every software needs to go through a software development life cycle before being released to the end-user to ensure its proper functioning and also to make sure that it doesn't jeopardize the security of the system on which it is used. However, the users never get to know whether a software has undergone proper development stages or not. In the modern software development life cycle, Continuous Integration (CI) has become an established best practice. It significantly speeds up the lifecycle of the product by triggering automated builds and unit tests for each integration done by the developers. These automated builds are made possible by integrating the Version Control Systems with the Continuous Integration Systems.

Our research work aims to create a transparency between the users and the software development phases so that the users are able to verify the results of each step before they install the software on their systems. We achieve this goal by capturing the metadata from each phase of the continuous integration workflow, storing them in the form of a key-value database and then finally merging the database file with the final artifact. Then we develop an application which can retrieve the information from the stored metadata. To develop a prototype, we use Git as the Version Control System and Jenkins as the Continuous Integration System. We develop a plugin for Jenkins which captures the metadata from every phase and then stores it. We use Maven and Java to develop the Jenkins plugin.

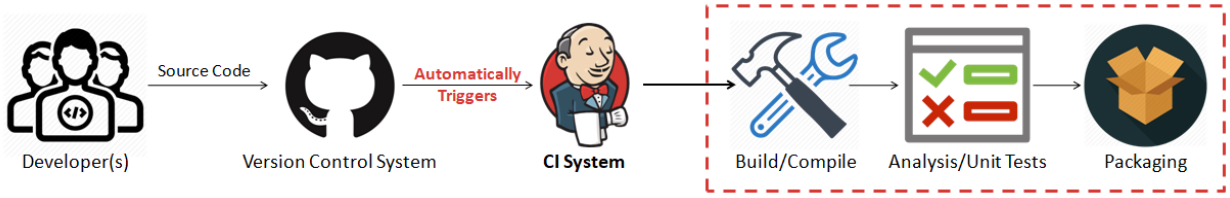

Fig 1. A typical Continuous Integration Workflow

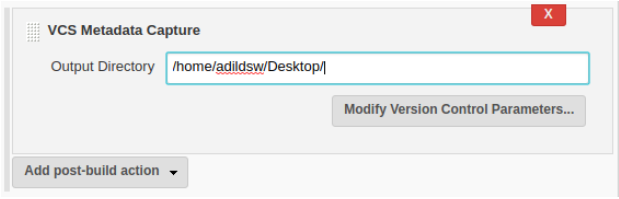

Fig 2. Developed Jenkins Plugin UI which captures the Version Control System Metadata

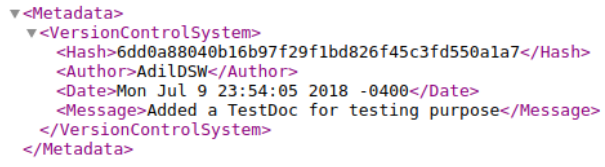

Fig 3. Captured Metadata from our Jenkins Plugin showing details about the Version Control System

Effect of Bottom Shape and Liquid Level on Power Dissipation and Power Number for Stirred Vessels under Different Baffle Configurations

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In liquid mixing vessels, the power dissipated in the liquid by a rotating the impeller is critical for a number of industrially-relevant mixing systems, since the mechanical energy so dissipated can be correlated to the phenomena such as the level of homogenization of the vessel content, the suspension of dispersed solids, and thus result in the achievement of the desired process goals. A significant body of knowledge exists on power dissipation in fully baffled tanks for standard vessel configurations and for different types impellers. However, little information is available regarding the power dissipation, *P*, and the corresponding non-dimensional value, i.e., the power number Po, in other mixing systems, especially those with different baffling conditions, liquid levels, and shape of tank bottom. The power, *P*, dissipated by an impeller rotating in a liquid depends on the system's geometry, including impeller type, diameter, and location, the number and location of baffles, and tank dimensions; the physical properties of the liquid; and the dynamic operating conditions of the system, mainly related to the impeller agitation speed. Using non-dimensional analysis (Buckingham Pi Theorem) it can be shown that the non-dimensional Power Number, Po, is a function of the Reynolds Number, Re, the Froude Number, Fr, baffling conditions, and other geometrical ratios. Keeping all the geometrical ratios constant, Po, becomes a function only of Re and the baffling conditions as the effect of, Fr, can be neglected for most baffling configurations. Thus by, changing the baffling conditions, keeping all the other conditions constant (except for the liquid level), we can obtain graphs of Po *vs* Re.[1] Therefore, the objectives of this work are to determine experimentally *P*, and hence Po, in a scaled-down versions of industrial mixing tanks with different bottom shapes (hemispherical and flat), different liquid levels, and under different baffling conditions (fully baffled and unbaffled), and to obtain Po-*vs*-Re correlations that can be used to predict the power dissipation in industrial mixing vessels.

In this work, two cylindrical tanks with different bottoms shapes; hemispherical and flat bottom shape and a single 6-bladed Rushton disk turbine were used. Two different systems were used to measure the torque and hence the impeller power dissipation, one using an external strain gauge-based rotary torque transducer mounted in line between the motor and the impeller shaft and another by measuring the electric power consumed by the stirrer motor and directly connected to the impeller shaft.[1]

The Power Number was found to be a function of the liquid height (related to the impeller submergence) especially as the baffling type was varied. The shape of the vessel bottom was also found to have an effect on Po. A number of Po-*vs*-Re plots were obtained in which the other operating variables were used as parameters. The results obtained in this work are expected to be of significant importance for liquid mixing in industrial manufacturing systems at larger scales.

[1]*Sirasitthichoke, C. and Armenante, P.M. 2017. Power Dissipation and Power Number Correlations for a Retreat Blade Impeller under Different Baffling Conditions. Ind. Eng. Chem. Res.* ***56****(36): 10123–10133.*

Synthesis of metallic nanoparticles: Comparing batch to continuous micro-scale production

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Abstract: Gold (Au) and silver (Ag) nanoparticles (NPs) have extensive applications in photovoltaic technology, catalysis, information storage, optoelectronics, biomedicine and environmental technology. In particular, Ag-NPs have proved to be an excellent substrate for a multitude of different spectroscopic techniques like fluorescence, Surface-enhanced Raman Spectroscopy (SERS), Localized Surface Plasmon Resonance (LSPR) and also in sensing, catalysis and antimicrobial applications. Further, hydrogen tetrachloroaurate (III) ($HAuCl_4$), a precursor to prepare Au-NPs is significantly more expensive than silver nitrate ($AgNO_3$), the precursor to Ag-NPs. Batch production is often plagued by poor size distribution. This arises from the inability to tightly and accurately control the reaction temperature during the heating and cooling phases that govern the nucleation and growth processes arising in NP synthesis.

Our primary research objective is to synthesize Au-NPs and Ag-NPs with tight and narrow size distribution. Initially, Au-NPs are synthesized from $HAuCl_4$ and Sodium citrate (reducing agent) in batch mode using the classical Turkevich method[1]. The method involves continuous stirring of 0.75mM $HAuCl_4$ and 1% sodium citrate solution heated at 100˚C using a hot plate. This has been suitably modified to synthesize Au-NPs using a micro-device. The micro-device is primarily a microfluidic device with a channel made of an acrylic spacer of height 25μm. The spacer is sandwiched between two glass slides. A T-channel of dimensions (112mm×700μm) is cut into the spacer using Cricut software. A UV-Vis Spectrophotometer is used to characterize the absorption spectrum. The size of NPs has been determined using Dynamic Light Scattering (DLS). The effect of different parameters like reactant flow rates, concentration ratios, and reaction temperature was carried out to optimize the process to obtain a tight and narrow size distribution of Au-NPs. Post successful completion of Au-NP synthesis in the micro-device, synthesis of Ag-NPs has been planned. It is worthwhile to note that Ag-NPs require $AgNO_3$ as a precursor, Sodium borohydride ($NaBH_4$) as a reducing agent, a complexant such as Ethylenediaminetetraacetic acid (EDTA) and a dispersant such as Polyvinylpyrrolidone (PVP) for successful synthesis. We expect that the operating conditions will again need to be optimized to obtain a tight and narrow size distribution of Ag-NPs.

Fig1: Batch Mode

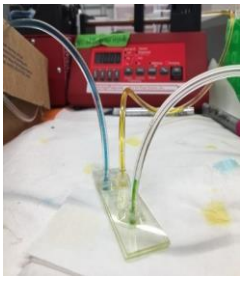


Fig 2: Micro-Device

[1]*A. D. McFarland, C. L. Haynes, C. A. Mirkin, R. P. Van Duyne and H. A. Godwin, "Color My Nanoworld," J. Chem. Educ. (2004) 81, 544A*

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

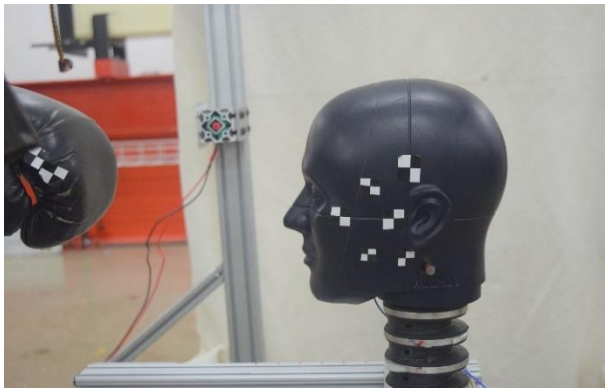
Evaluation of Boxing Headgear Protection Efficiency

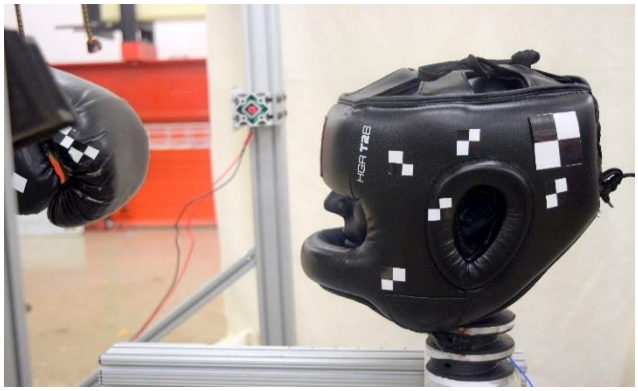
Shahbaz Choudhry & Osama Mahgob, Advisor: Drs. Maciej Skotak and Namas Chandra

Boxing is considered a brutal contact sport by many, consisting of two individuals administering and receiving multiple blows to the head and torso in a fight. Not many take into consideration the training that a boxer must endure before fighting. For a boxer to be adequately prepared for a fight he/she must partake in multiple sparing sessions. Sparing is training which consists of a simulated fight with the use of protective equipment such as boxing headgear and gloves. Many boxers spar multiple rounds as part of their training in preparation for a fight, some even partake in sparing every day. This leaves an underlying question regarding the protectiveness of the protective equipment used in sparing sessions, specifically the headgear, and whether it provides adequate protection to prevent or reduce brain injury.

The aim of this project was to test the boxing headgear effectiveness in reducing the amount of injury from a direct hit. To accomplish this task, a pendulum was developed that delivered impacts to a NOCSAE head form. The pendulum included an impactor that mimics a human hand with attached boxing glove to emulate punch conditions. The impactor was designed to allow wide range of impact forces and velocities by incorporating weights and propulsion band. The impactor was calibrated to reach impact velocities between 4 to 12 m/s and produce forces from 1.8 to 4.5kN. These impact conditions correspond to human biomechanical data based on our results and published literature [1].

The headgear evaluation was conducted using a NOCSAE head form attached to the Hybrid III neck via custom made adapter, and a baseline data were obtained without a headgear. The tests were conducted using impactor with no added weight, 17 pounds and 38 pounds of added weight, and four repetitions were conducted using 40°, 50° and 60° extension. The impactor and headform kinematics was quantified based on the high-speed video analysis (videos recorded at 5000 fps using Photon Mini UX100 camera) and pair of accelerometers (DTX 6DX Pro and PCB 656A33 recording rotational and linear acceleration, respectively). We found peak linear acceleration is a function of impactor velocity, while peak angular acceleration scales with the added weight.





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The Effects of Blast-Induced Neurotrauma on NLRP3 Inflammasome Activation

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Abstract: Blast-induced traumatic brain injury (bTBI) is a signature wound in soldiers in combat zones as well as in training facilities due to widespread use of explosives. In recent years, bTBI has also become alarmingly high in civilian populations due to the high use of explosives by insurgents. bTBI is associated with several pathological outcomes including blood brain barrier damage, oxidative/nitrosative stress as well as neuroinflammation, all of which contribute to neurobehavioral deficits. One major factor responsible for neuroinflammation is the activation of the Nod-Like Receptor Protein-3 (NLRP3) inflammasome by formation of an inflammasome complex consisting of NLRP3, ASC, and pro-caspase-1. This complex produces the Caspase-1 enzyme which catalyzes the conversion of pro-IL-1β to active IL-1β, a pro-inflammatory cytokine. Inflammasomes are usually activated by either pathogen associated molecular patterns (PAMPs) (in case of infections) or by damage associated molecular patterns (DAMPS) (usually due to brain injury). Several studies have shown activation of NLRP3 inflammasome in blunt TBI, whereas such effects have not been investigated in bTBI. Therefore, our goal is to investigate the spatial and temporal effects of blast-induced neurotrauma on the expression levels and the cell types responsible for the NLRP3 inflammasome and its downstream products. We hypothesize that there will be an overall increase in expression of NLRP3 and its colocalization in microglia (neuroinflammatory cells) and/or neurons (more vulnerable cells in the brain).

Rats were exposed to a moderate blast overpressure (180 kPa) and were perfused with PBS and 4% paraformaldehyde (PFA) at 4 hr, 24 hr, 3 day, 7 day, 15 day, and 30 days post injury. One group of rats were microdissected for the frontal cortex (FC), hippocampus (HC), and thalamus (TH) regions to be used for Western blot analysis of pro-caspase-1, caspase-1, pro-Il-1β, and IL-1β. Another group of rats were prepared for immunostaining of the NLRP3 complex (as noted above) across the same time points. We also performed ELISA analysis of IL-1β in the hippocampal and thalamic regions. Analyzing the expression patterns of these proteins via western blot and ELISA analysis gave us a temporal profile of IL-1β. Double immunostaining for different neural cell markers was used to determine cell specific expression of the proteins in the NLRP3 complex. In addition, the immunostaining was also performed to map the expression patterns of these proteins as a function of time and space and to verify our western blot and ELISA results. Using fluorescent microscopy, we were able to capture images of NLRP3 colocalization with markers of different neural cells and also quantify the variation between the protein expression levels in control and blast animals. Our data suggests that there is an overall increase in expression of NLRP3, ASC, Caspase-1, and IL-1β over time while there is a decrease in pro-caspase-1 and pro-Il-1β, which precedes the activation of the pro-inflammatory cytokines. This data collectively indicates that NLRP3 activation is a major factor in the mechanism of neuroinflammation in bTBI. In the future, targeting NLRP3 may have therapeutic benefits to ameliorate bTBI pathology.

Studying the Behavioral Effects of Blast Induced Traumatic Brain Injury

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Though the implications of penetrative brain injuries on behavior have been heavily studied, behavioral changes due to blast induced traumatic brain injury (bTBI) have not been. bTBI affects memory and anxiety levels and is the cause for many neuropsychiatric problems. In order to investigate the behavioral deficits following blast TBI, we conducted several behavioral assays in mice. To this end, 8-10 weeks old wild type mice were subjected to moderate blast TBI (180 kPa) by placing them in a shocktube and the respective controls were kept outside the shocktube. The behavioral assays conducted include the Novel Object Recognition (NOR) test for short-term memory and Elevated Plus Maze (EPM) for anxiety. The NOR test is based on the principle that a mice would spend significantly more time exploring a novel object compared to a familiar object. We found that blast exposed mice failed to discriminate between a novel object and familiar object at 7 days and 28 days following blast, suggesting that bTBI caused deficits in short term memory. The EPM test uses the general aversion of rodents to open spaces to measure anxiety levels. Blast exposed mice displayed increased anxiety at 1 day and 30 days after bTBI as evidenced by a significant increase in the proportion of time spent in the closed spaces as opposed that spent in the open spaces. Future studies will be performed on transgenic mice lacking CCR2 receptor (CCR2 knockout mice), a key receptor involved in macrophage infiltration and inflammation, in order to investigate the role of inflammation in bTBI induced behavioral deficits.

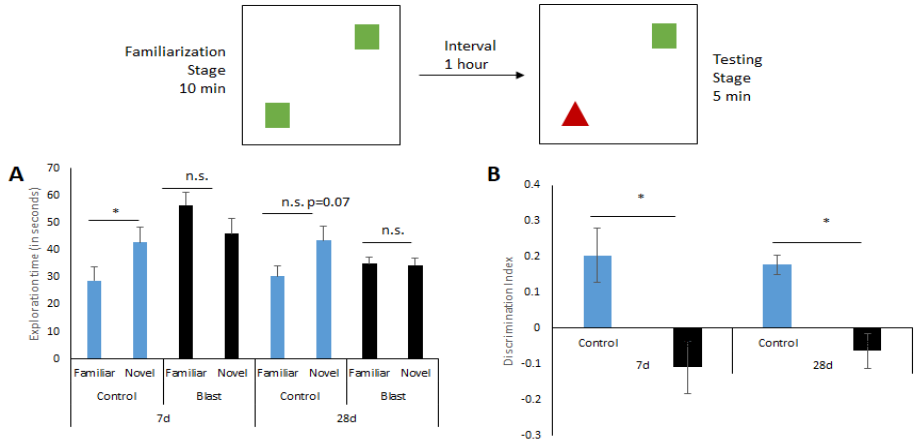

Fig. 1 Reduced short-term memory in blast exposed mice. Novel Object Recognition Test shows control mice spend more time exploring the novel object during the testing phase compared to the blast animals at 7 days following blast exposure (180kPa) **(A).** The blast exposed mice lack ability to discriminate between the familiar and novel object suggest short-term memory deficient **(B).** 7 days n=5 Sham; n=8 Blast mice. For 30 days: n=6 Sham; n=5 Blast *indicates* <0.05 and 0.01. Student's *t*-test.

Measuring Susceptibility to Seizures After Blast-Induced Traumatic Brain Injury in Rats with Alzheimer's Disease

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Post-traumatic epilepsy (PTE) is a lifelong complication caused by traumatic brain injury (TBI) and is defined as recurrent and unprovoked post-traumatic seizures. Although the presence of a link between Alzheimer's Disease (AD) and epilepsy has been identified, there is currently no clear understanding regarding the extent of the relationship between the two. *This proposal focuses on investigating genetic predisposition to AD in exacerbating blast-induced brain injury, particularly in developing PTE.* Rats used in this experiment were split into two groups: control and blast, each of which possess three genotypes: h/h, h/s, and s/s (h refers to the humanized version of beta APP region and s refers to the Swedish mutation) and were used for evoked seizure experiments. Cortical surface electrodes were implanted in 8 weeks old male Long-Evans rats and, following this surgical procedure, the rats were allowed to recover for a 1-week period. The basal, as well as kainic acid (5 mg kg^{-1} weight of rat)-induced changes in EEG oscillations were recorded along with continuous video monitoring for 30 minutes prior to and 120 minutes following the kainic acid injection, respectively. Spectral density and average power was analyzed for various frequency bandwidths: delta (1-3 Hz), theta (4-12 Hz), low gamma (30-60 Hz), high gamma (60-90 Hz) and high frequency oscillations (90-200 Hz), and susceptibility to seizures was analyzed using modified Racine scoring. In the control group, the average power of various bandwidths of EEG oscillations (theta, low gamma and high gamma) were significantly lower in rats with AD-causing mutation (both h/s and s/s groups) compared to the h/h group. Moreover, rats with heterozygous and homozygous mutations experienced greater severity in seizures and had a significantly shorter latency to develop seizures, suggesting that a single copy of AD mutation is sufficient to increase susceptibility to developing KA-induced seizures. Further studies would involve testing whether blast models of TBI can exaggerate the seizure vulnerability in this AD model. In addition, we will test whether the presence of an AD-protective mutation can rescue the pro-epileptic phenotype seen in the AD rats.

Cavitation in heterogeneous environments

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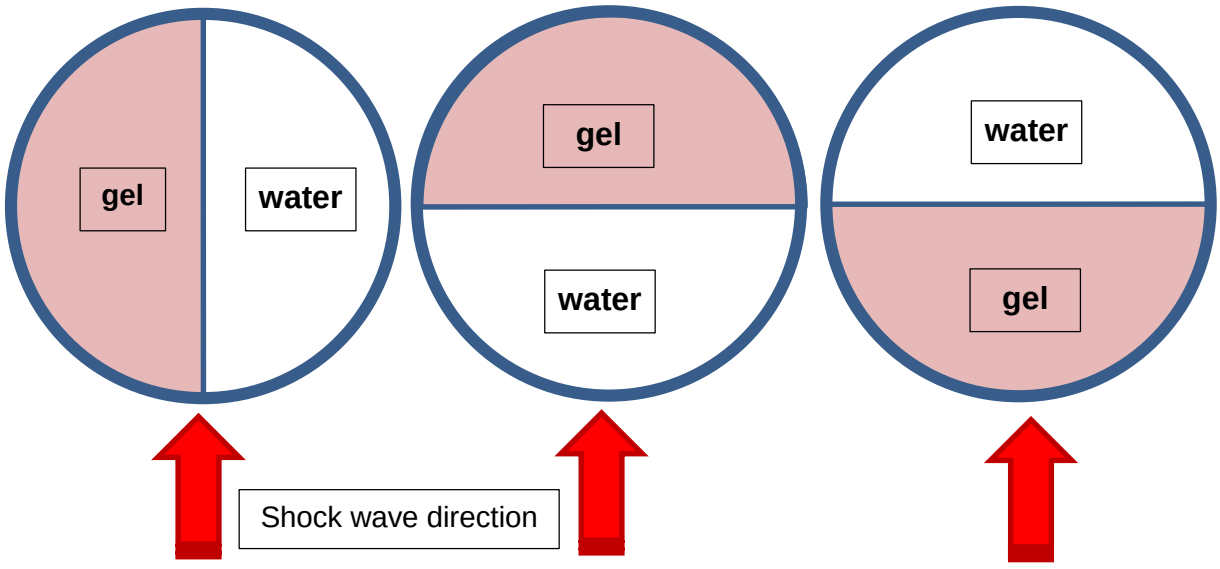
Brain injuries can be caused by direct effect of the blast wave, but it is still not clear whether which are the mechanisms mediating the injury. Over the past few years, several mechanisms of blast TBI have been suggested: a) thoracic mechanism which blast waves are transferred to the brain through thorax and result in a brain damaging pressure surge carried by blood in vasculature, b) translational and rotational head acceleration, c) blast wave transmission through cranium, d) skull flexure, and e) cavitation. Most of these mechanisms are result of studies using numerical models exclusively with little or no experimental evidence. In this research effort, we focus on one of those suggested mechanisms, cavitation. Cavitation is a mechanism that proposes that, during a blast wave impact, microscopic pockets of negative pressure (cavities) are formed. The prime locations for these cavities to form are in the interphases between the brain matter and cerebrospinal fluid (CSF). We studied this mechanism using the shock tube and simplified surrogate head model. The skull is modeled using a 2 inch diameter polycarbonate cylinder, since polycarbonate and the human skull have similar acoustic impedance. Half of the cylinder is filled with 10% gelatin (brain surrogate) and the remaining space is occupied by deionized water (CSF surrogate).



We observed that the introduction of the gel into the internal space of the cylinder attenuated the vibration of the polycarbonate shell subjected to a shock wave loading, compared to the baseline model with water. The same was also true for the pressures measured inside of the cylinder by miniature sensors. The cavitation was observed only when the seed microbubbles were present in the water on the interface between water and the cylinder wall.