2016

TENTH ANNUAL

SUMMER RESEARCH PROGRAM UNDERGRADUATE ABSTRACTS

NYU | TANDON SCHOOL OF ENGINEERING

2016 SUMMER RESEARCH

NYU Tandon School of Engineering's Undergraduate Summer Research Program provides a unique opportunity for NYU Tandon, NYU College of Arts and Science, NYU Abu Dhabi and other select students to engage in research over the course of the summer. This program offers students far more than the traditional classroom experience; it allows them to work alongside faculty mentors on cutting-edge research projects. Close interaction with faculty and research staff promotes an educational experience that advances the i^2e model of invention, innovation and entrepreneurship. Undergraduate students are afforded the opportunity to conduct research as paid interns during this 10-week period. The program aims to enhance and broaden students' knowledge base by applying classroom learning to solve practical and contemporary problems and to better prepare them for lifelong learning.

Summer 2016 marked the 10th year of the Undergraduate Summer Research Program. Since its inception, the program has seen 588 student participants, as well as contributions from faculty members across a variety of departments. In addition to their work in labs, students attended multiple seminars focused on both academic and career development. Additionally, students participated in a poster session in collaboration with the NYU CAS Department of Chemistry's MRSEC program, in which they present their research to other members of the research cohort and outside attendees.

Tandon's faculty participation in this program was essential, as was the financial support provided by faculty mentors. The gifts from several alumni donors have also propelled the program's success. I would like to thank Dr. Joseph G. Lombardino '58 Chem; James J. Oussani, Jr. '77 ME; and Dr. Harry C. Wechsler '48 CM, for their generous support of this year's program. Additionally, this year marked the fifth year of the Thompson Bartlett Fellowship. Ten of this summer's researchers were graciously supported by this fellowship made possible by Mrs. Dede Bartlett. Mrs. Bartlett's father, Mr. George Juul Thompson, was a graduate of the Polytechnic Institute of Brooklyn in 1930. Donors' gifts allow us to engage more student researchers, faculty mentors, and further strengthen this truly unique summer experience.

Thanks to Nicole Johnson, who volunteered her time to mentor the TB Fellows, providing them with additional programming and engagement throughout the summer. I would also like to acknowledge Sara-Lee Ramsawak, who coordinated this year's Undergraduate Summer Research Program and ensured the programs daily operations ran seamlessly. She has coordinated the Program for the past three years, and continues to develop and enhance it at every turn.

The abstracts published in this volume are representative of the research done over the summer and celebrates the accomplishments of the undergraduate researchers. I offer my congratulations to all of the student researchers who participated in the 2016 Undergraduate Summer Research Program and look forward to future summers of intellectual and scholarly activities.

Iraj Kalkhoran
Associate Dean of Academic Affairs

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APPLIED PHYSICS

DARK ENERGY IN A WEAK GRAVITATIONAL FIELD

Dark energy is a very mysterious subject in contemporary science, accounting for 70% of the energy in our universe. While it may be responsible for the accelerated expansion of the universe, there are no viable independent experiments, to date, to detect the presence of dark energy.

In order to understand how dark energy might influence the motion of particles in ambient conditions, we developed the geodesic equation for the motion based on the metric of our universe, the Robertson-Walker metric. The equation for the geodesic predicts the motion of a particle free from all external force. The Einstein equation, $R\mu\nu - \frac{1}{2} R\, g\mu\nu + \Lambda\, g\mu\nu = [8\pi G / c4]\, T\mu\nu$ which relates the geometry of spacetime to energy, includes the Ricci tensor $R\mu\nu$, the Ricci scalar R, the metric tensor $g\mu\nu$ (in this case, the Robertson-Walker metric), and the stress-energy tensor $T\mu\nu$. The factor Λ is the cosmological constant, which describes dark energy.

Using the Einstein equation, along with the Robertson-Walker metric, we analyze the possibility of detection of dark energy in the peculiar motion of galaxies.

TASFIA TASNIM

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CHEMICAL AND BIOMOLECULAR ENGINEERING

LASER-INDUCED CRYSTALLIZATION OF SUPERSATURATED AQUEOUS GLYCINE IN AGAROSE GELS

Crystal growth, achieved by controlling diverse physical and chemical parameters, has long been studied by chemists for various applications, such as purification, diffraction and gas storage. Yet, the unpredictable initial stage of crystallization—nucleation – makes it difficult and tedious to engineer its morphology and polymorphism. From previous experiments, Garetz et al. discovered a phenomenon they called non-photochemical laser induced nucleation (NPLIN), where a near-infrared high intensity laser can induce nucleation in a supersaturated solution, without the laser pulses inducing any photochemical process. NPLIN can produce unexpected morphologies and polymorphs in some systems.

The selectivity for certain polymorphs is due to "polarization switching", where the structure of the polymorph depends on the state of the polarization and the degree of supersaturation. The peak electric field from the polarized beam aligns the pre-nucleating clusters in a supersaturated solution along the direction of polarization of the laser beam. Alexander and coworkers have shown that they could achieve spatial control of nucleation in the NPLIN of aqueous potassium chloride in agarose gel. We are interested in seeing whether such spatial control can be achieve in the NPLIN of aqueous glycine in agarose gels. Agarose gels create an environment similar to microgravity due to the suppression of sedimentation and convectional current, producing larger, single crystals. In this experiment, the effects of various factors on crystal growth, such as polarization of the laser beam and the concentration of glycine, were analyzed in supersaturated glycine-agarose gels. Initially, aqueous glycine with a supersaturation of 1.5 in 0.5% w/w agarose was irradiated with a single shot of horizontally polarized light of wavelength 1064 nm to observe the correlation between the crystal growth and the plane of polarization. Later, the supersaturation of glycine was varied between 1.55-1.60 to observe the morphology and polymorph achieved—α, β or γ.

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DIPYRIDAMOLE DELIVERY BY ENGINEERED PROTEIN FOR BONE FRACTURE TREATMENT

Annually, it's estimated that over two million bone fractures are treated in the United States. Although many fractures heal spontaneously, bone graft surgery and other therapies may be used to aid compromised bone healing. Growth factors, such as bone morphogenetic proteins (BMP-2), have been used to stimulate bone growth on scaffolds. However, alternatives to BMP-2 are sought-after due to the compound reportedly causing osteolysis, radiculitis, ectopic bone formation, and cancer. The activation of adenosine A2A receptors (ADORA2A) has been shown to increase the proliferation of osteoblasts within tissues. Dipyridamole, which prevents reuptake of adenosine, may also be used to aid in bone growth, as the compound indirectly simulates A2A receptors. However, dipyridamole is cleared too quickly within the body to be practical in clinical use. To prevent the daily administration required for the drug, we hypothesize the use of the coiled-coil domain cartilage oligomeric matrix protein (COMPcc), which could bind and deliver the drug. COMPcc in the homopentamer form creates a hydrophobic cavity, which has been reported to bind hydrophobic molecules, such as vitamin A, vitamin D, curcumin, and doxorubicin. Since dipyridamole is hydrophobic, COMPcc might be a suitable drug delivery vehicle to prolong dipyridamole half-life. We will investigate the binding properties of dipyridamole to COMPcc and the effects on protein structural stability.

▲ Patrick Stevens (pictured right) is working to test a new method of delivering bone growth-related medication to heal fractures.

WEIXIAN ZHENG

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PROTEIN AGGREGATION IN NEURODEGENERATIVE DISEASES

Alzheimer's disease is a neurodegenerative disorder characterized by loss of memory and cognitive impairment. Aggregation of β-amyloid in the grey matter of the brain is the histopathological feature of Alzheimer's disease. β-amyloid monomers are non-toxic but they can aggregate into primary toxic agents such as β-amyloid oligomers and fibrils which eventually lead to neuronal death in the brain. The detection and study of the β-amyloid aggregates are of the diagnosis purpose and better understanding of Alzheimer's disease on the molecular level.

Microfluidic devices are characterized by fluidic channels with a linear dimension that is on the order of tens to hundreds of micrometers. Devices in this size enable lab-on-a-chip technology that satisfies low consumption of reagents, small amount of work, and easy evaluation of results. For the purpose of observing aggregation of engineered amyloid peptides, microfluidic chips are fabricated and used. The microfluidic chips are constructed by poly (dimethylsiloxane) (PDMS) molding on a patterned silicon wafer. Microchannels are sealed by bonding the PDMS chips to a glass slide irreversibly with oxygen plasma treatment. Fluorescence will be applied for the purpose of amyloid aggregates analysis.

▲ To improve our understanding Alzheimer's disease, Weixian Zheng is creating a new device for detecting and analyzing amyloid masses in the brain.

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ENGINEERED PROTEIN-IRON OXIDE HYBRID BIOMATERIALS FOR THERANOSTIC APPLICATIONS

Iron-based magnetic nanoparticles exhibit unique features given their nanoscale size and superparamagnetic properties, which allow them to be directed to and maintained at desired anatomical regions by a magnetic field. The templation of drug-carrying protein materials to these nanoparticles results in a hybrid with potential as a dual therapeutic and diagnostic, or theranostic, agent monitored by magnetic resonance imaging. Our system is based on the pentameric coiled-coil domain of the Cartilage Oligomeric Matrix Protein, dubbed COMPcc. This non-collagenous extracellular matrix protein contains a hydrophobic core capable of carrying small therapeutic molecules such as doxorubicin and curcumin, a derivative of turmeric with anti-neoplastic properties. Q, an engineered variant of the protein COMPcc, self-assembles into functional nanofibers as a result of patches of surfaces charges distributed axially along the protein. These fibers subsequently form mesofibers upon curcumin binding. Through the use of residue-specific incorporation of the non-natural methionine analog, azidohomoalanine, we have synthesized an azide-functional variant, Q-AHA. The azide group of this residue is capable of [3+2] alkyne-azide cycloaddition, a form of click chemistry, to attach it to an alkyne-functionalized iron oxide-templating peptide called CMms6. The carboxyl-terminus of the Mms6 protein, or CMms6, is found in magnetotactic bacteria and is capable of binding iron salts and organizing the crystallization of iron oxide nanoparticles. Performing click chemistry between protein Q and alkyne-functionalized CMms6 permits this drug-carrying construct to template iron oxide nanoparticles, creating a hybrid biomaterial that is susceptible to magnetic field for potential theranostic applications.

▲ Teeba Jihad is developing a biomaterial, with both therapeutic and diagnostic applications, for use with magnetic resonance imaging.

MICHAEL YANG

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NYU CAS/Tandon 3+2 Program

NANOLITER BIODIAGNOSTICS

Oligonucleotide surface hybridization based assays, such as DNA microarrays, have found a plethora of applications in fundamental biology and biomedical research as genetic diagnostic tools. Typically, surface-immobilized oligomer "probes" consist of single-stranded DNA, however the negatively charged phosphate backbone of DNA can hinder hybridization of solution DNA "targets" through electrostatic repulsion. To overcome the issue of probe-target electrostatic repulsion, our group is interested in the application of morpholino (MO), a neutrally-charged DNA analogue. Arrays using both DNA and morpholino probes have been created. To determine the efficiency of DNA and MO probe-target surface hybridization, the concentration of DNA or MO strands immobilized at the surface must be known. This work aims to use X-ray photoelectron spectroscopy (XPS) and calibration with a reference standard to quantitatively characterize surface coverage of both morpholino and DNA oligomers.

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NANOLITER REACTORS

This project is aimed at advancing sample cells for analyzing reactions within nanoliter volumes and on surfaces in contact with nanoliter quantities of solution. By utilizing Gradient Refractive Index (GRIN) lenses, nanoliter scale droplets can be successfully imaged when pressed against a flat surface on which reactions take place. One potential application of such a technology is for microarray imaging, in which microarrays of nucleic acids or proteins associate with analyte molecules using very minimal quantities of sample. We are developing methods that work in conjunction with a custom-built GRIN lens microscope to allow nanoliter sized droplets to be accurately dispensed and subsequently imaged.

The procedure for dispensing the droplet involves a 250 mL syringe connected to a LabNEXT Xtend microarray pin. The syringe is connected to a step motor which operates the plunger and can control the flowrate of dispensing. The microarray pin delivers the droplet inside the custom-built chamber where it is covered with oil and placed under the GRIN lens. Differently sized microarray pins enable different volume ranges to be dispensed. In order to determine the volumes dispensed, our approach uses a red, 640 nanometer laser to excite a fluorescent dye added to the droplet. An Andor iXon+ 885 CCD camera is used to capture the image of the droplet. By using the camera's accompanying computer program, the volume of the droplet can be calculated based off of its size in the image.

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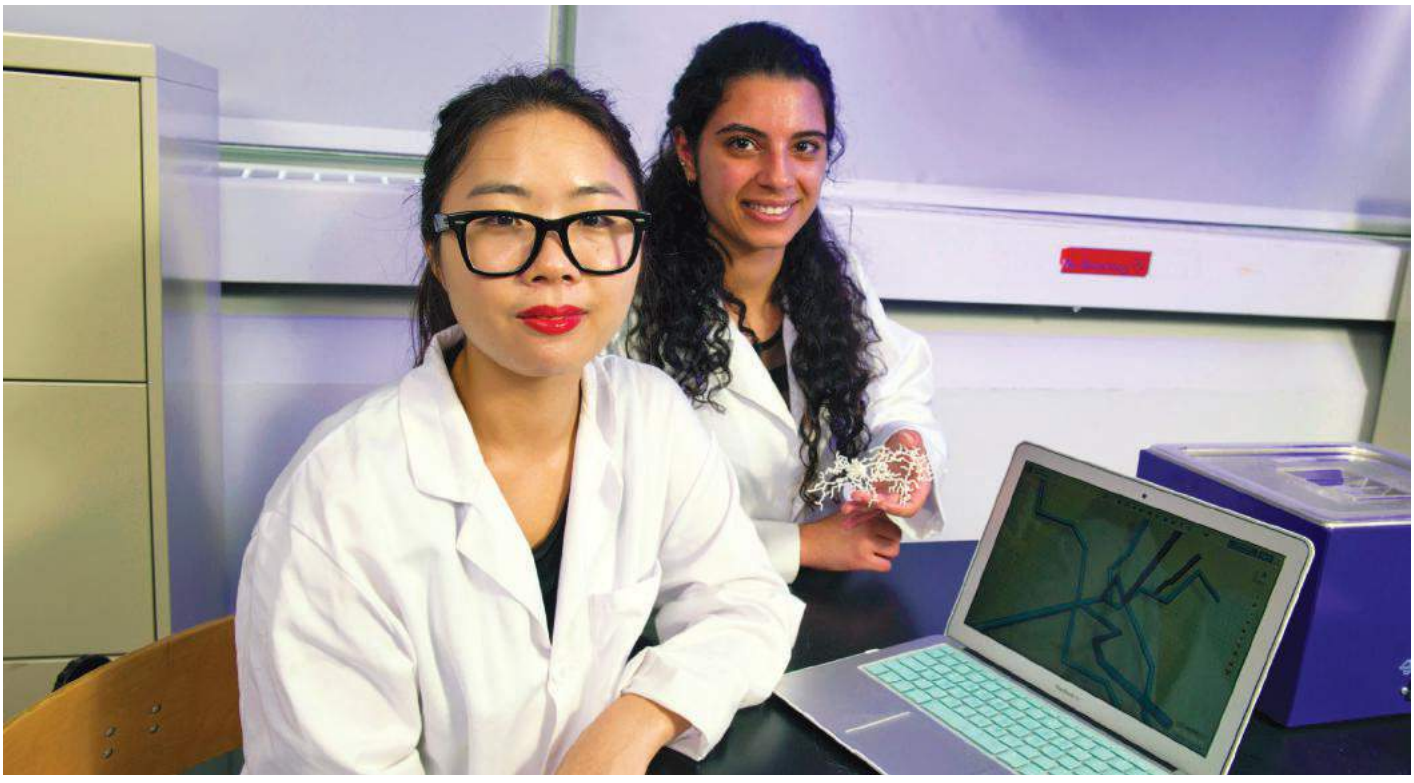

▲ Chanyong (Tina) Kim, Nadine Ibrahim (pictured left to right) and Kimberly Shaw (not shown) are creating a 3D model of a bipolar neuron to deepen our knowledge of its physical structure.

3D MODELING OF THE NEURON

Neurons are a core component of the brain and the central nervous system. They transmit information through chemical and electrical signals. There are three types of neurons: the bipolar, multipolar and pseudo unipolar neuron. This project will focus on the bipolar neuron, a specialized sensory neuron that transmits connections for taste, touch and smell. Neurons are comprised of four major components: the dendrite, soma, axon and axon terminal. Dendrites receive electrochemical signals and are branched projections that protrude from both ends of the soma. The soma contains the nucleus and all other organelles, and connects to the axon. The axon serves as a path for electrochemical signals between different neurons and muscles. The axon terminals send the message. In this project, we aim to create a 3D model of the neuron to have a physical understanding of a neuron's structure. NEURON, a Python-based program, will be used to generate potential models. Then, AutoCAD software will be used to create an anatomically correct bipolar neuron. In order to accurately visualize the neuron model, it will be scaled up 25 times the actual size in neurite diameters. Attention must be paid to the effect of gravity on the physical model. Due to the long and thin nature of neurons, this results in a non-uniform scaling up of the neuron.

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LASER-INDUCED CRYSTALLIZATION OF GLYCINE ENHANCED WITH GOLD NANOPARTICLES

Non-photochemical laser induced nucleation (NPLIN), discovered by Professor Garetz et al. in 1996, is the phenomenon whereby nucleation is induced in supersaturated solutions through the interaction of the electromagnetic field of a laser's output with pre-nucleation clusters in the solution. Garetz et al theorized that this occurred as a result of optical Kerr's effect, where the electric field causes a certain kind of alignment in the molecules. This phenomenon was evident by previous experiments, when the polymorph of the glycine crystals was affected by different laser polarizations (ex. circular, causing alpha and linear, causing gamma). NPLIN is significant in that it is a non-photochemical method of inducing desirable polymorphs from supersaturated solutions, which are valuable to industries such as pharmaceuticals, since different polymorphs have different solubility, bio-availability, etc. For this project, it is postulated that due to the non-photochemical nature of this experiment, NPLIN can be observed under a lower light intensity by enhancing the electric field with gold nanorods.

The surface layer of gold nanoparticles has free electrons that can interact with the polarized light and create surface plasmon waves under the right conditions (wavelength, incident angle, polarization). The idea is that a gold nanoparticle, of optimal shape and size, will shift the plasmon resonance wavelength and may increase the probability of occurrence of NPLIN. The wavelength of the resonances used in this experiment ranged from 660nm to 980nm. Aqueous glycine solutions with a supersaturation of 1.5 containing gold nanorods were made and exposed to near-infrared nanosecond laser pulses with a wavelength of 1064 nm.

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SYNTHESIS AND STABILIZATION OF A PROTEIN-BASED MAGNETICALLY-FUNCTIONALIZED BIOMATERIAL

Synthesis and stabilization of protein- based biomaterials that are capable of magnetic iron oxide templation are particularly promising for monitored drug-delivery applications in cancer treatment. While their biological synthesis provides advantageous biocompatibility, ensuring the structure and stability of the agents *in vivo* is required. Here, we present a technique to stabilize protein fibers capable of carrying hydrophobic small molecules such as curcumin, which maintains anti-inflammatory and anti-neoplastic properties, as a basis for a magnetically-functionalized biomaterial. We employ the N-terminal coiled-coil domain of the Cartilage Oligomeric Matrix Protein (COMPcc), which is a non-collagenous extracellular matrix glycoprotein found in cartilage, tendons, and ligaments. COMPcc is comprised of a heptad repeat pentamerization domain maintaining a partitioned hydrophobic pore capable of binding small hydrophobic, chemotherapeutic agents. Our variant of COMPcc, dubbed Q, has been engineered to maintain patches of positive and negative charges along the protein surface that result in optimal lateral fiber formation on the nanoscale. Upon binding to curcumin, these fibers further self-assemble into microfibers. The microfibers demonstrate fluorescence, allowing for visualization by fluorescence microscopy. A chemical crosslinker, bis(sulfosuccinimidyl) suberate (BS3), is used to covalently link the protein amine groups of the fibers to further stabilize the curcumin- bound microfibers. The stabilized Q fibers are then assessed for their ability to be clicked via azide alkyne cycloaddition to a peptide CMms6 which is capable of templating iron oxides.

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KINETIC MODELING FOR PULSED FIELD SURFACE HYBRIDIZATION (PFSH)

Surface hybridization, the phenomenon behind numerous bioanalytical applications such as microarrays and biosensors, consists of single strands of surface bound nucleic acid "probes" annealing to solution based complementary strand "targets". Though highly appealing and efficacious in a variety of contexts, surface hybridization remains enigmatic. As a result, our aim is to use experimental data to predict the outcome of competitive hybridization by fitting existing data to kinetic models.

Due to DNA's inherent negative charge, electrostatic repulsions between DNA probes and targets result in hindered interactions. Morpholino (MO), a DNA analogue, was chosen to be the probe due to its neutral charge and stability of MO-DNA hybrid duplexes. Despite these advantages, complications in the form of cross-hybridization still arise, whereby a target strand binds to a mismatched complementary surface bound probe.

We have employed the electrochemical technique of pulsed field surface hybridization (PFSH) to envelop the reaction in a pulsed field, with positive potentials inducing hybridization and negative potentials inducing dehybridization of cross-hybridized sequences. Such reactions were conducted under competitive hybridization environments, containing a complementary fully-matched target and a single-base "mismatched" target placed in the same hybridization buffer. We aim to fit this data to kinetic models to predict the resulting behavior of competitive hybridization interactions according to varying parameters in a given environment.

MACKENSIE GROSS

BS Biomolecular Science 2018

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3D MODELING OF A MUSCLE

Human skeletal muscles are responsible for most of the physical actions we perform in our day-to-day lives. It is important to be able to understand how these actions take place and what our body does in order for our muscles to function. The basic muscle subunit that is responsible for the contractions that move our muscles is called the sarcomere. Two-dimensional graphics of this subunit do not show the importance of its three-dimensional shape, especially for upper-level biology students studying muscle processes. By creating a three-dimensional model and printing it as a tangible entity, we will be able to better visualize these subunits and how they carry out their important tasks within the body. The three-dimensional design software AutoCAD will be used to make a model of the sarcomere. The components of the sarcomere such as the thick and thin filaments will be modeled and 3D printed, and will be arranged in a lattice formation in the complete sarcomere. This formation is most important in the model because it is not easily seen in the conventional two-dimensional model. Adding motion to the tangible model will allow for a better understanding of the mechanisms behind the sarcomere contraction. The shortening of the sarcomere as well as the cross-bridge interactions of the actin and myosin within the thick and thin filaments would be a strong addition to the model. It will also provide a visual to help see why certain muscle mutations or abnormalities can lead to disabilities and muscle failures.

▲ Mackensie Gross (pictured left) works on 3D modeling of a muscle for a detailed exploration of the processes responsible for movement.

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▲ To help the visually impaired, Yohana Mpuya, Francesca Santacroce and Hazem Ibrahim (pictured left to right) are developing a technologically advanced Electronic Transport Aid.

THE STAFF OF GANDALF

The Staff of Gandalf is an Electronic Transport Aid that allows the visually impaired to seamlessly navigate their surroundings. According to the World Health Organization, there are currently over 285 million people around the globe who are classified as visually impaired, with 39 million of them being legally blind. Many of those who suffer from blindness continue to use a white walking cane, despite its limitations and advances in technology. For example, the white cane cannot be used to detect obstacles above the user's waist, detect objects more than a few feet away, nor accurately describe what obstacle is in the user's way. With inspiration from Lord of the Rings, the white cane will be redesigned and turned into the Staff of Gandalf. The Staff of Gandalf utilizes an array of sensors in order to detect objects using sensors positioned at various sections of the staff. This would allow for a full 180 degree coverage of the user's surroundings, to a range of about 10 feet with 3D awareness of the user's environment. The sensors will input information, such as the range, distance, and angle of an obstacle, and output feedback to the user through the sense of touch to safely navigate them. The output would be in the form of a vibrating panel that would indicate where the objects are depending where on the panel the vibration is occurring. The ultimate goal is to create a convenient, simple, and inexpensive device that safely and efficiently navigates the blind community.

CHAPPEL SHARROCK

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CIRCULARLY POLARIZED LIGHT SCATTERING FROM BLOCK COPOLYMER GRAINS

Balsara et al. proposed a "slab" model of block copolymers (BCPs) in 1992. Such a model treats each grain as a thin portion of crystalline material. This ignores the effects of diffraction, taking into account only the impacts of polarization. With the use of Jones calculus, this model can be employed to derive a formula that describes the total amount of light transmitted through a crossed polarizer as plane polarized light propagates through a series of birefringent BCP grains.

We will execute a similar derivation, again using Jones calculus, to obtain a formula using circular polarization, rather than the aforementioned crossed linear polarization. It is predicted that the outcome of this calculation will be double that of the original formula. In other words, the intensity is expected to double when crossed polarizers are replaced with circular ones. This theoretical result will be tested experimentally by measuring the light scattering from an actual BCP sample composed of polystyrene (PS) and polyethylene oxide (PEO).

The uses of block copolymers are vast within industry and research. Our research group is studying the use of PS-PEO block copolymers mixed with lithium salts as possible electrolytes for lithium batteries. Doubling the intensity of the scattered light will allow a more precise determination of BCP grain sizes and grain growth kinetics.

Ref: Balsara, N.P.; Garetz, B.A.; Dai, H.J. Macromolecules 1992, 25, 6072-6074

▲ Amy Wu, Jenny Ijoma, Akash Das and CVK Abhiroop (pictured left to right) are enhancing a computational model of the brain to investigate the effects of ischemic stroke.

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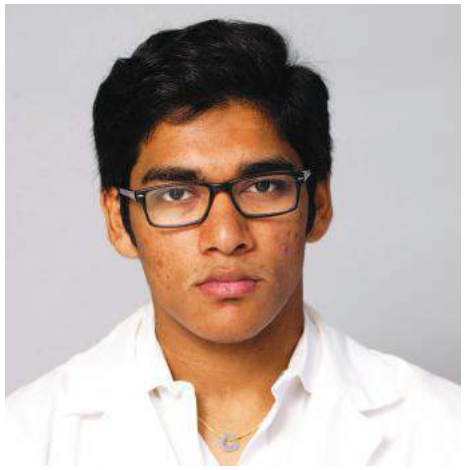

AKASH DAS

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BIOMARKER ASSAY DEVELOPMENT FOR GLYCOSAMINOGLYCAN FRAGMENTS

Hyaluronan (hyaluronic acid, HA) is a glycosaminoglycan that is found in the extracellular matrix, where it was observed to be involved in fundamental functions like cell signaling, cell migration, and wound repair. HA fragments, which can be made by different chemical and enzymatic processes, have been proposed as biomarkers of inflammation. The products of both chemical and enzymatic cleavages of HA yield fragments of different structures (average molecular weight) and chain structure (differing in end residue type and/or modifications to the sugar rings and pendant groups), which can give them opposing biological effects. Different concentrations and molecular weights have been associated with unique diseases, such as metastatic breast cancer and prostate cancer. Similarly, there have been several reports that HA degraded by a bacterial hyaluronidase lacks the danger signaling effects of a HA degraded by a mammalian hyaluronidase. Thus the use of bacterial hyaluronidase as a means to block inflammation-related diseases has been proposed.

The aim of this project is to compare the roles of HA oligosaccharides with differing structures to seek biologically relevant differences in the properties of these HA fragments and their potential for diagnostic or therapeutic use.

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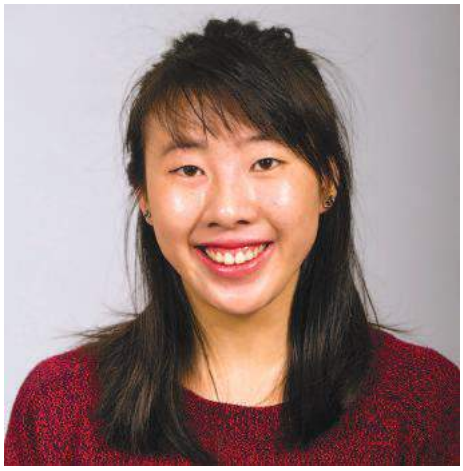
COMPUTATIONAL MODELING OF ISCHEMIA

Ischemic stroke is one of the leading causes of death and a major cause of disability and impairment of cognitive function. Ischemia refers to damage arising from inadequate blood supply, and can take place in many organs of the body, and when it occurs in the brain, it is called ischemic stroke. The initial site of the brain that suffers from the lack of blood is called the umbra. Because metabolites like oxygen and glucose are unable to reach the brain, the umbral brain tissue suffers irreversible damage. The surrounding tissue to which the damage then spreads is called the penumbra, but the cells in this area remain salvageable. The ability to target and potentially reverse damage to the area makes the penumbral area the best region for recovery. In order to understand the ischemic cascade without invasive procedures, 3D computational modeling is currently being explored as an alternative. NEURON is a simulation environment that is capable of modeling a biophysical network of neurons. To simulate molecular mechanisms and membrane passages, a model will be created in NEURON that builds from a framework provided by existing computational models of membrane dynamics that occur due to stroke. Varying parameters of ion concentrations, temperatures, and other variables that come into play will be added to the model. The resulting neural activity graphs can be extrapolated and analyzed to bridge connections between pathways and visualize how the cascade of mechanisms induce cell death.

ROLE OF EXOGENEOUS HYALURONAN IN CANCER CELL SIGNALING

Metastatic cancer is the leading cause of cancer mortality. Impeding cancer metastasis is a useful therapeutic tool for treating cancer. Metastasis occurs when tumor cells detach from the primary site, then migrate to a secondary tumor site. The extracellular matrix (ECM) is modified in the tumor environment and serves as both physical support and cell signaling regulator. The ECM is composed of insoluble proteins such as collagen and the glycosaminoglycan hyaluronan (HA). HA is highly concentrated in tissues such as joints, skin and vitreous of eyes. The varying average molecular weight of HA is significant to its function; low molecular weight HA causes an inflammatory response whereas cells maintain a quiescent state in the presence of high molecular weight HA. Cells express multiple cell-surface receptors for HA. One of these receptors, layilin, has recently been identified as being involved in cell migration. Its interaction with HA is similar to that of CD44, the most prominent HA receptor. Layilin and CD44 interact with Src, a tumor promoting tyrosine kinase, and Merlin, a tumor suppressor. The phosphorylated forms of Src and Merlin stimulate their activities.

In this study, HT1080 fibrosarcoma cells are used to investigate the effects of layilin and CD44 on cell proliferation, migration, and morphology in the presence or absence of low molecular weight or high molecular weight HA. shRNA was used to generate cell lines with diminished expression of layilin or CD44. Decreased expression of layilin resulted in slower motility compared to control cells. Western Blot analysis was performed to determine protein expression of layilin and CD44 knockdowns as well as different phosphorylation levels of Merlin and Src. Cell proliferation assays were studied to assess influence of layilin deficiency on growth. These results suggest that layilin plays a role in multiple aspects of cell behavior.



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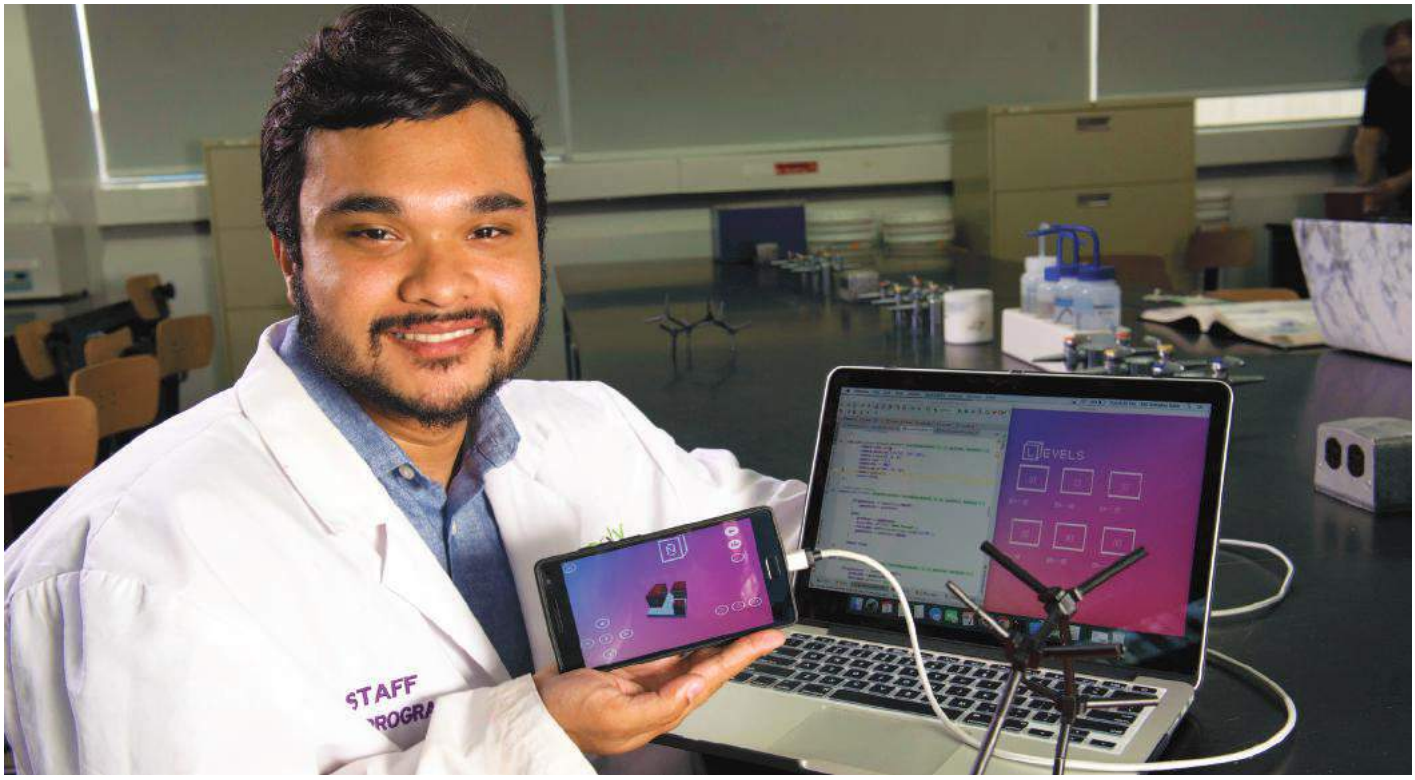
CHEMTRIS

Students tend to have a difficult time understanding how organic molecules move and function due to the complexity of seeing how the molecules would move in the 3D space. The Chemtris application was created in order to help students. In recent years, studies have shown that a virtual interactive environment allows students to comprehend materials that they typically do not understand in a classroom. Thus, the application is made into a fun and interactive game. This game is written in JAVA programming language and it is built on the Libgdx framework. It is primarily designed for Android devices and will be published in the Google Play Store; however it can also be used in any computer with JAVA installed. Users can move game models in the X, Y, and Z directions, rotate game models in all three of those directions, and rotate the game environment at any angle or orientation they want. This application allows users to understand how 3D models move and fit together through various levels of puzzles. These puzzles tackle various aspects of Organic Chemistry, such as joining organic molecules. The difficulty of these levels is standard so anyone regardless of their knowledge of Chemistry can play and the enjoy the game; because it is primarily designed to teach basic principles of Chemistry and arouse users' interest in Chemistry.



▲ MD Kabir is designing an application that helps users learn important aspects of organic chemistry, such as how molecules move in a 3D space.

CIVIL AND URBAN ENGINEERING

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DISTRIBUTED, COLLABORATIVE DEEP LEARNING THAT MAINTAINS MUTUAL PRIVACY

Deep Learning is transforming how Engineers solve problems, with Neural Networks at the center of this new toolkit. These biologically-inspired Networks are used to model highly non-linear patterns, but their utility is restricted by both the volume and quality of training data. To meet these constraints, collaborative neural networks trained on combined datasets for universal-use have been proposed, where the variation in high-quality samples and sampling methods would intuitively produce more representative datasets and models. With this method, for example, a Public-Sector Transportation Agency (e.g. MTA) could assess the aggregated transportation network impact of Private-Sector Transportation Companies (e.g. Uber, Lyft, zipcar, etc.), which is agnostic about particular companies.

Unfortunately, sharing data leads to serious concerns regarding privacy. Shmatikov and Shokri (2015) developed a framework around Selective Gradient Descent to address these concerns, in which constituent servers train a collective Neural Network as a global resource without explicitly propagating privately-maintained data. Having obliviously learnt from its contributors' heterogeneous data, the trained Neural Network can consequently be used by anybody — without compromising contributor privacy. The first objective of this project is to implement the model of Shmatikov and Shokri. Next, we will attempt to improve the model's efficacy, with a goal of faster and more accurate convergence. Finally, time permitting, we make an ambitious attempt to implement a fully distributed, gossip-based network implementing the model.

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DEMAND EVALUATION OF TAXI SHARING POLICIES FOR JFK AIRPORT ACCESS

Despite recent improvements in mass transit access to the two major airports within New York City's boundaries, taxicabs remain the top ground transportation choice for arriving and departing airline passengers. According to the taxi trip record data published by NYC Taxi & Limousine Commission, most trips to two major airports in NYC only serve one customer; the empty seats are wasted resources and environmental cost. Now passengers have the option to request ride-sourcing or shared-ride services from transportation network companies (TNC) such as Uber and Lyft. Carpooling services with TNC usually cost less because the fare is split; however, the travel time is usually longer. Currently, the impact of such operations on passenger demand is not well understood, and thus it makes it challenging to design more efficient operations, such as considering more advanced fare splitting or ride matching algorithms. The demand of taxi sharing policies for John F. Kennedy International Airport (JFK) access can be evaluated by discrete mode choice modeling—a mathematical model also known as disaggregate model. The model is developed based on the observations of individual travelers' choices of transportation mode. Compared to aggregate transport models, discrete models are usually more realistic and more likely to correctly predict individual choices.

The goal is to develop a demand model to quantify the social impacts of first and last mile taxi sharing policies—including how to split a fare, and how to match passengers—to help design them.

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SYSTEMATIC DESIGN OF WIRELESS CHARGING TRANSPORTATION NETWORK

Many cities around the world encourage the transition to battery powered vehicles in order minimize the emissions of greenhouse gases. The standard plug-in electric vehicles have a limited amount of power that can be stored in the battery resulting in frequent stops to refill the power. Online Electric Vehicle (OLEV) is a new technology that allows the vehicle to be charged while it's in motion, thus removing the need to stop at a charging station. Developed by the Korea Advanced Institute of Science and Technology (KAIST), OLEV picks up electricity from power transmitters buried underground. OLEV technology aims be served as a pilot study for a bus service transit in New York City. The study demands a new approach of integrated infrastructure and service network route planning.

In this project, information was collected from the Metropolitan Transportation Authority (MTA) data feeds for the transportation services of NYC Manhattan Transit Bus. Bus routes were investigated to determine the optimum study area for planning out the costs of deploying a pilot service network. The use of QGIS tools were used to provide a network file from the bus routes which will be used to run optimization models to assign locations for the wireless charging pavement. The optimization model should obtain a best solution to implement the charging pavement based parameters given, such as length of charging pavement provided, length of bus routes, bus route ridership, etc. Additional python scripts were written to convert MTA data feeds into data visualization to obtain useful information.

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SIMULATION STUDY TO COMPARE AUTONOMOUS VEHICLE FLEET AGAINST BROOKLYN-QUEENS STREETCAR LINE

The Brooklyn-Queens Waterfront Connector (BQX) is a proposed streetcar line, politically backed by Mayor Bill de Blasio, that was announced in 2016 and has a total cost estimated at $2.5 billion. The New York City Development Corporation (NYCEDC) and the New York City Department of Transportation (NYCDOT) conducted an assessment in order to evaluate the BQX Technical Feasibility and Impact Study, completed in 2015 by a non-profit organization called Friends of the BQX. In this assessment document, we have access to, among other information, full origin-destination matrix and average waiting/travel in this system per periods.

This simulation study will use the same ridership forecast of the BQX study to conduct some discrete-event simulation of possible autonomous vehicle fleet to attend this demand in the peak hour, considering that the passenger arrival time will follow a Poisson process. It will also be used as reference, the autonomous shuttle EZ10 by Easymile that has a total capacity of 12 persons. The goal of this research is to get computational results related to scenario simulation tests of service, in order to compare the performance of the proposed streetcar line, using the data available in the assessment document, with a possible autonomous vehicle fleet. To achieve those results, this study will work based on two main scenarios. In the first scenario, the autonomous fleet will work by demand (similar to services like Uber), and in the second scenario, it works on a pre-determined route.

COMPUTER SCIENCE AND ENGINEERING

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COMPARING USER'S INFORMATION DISCLOSURE BEHAVIOR ACROSS ANDROID'S OPERATING SYSTEMS

Given a number of recent high-profile online attacks where users' personal information has been stolen, privacy perception is becoming a significantly important concern for members of the public. However, users can often disclose their data without knowing that it's being collected. The Android operating system has been criticized for how it deals with privacy permissions as it requires the user to accept a complete set of permissions in order to install an application, some of which could be dangerous. Dangerous permissions are those that give the app access to data or resources that involve the user's private information. In 2015, Android released their latest operating system, "Marshmallow". In this version, users can pick and choose which information they wish to disclose. This permission pops up at runtime, at the points when it actually needs to access the information.

This project seeks to investigate how users take advantage of the permission update available in Marshmallow, and how this affects their perceptions of privacy. To do this, we are building an application that can mimic the Android privacy page, which will then be used to gather data in a user study. The study will involve participants downloading the application onto their own Android devices which will then log their privacy behaviors. Having presented the user with the permissions page, the app will record whether or not the user installed an app, and which dangerous permissions they allowed. This project will allow us to investigate whether individuals' information disclosure behaviors or privacy perceptions are altered by the new privacy permissions framework of Marshmallow.

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POLYPASSWORDHASHER: PROTECTING PASSWORDS IN THE EVENT OF A PASSWORD FILE DISCLOSURE

Over the years, various password-hash database breaches have occurred that have compromised the interests of both individual users and companies. The current industry security standard, salted hashing, has proven to be insufficient protection, especially for the majority of users who choose weak passwords.

PolyPasswordHasher (PPH) is an algorithm that creates a inter-relationship between passwords. This ensures that no password can be cracked individually unless a pre-determined threshold of correct passwords is known. Based on salted hashing and Shamir's Secret Sharing algorithm, PPH leverages users who are trustworthy and choose strong passwords as a way to automatically protect other users' passwords. In many realistic scenarios, cracking a PPH-enabled database would be infeasible. As a software-only, single-server enhancement, it is easy to implement and adopt on the server side, and requires no changes on the user side.

Research initiatives on PPH this summer have focused on providing easy to integrate libraries for different applications, including the Pluggable Authentication Module (PAM) and a Passport module. PAM is an authentication scheme used in a number of operating systems, including Linux and OS X. These operating systems can benefit from PPH's enhanced security by simply adding the module to its authentication stack in place of conventional salted hashing. The Passport module is authentication middleware that allows web users to store and authenticate their account with PPH by choosing "login with PPH". Both modules can enable more applications to use PPH and increase the security of their password database exponentially in exchange for only modest adaptations to the OS or user behavior.

FINDING YOUR OWN WAY: AN AUTONOMOUS NAVIGATION SYSTEM

Location services such as the Global Positioning System (GPS) have become an integral part of many people's lives. Systems that rely on a WiFi connection or GPS have their shortcomings, however, as functionality is greatly decreased in areas with poor coverage, such as underground or inside buildings. The ability to track location using another method would be invaluable, and have applications in a range of fields.

The indoor localization project (ILP) is aimed at developing an accurate indoor positioning system in situations where GPS is not available or sufficiently precise. The ILP operates through the use of an Android application, which collects data from the phone's sensors and transfers that data to researchers while maintaining user's privacy using the Sensibility Testbed platform.

There are two primary components, both of which operate through the use of a smartphone's built-in sensors: distance and heading. Distance uses the phone's accelerometer to determine an individual's stride length and step count. When a user takes a step, the accelerometer senses a spike in acceleration forces. Irrelevant motion is also filtered out for more accurate results. The heading estimation functions through the analysis of information from the accelerometer, gyroscope, and magnetometer, which yields orientation. The gyroscope and magnetometer use the change in axis and magnetic field, respectively, to calculate the change in direction. By combining these components, an indoor positioning system is created that takes a step towards a more advanced location services system.

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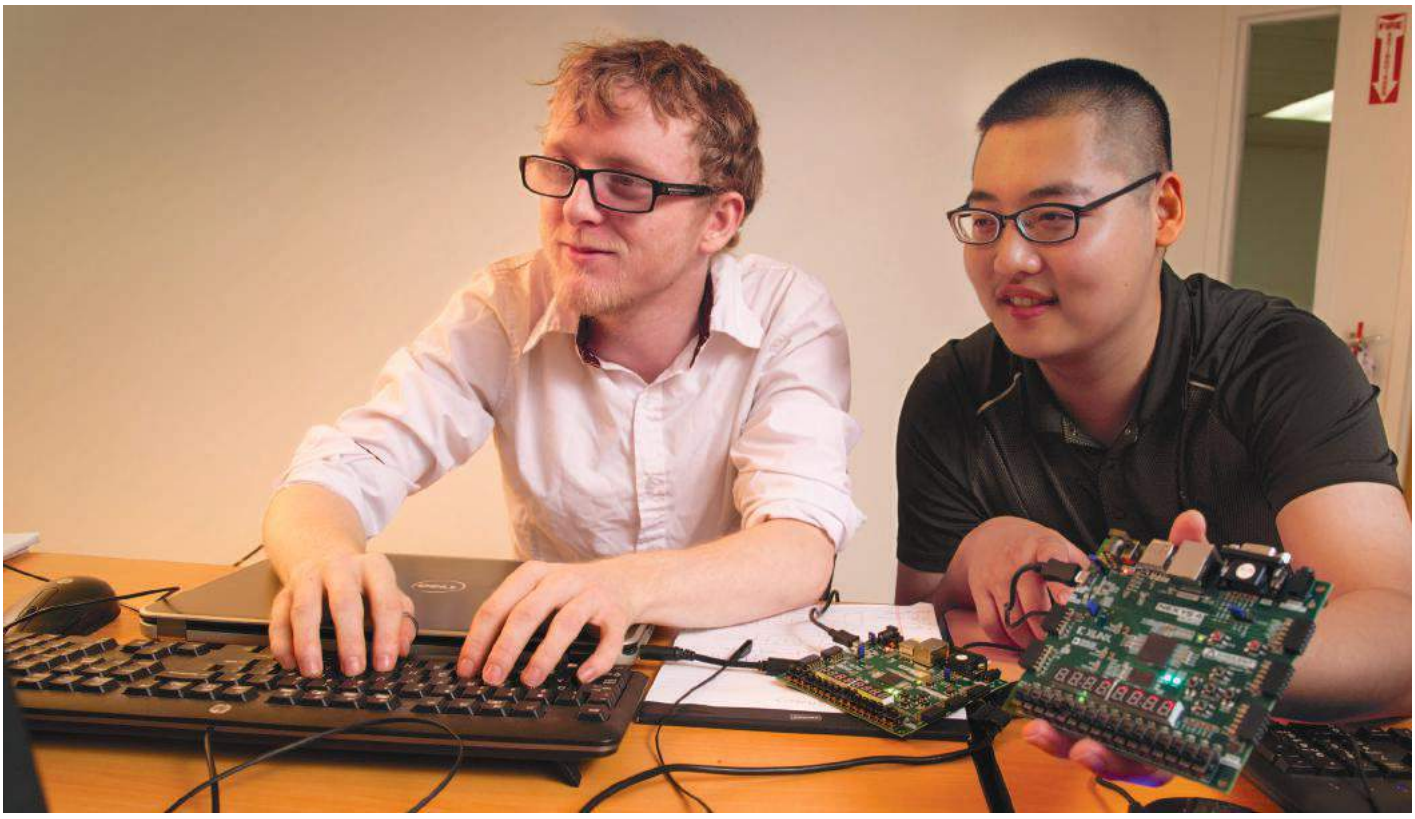


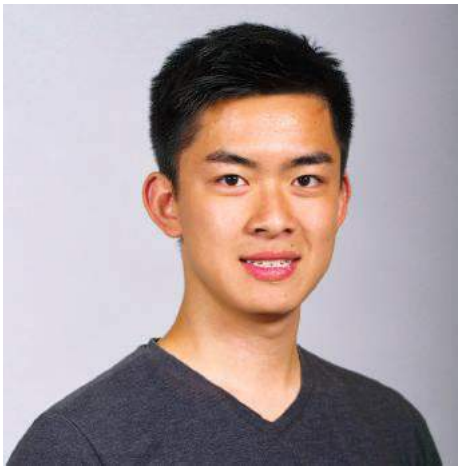
▲ To improve system performance, Kenan Millet, Xikun Yuan (pictured left to right) and Ana Bolsoni (not pictured) collaborate to convert apps into modules and reconfigure them.

RECONFIGURABLE SOFTWARE ON RECONFIGURABLE HARDWARE

Reconfigurable computing, often taken as running an application (app) on reconfigurable hardware, can also apply to traditional computer systems, where our work extends the meaning to simultaneously run this app on both traditional computer systems (software) and reconfigurable hardware (software or hardware) and more as explained below. Reconfigurable hardware, by using commercially available field programmable gate array (FPGA) chips, has gained ground against traditional computers in such areas as scientific computing, high-frequency stock trading, network processing and cloud computing. Today's FPGAs provide a faster running environment for applications; memristor and spin-based nano implementations may completely displace traditional computers as these systems can adapt/learn by themselves at run time.

We propose that any app can be decomposed into pieces, where we can reimplement each piece on traditional computer software, pure hardware with the use of FPGAs and also on a heterogenous system with both software and hardware tools. In the first phase of the project, the Gomoku game app is developed in a modular way, where a module is a piece. The modules are written in C++ using Qt application to run as software on the computer and on the reconfigurable hardware, and in Verilog using Vivado Design Suite by Xilinx to run as hardware on the reconfigurable hardware. A Microblaze softcore on the Xilinx FPGA chip implements the communication between the FPGA chip and the PC.

We plan to emulate moving modules around by activating/deactivating the modules manually. Additional modules are developed to support the environment, such as a data hub that connects the active modules. Subsequently we will develop a new app and a more robust way to select and connect these modules. We plan to continue the work to also implement composing/decomposing of modules autonomously and requiring less manual control.



RAYMOND FOK

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PORTING AND PACKAGING SEATTLE TESTBED FOR OPENWRT

Seattle Testbed is an open-source, peer-to-peer platform designed to enhance networking and distributed systems research. Established on the resource donation of users and institutions worldwide, Seattle's global distribution makes it ideal for applications in cloud computing, networking, and ubiquitous computing. Users can install Seattle for code experimentation in a safe and contained sandboxed environment, limiting the consumption of resources such as CPU, memory, storage space, and network bandwidth, and ensuring that the tested programs are isolated from other files or programs. These characteristics allow distributed code testing without compromising the machine's performance or security.

Our goal is to deploy Seattle on OpenWrt, an extensible Linux distribution for embedded devices designed to offer users a full customization of their wireless routers. It includes a fully writable filesystem with a package management system to free the user from the restrictions of vendor application selection and configuration, and a cross-compilation toolchain to build executables across architectures. Compared to computer and mobile environments, modern routers offer limited computational resources and require an optimization of the minimal flash storage available. Solutions include customizing a lightweight image with OpenWrt's Image Generator or mounting an external filesystem on a USB. A previously explored deployment option for Seattle involves building an IPK, a compressed archive file that could then be installed via OpenWrt's package management system. This approach benefits from the built-in dependency and install location tracking. This project investigates a different deployment approach, using Seattle's Custom Installer Builder to package Seattle's base installers into a tarball for shipment alongside other platforms, with its dependencies managed separately.

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FITNESS BAND PRIVACY

With the advent of modern fitness tracking technology, many people have started relying on fitness bands to track and record their fitness information. As opposed to previous fitness tracking devices which store fitness information locally, many of these new fitness bands have been designed to be paired with mobile devices through which fitness information is sent to remote servers so that the data is able to be displayed in multiple interfaces. This is typically done over a Bluetooth connection, where the fitness band sends the fitness data that has been recorded to a phone that has the corresponding application for the fitness band installed. The fitness data is then sent from the phone to the remote servers over the Internet, at which point the user is able to access the fitness information any time. In order to determine what and how data is transmitted from the band to these remote servers, various methods will be utilized to intercept traffic sent from and received by the phone. Additional tools will also be used to analyze how the application on the phone has been implemented. This will be repeated for various fitness bands made by different companies, and ultimately, these techniques will lead to a better understanding of how a variety of fitness bands and applications have been designed.

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EXPLORING FACEBOOK USING NATURAL LANGUAGE PROCESSING

In the 12 years since it was created, Facebook has amassed over 1.6 billion worldwide users, and this number is continuing to grow. However, there are many people who choose not to use specific features of Facebook, or do not use the service altogether. This project investigates the reasons for Facebook non-adoption by looking at comments and responses of Internet users as posted publicly on various blogs and forums. Comments are analyzed using Natural Language Processing and Web Scraping techniques, with the goal of identifying the various factors that contribute to non-use. Early findings indicate that many individuals are against using social media due to the risk of privacy violations and data misuse, while others state concerns around productivity, social pressure, and banality. The research will involve delving deeper into online comments to build a detailed and refined insight regarding these factors. These results will build on previous work to show the perceived lack of privacy users receive on social media and provide us with better understanding of online sociality.

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LEGAL DATA FOR PRIVACY IDEATION CARDS

Privacy in the current times of big data and massive internet outreach became an important source of concern for people and developers. In the software design process, many times privacy isn't addressed until the end of the design development. Also, laws and regulations around privacy can be difficult to understand and implement, especially to those without a legal background. A set of privacy ideation cards are being developed as a tool to be used by groups of designers and developers to apply privacy concepts to systems design. My project consisted of helping the main researcher (Lesley Fosh) with some aspects of these cards, in regard to its legal aspect.

The cards would be built upon a legal survey made with privacy law experts, and its effect tested on software design workshops. The survey would consist of privacy principles, with questions about the importance and legal enforcement of each. After presenting designers with the cards and analysing their response to it, we could conclude on how having these concepts given before the design process would build toward a privacy compliant design.

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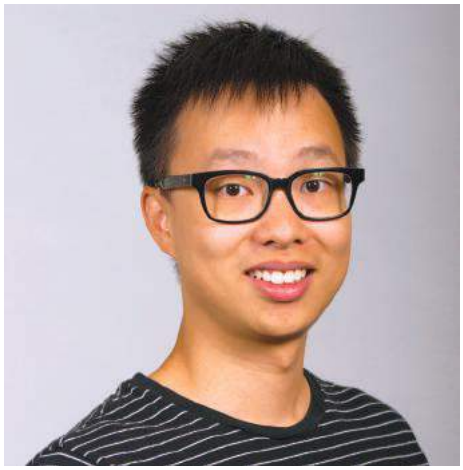
PROFILEINFO

In a rapidly evolving and constantly changing online environment, privacy has emerged as one of the major challenges to be dealt with. In addition, the shift to an interactive online experience increases the need for individuals to reveal personal information. In order to access contemporary services, individuals should have an incentive to provide a sufficient amount of data in order for these services to be delivered, but should not feel that their privacy is being compromised. This project investigates how an individual's information disclosure behavior varies depending on the company asking for their personal information. The project looks at the types of information being requested and the individual's familiarity and trust for the company requesting the information. We created an online survey tool that compares participants' familiarity and trust for a company with the degree of accuracy with which they complete a personal profile for that company's website. The data will allow us to determine the disclosure behavior of online service users based on the context in which information is being requested. The results are expected to help future developers to design privacy management tools for applications involving sensitive information.

FORENSIC EMAIL SEARCH RESULT SUMMARIZATION

Finding connections in large communication data sets is a difficult challenge that requires enormous amount of time and resources. Criminal investigators often have to navigate through hundreds of thousands of emails, text messages, posts and tens of thousands of unique users. In this project, we create a dynamic visual analytic tool to assist in these investigative efforts. This tool, called Beagle, will allow the user to filter the data set by user IDs, specific words, frequency and various other combination of filters to transform these queries into two major components. The first, will encompass structured results such as word summaries of the most frequent significant words and the most relevant documents. The second, which is the focus of the tool, is to present a graphical representation of the social network and the contents of the results from the query to further assist in the understanding of the data.

The graphical component will provide users with a new perspective and draw connections that would otherwise be missed with word summaries alone. Users will be allowed to expand on the graph by focusing on nodes which represent relationships in the data. Using a graphical language database, the graphical component will be updated in real time as users add on to the query stream. By providing an efficient tool in analyzing these data sets, the time used in investigations can be drastically reduced while increasing in productivity. Future work will involve improving the UI/UX of the tool and researching the effectiveness of this technique.



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CARDS WEB INTERFACE

It can be difficult for software engineering students and professionals to apply privacy principles to systems design, since regulatory language can be difficult to apply to real-world projects, and there can be a lack of training in privacy compliance for both students and professionals. To tackle this problem of making privacy compliance more accessible, a deck of "privacy ideation cards" has been developed to help systems designers and developers to consider how to best comply with US privacy guidelines, laws and regulations. To date, the ideation cards developed for US-based projects have only been used in research settings, however, making the cards publicly available will increase the number of people who will be able to access the cards and use them to create privacy compliant system designs. This project develops a website that will make the cards available for anyone to download and use. In particular, the project develops an interface for users to create a set of ideation cards specific to the types of projects they may work on, and will also communicate the research findings, generating impact outside of academia. By the end of this project the website will showcase the ideation cards and the findings of NYU's research around it. It is expected that this website will make US privacy principles, laws and regulations more accessible to students and professionals involved in software development, resulting in privacy compliant systems that are safer for future users.

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DISTRIBUTED MONITORING SOLUTIONS FOR THE SEATTLE TESTBED

Seattle Testbed is an open-source, peer-to-peer cloud computing platform that operates on shared resources of computers donated by users and institutions worldwide. By providing a safe and contained environment with support for multiple platforms, Seattle enables its users to run their test codes in a sandboxed environment that limits the consumption of resources and, hence, allows the users to run experiments without compromising the host machines. Each machine running Seattle in this manner is called a vessel. The processes of distributing resources and maintaining all functions of Seattle depend on three central infrastructure components of the testbed: Seattle Clearinghouse, Custom Installer Builder, and Software Updater.

The purpose of this project is to build a suite of monitoring tools for the entire Seattle infrastructure. The targets to be monitored includes the three central components as well as the advertise service. The Seattle Clearinghouse relies on the advertise service to announce a user-specific public key to track and propagate the donated resources. The Custom Installer Builder allows the users to customize the configuration of their vessels. The Software Updater assures that the latest Seattle is available to the users. The design criteria of the monitoring tools include the metrics, the locations where the tools run, the users of the tools, and the notification system. Although a few of the monitoring processes have already been implemented in the integration tests library, access to these tests is limited to the system administrators. This project is to implement the monitoring tools such that public users can also check the status of all components directly on the command shell. Because Seattle is deployed on over 20,000 computers worldwide, increasing the accessibility of the monitoring tools will increase the overall scalability of the platform.

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A PRIVACY INCIDENT DATABASE

A privacy incident refers to an occurrence of personal data compromisation, disclosure or unauthorized acquisition. Examples include the unauthorized access to social security numbers by online hackers, or the unauthorized collection of information by a software enterprise. By analyzing trends in privacy incidents, it is possible to gain the insight needed to combat such events. This project contributes to a database of privacy incidents that makes such an analysis possible, by drawing upon existing documentation in news articles and online communities.

The project seeks to automate the collection, classification, and analysis of privacy related news articles in the database by employing technologies commonly used in the field of data and text mining, including natural language processing, topic modelling, and machine learning. The iterative development of the database is expected to increase its robustness, while ensuring it is capable of supporting complex tasks such as trend identification. Some measures we are taking towards this goal include expanding the textual context of incidents already in the database, and working with privacy ontologies to classify these incidents in the academic domain of privacy. The project will develop a robust and versatile dataset for researchers, journalists, and privacy specialists to evaluate and engineer the privacy policies and technologies of the future.

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ELECTRICAL AND COMPUTER ENGINEERING

DEVELOPMENT OF NAVIGATION AND CONTROL ALGORITHMS FOR UAVS LANDING ON MOVING TARGETS

Unmanned Aerial Vehicles (UAV) have numerous applications due to their low cost and applicability to many situations where a human pilot would add unnecessary complexity to a system. In particular, quad-rotor UAV platforms are highly maneuverable and mechanically simple. It is the intent of this project to develop a quadrotor for purposes of detecting and landing on a moving object. Such application may arise in coordinated maneuvers among UAVs with other ground vehicles or for purposes of using the ground vehicle for recharging the batteries on the UAV or delivering a payload. The current project goal is to autonomously detect the ground vehicle and its landing pad using only camera(s) on-board the quadrotor. As the first step, a new airframe for the quadrotor is developed using laser-cutting and 3D printing methods of manufacture, and weight distribution is optimized to create a better balance between ease of assembly, reduced parts count, vehicle stability and maneuverability in the expected flight environments. Additionally, an adjustable landing gear system is developed with a suspension system, in order to absorb any excessive difference in velocity between the UAV and moving ground vehicle at the final phase of landing and touchdown. Additionally, inner-loop control and navigation algorithms are developed to robustly estimate vehicle position and orientation, and satisfactorily track velocity and orientation commands from aforementioned path-planning algorithms in all flight regimes. Potential issues such as sensor noise, actuator bandwidth limitations and limited processing power on-board the UAV are tackled, and robust solutions developed and validated in simulation, flight-like and in-flight environments. In addition, embedded software and firmware is developed to handle timing, telemetry, command and data handling as well as range safety to ensure consistent, stable flight and monitoring of all critical system parameters. Interface software is developed in order to relay data between a real-time control unit, high-level single-board Linux computer and remote ground station.

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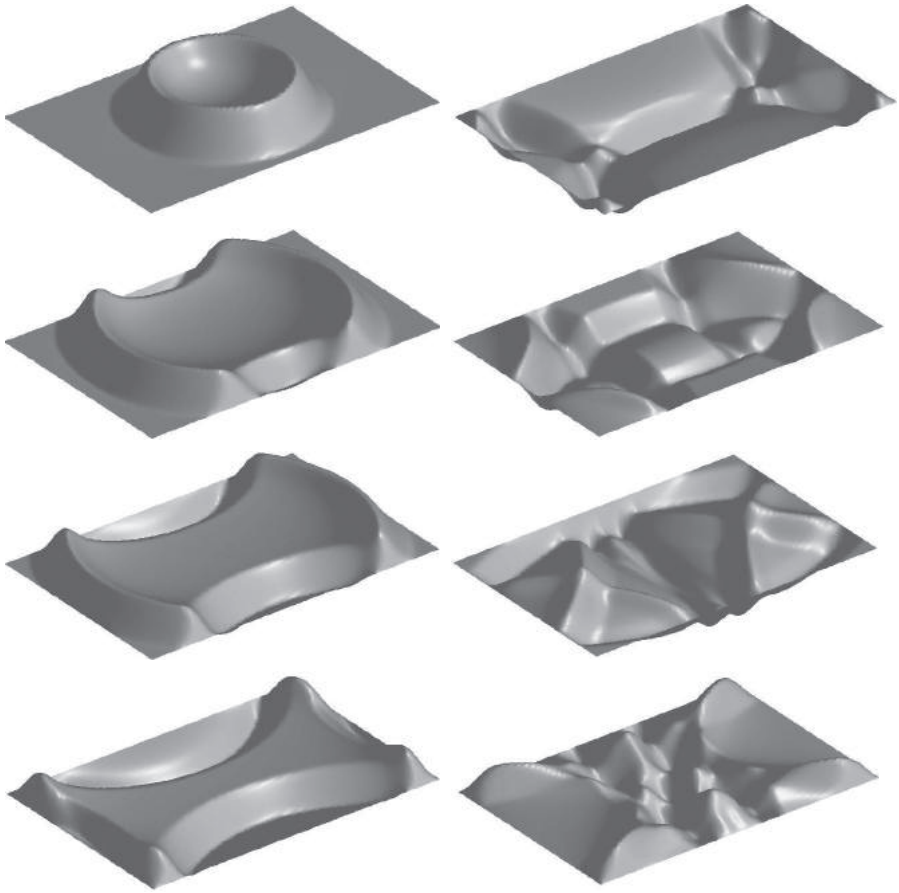
FOUR DIMENSIONAL SOUND SYNTHESIS

The functional transformation method (FTM) allows for transformations with respect to time and space and helps to model sounds of musical instruments that can be described by partial differential equations (PDEs) such as a string or a drum. A string vibrates along two dimensions (space and time) whereas a drum vibrates in 3 dimensions (time and two spatial dimensions). Various parameters, i.e. the coefficients for PDEs, can be utilized to model a sound of a specific instrument. For example, a string would include parameters such as stiffness of the string and string length. Each instrument also has specific zeroes and poles that correspond to the Fourier transform of its PDE which also has to do with the sound that is produced. Together, the parameters and the poles of the PDE help create the unique sound of the instrument.

The purpose of this research is to develop a way to traverse the dimensions of sound, and assimilate to higher dimensions of sound that cannot be physically produced. The implementation of these equations will be done in real-time, using Python. In order to carry out the implementation, we first derive the appropriate PDE for the string. Next, we apply the FTM to account for another dimension, producing the sound of a drum. This allows for the morphing of the sound of a string and a drum. Furthermore, utilizing the FTM again will allow for the addition of another dimension to produce 4-D sound.



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PATH PLANNING FOR A QUADROTOR TO DETECT AND LAND ON A MOVING TARGET

In recent years, the prevalence of Unmanned Aerial Vehicles (UAVs) in several applications has been increasing. A UAV can be remotely controlled by a pilot on the ground or can fly autonomously based on a pre-defined flight plan which is specified to its autopilot. Among the diverse categories of UAVs, quadrotors are characterized as having four propellers making them highly maneuverable. This project focuses on developing a time-optimal path planning system to search for a target moving on a specific path at a constant known speed (but unknown initial location on the path) in a specified geographical area, approach the target, and land on the target. Thus, the project may be defined as three phases: 1) search and detection, 2) approach, and 3) landing. The UAV's kinematic and dynamic constraints are considered in all three phases for the UAV's path planner. A simulation platform is developed to test various algorithmic approaches for this purpose. The geometry of the path is utilized to minimize the overall mission time. The moving object is detected using optical flow techniques based on data from a gimbal-mounted camera. From the camera-based estimates of the target position and heading, the optimal location at which to approach and land on the target is determined. Numerous simulation studies have been performed to validate the efficacy of the approach.

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OCT DATA-BASED APPLICATION OF CORRELATING RETINAL THICKNESS AND CONTRAST SENSITIVITY IN PARKINSON'S DISEASE

Optical coherence tomography (OCT) has proved to be remarkably useful in clinical study of the human retina. Our research stems from the work of Ding et al, where a detailed mathematical model was developed based on raw OCT data to allow differentiation of foveae of patients with Parkinson's disease (PD) from healthy controls [1]. A correlation of inner-retinal thickness as seen on the OCT, and functional visual (contrast sensitivity) changes was shown in a small study on PD by Adam et al [2]. Our studies focus on using data from OCT scans that focus on the Outer Nuclear Layer (ONL) of the retina using MATLAB. By measuring the thickness of the most concave part of the ONL, we can potentially use this information to make an even more informed diagnosis of PD in patients.

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MODELING, CONTROL AND TESTING OF CLOUD-ENABLED QUADROTORS

Autonomous robotics and feedback systems that use the environmental behavior to dictate the behaviors of the robot itself is an upcoming field of engineering, and fortunately these systems can be used to solve a wide variety of problems. The wide variety of problems include the autonomous driver-less car, robotic surgery, robotic 3D printing, and many other autonomous futuristic engineering problems. Programmed to model a certain system, autonomous robotics require algorithms which deal with issues that are expected and unexpected. The need for solving unexpected issues then involves using natural deceptive behaviors to form algorithms.

In this research project, the multiple ways for a robot to work autonomously and solve a set of issues are explored. Using a simulated cloud environment, gathered data from the robotic environment using sensors from the Qbot2 were executed in pre-built algorithms and tested for efficiency. The Qbot2 is a ground robot from Quanser which models a robot in the real-world. The algorithms were tested by simulating experiments on the Qbot2 such as detecting an edge on the floor and finding certain obstacles using their color. If the algorithms had a good success rate and computational time, it was deemed as efficient.

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USING COMPUTER VISION AND IMAGE PROCESSING FOR OBJECT IDENTIFICATION IN A CLOUD-CONTROLLED REFRIGERATOR

The primary purpose of this project is to utilize Computer Vision and Image Processing technologies to identify groceries in a refrigerator. Computer vision is integral to the navigation of autonomous vehicles, the effective recognition of license plates by automated traffic cameras, and is the underlying technology in face, gesture and handwriting recognition, among other broad ranging applications. In order to carry out the task at hand, images of individual grocery items within a dataset are analysed to determine their prominent features. This would also extend to extracting text from images in order to identify labeled boxes and containers with a generic shape and colour. Subsequently, internal images of a refrigerator are taken and the process of feature-matching is used to identify individual contents of the refrigerator. This project also explores cloud-based control of the refrigerator, which entails determining groceries going out of stock and placing a direct online order for more items, deducing the expiry date of items by either extracting text from labels on boxes or containers or by keeping track of how long individual items have been kept in the refrigerator and consequently issuing alert messages to the user, as well as offering health related advice to the user based on a high-level analysis of the contents of the refrigerator.

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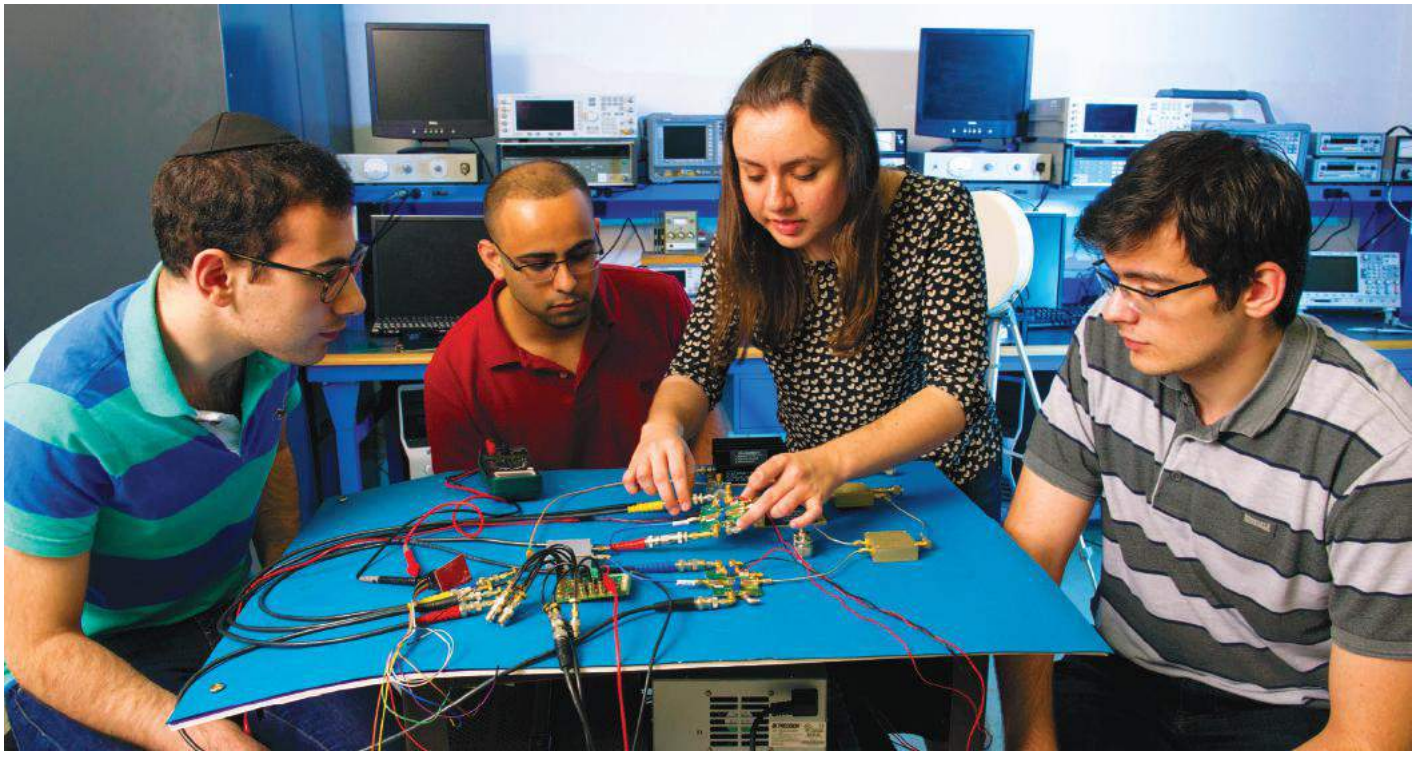

▲ Dov Salomon, Shivam Suleria and Enes Krijestorac (pictured left to right) work with their mentor, Fraida Fund (second from right), to devise wireless technology advances.

DOUBLING CELLULAR CAPACITY WITH FULL DUPLEX COMMUNICATION

Wireless networks already struggle with data heavy services such as video and games. Furthermore, according to CISCO the number of mobile-ready devices is expected to reach 11.6 billion by 2020, roughly a 50% increase from 2015. Drastic and immediate advances in wireless technology are necessary to keep up, as incremental improvements will not suffice to satisfy demand.

Full duplex technology promises to increase wireless data rates up to twofold without requiring more spectrum, by enabling simultaneous transmission and reception. However, to use full duplex effectively, we must reevaluate the protocols developed for current wireless networks. Full duplex can increase interference between devices; moreover, full duplex transmission creates self interference, in which the much stronger transmitted signal makes it difficult to recover the relatively weak received signal at the same device. Thus, the determination of which devices in a network transmit or forward data at a given time must be reconsidered.

Our research explores full duplex communication in several contexts. For wireless networks made of small cells, we identify environmental conditions under which full duplex gains are greatest, and apply those insights to improve performance in settings that currently have less full duplex gain. We also consider small cell networks where either full duplex or half duplex relay-assisted communication may be used. Finally, we investigate decentralized networks, where a user's decision about transmitting and forwarding traffic may increase its throughput at the expense of other users', and model the impact of full duplex on the payoffs associated with such non-cooperative behavior.

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UNDERSTANDING INTERDEPENDENCIES IN THE CONTEXT OF FOOD SECURITY

Food security is an important issue, and many efforts have been taken in different parts of the world to achieve food security in places where resources are scarce. It includes the utilization of resources such as water inputs to food, and different energy fuels involved. The effective management of resource systems is described as nexus interactions, and describes the linkages between countries involving two or more systems with intersectoral flows. The purpose of the project is to understand the inter-dependencies between the food, energy and water (FEW) sectors, in particular the interdependencies between the energy and food sectors on the issue of food security. Data from input-output table values of India and the United States is used to model a connected network showing the domestic and international sector inter-dependencies and the economic impact between sectors by modeling disruptions to the sectors. The paper focuses on the impact of electric power supply on the availability of food making use of the closeness centralities in I-O networks and the concept of betweenness.

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ANALYZING SECURITY, PRIVACY AND TRUST IN THE CLOUD-BASED INTERNET OF THINGS

The Internet of Things foresees a highly networked future, where every object is integrated to interact with each other, allowing for communications between objects, as well as between humans and objects, which enables the control of intelligent systems in our daily lives. As the boundary between humans and machines gets blurry, more focus is needed in order to provide security, privacy and trust solutions. Since IoT devices are not only monitoring, e.g., through sensors, but also controlling physical objects, e.g., though actuators, the impacts of security attacks can be devastating including serious safety impacts, as in the case of connected vehicles and smart Healthcare. The project aims to explore the security, privacy and trust vulnerabilities inherent in the infrastructure used to build the existing IoT applications. As more and more devices have started relying on cloud-enabled technology to outsource complex computation, cloud security concerns such as ciphered-only and message modification attacks have increased drastically. Using the smart-traffic system application, inherent vulnerabilities such as eavesdropping, unauthorized access and data modification will be explored and different possible models to tackle these problems will be analyzed. Similarly, the applications of IoT will be analyzed for anonymity, unlinkability and data secrecy. Suggestions will be made towards the end about the areas in this field that require future research.

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URBAN CROWD-SENSING FOR URBAN POLLUTION MONITORING

Air pollution is the contamination of the air with harmful substances known as particulate matter such as smoke, soot, nitrogen oxides, sulfur dioxide, etc. Pollution caused by particulate matter can be very deadly if left ignored. Particulate matter, when inhaled, can enter the lungs and bloodstream causing a plethora of diseases including but not limited to respiratory infections, asthma, heart disease, and in extreme cases lung cancer.

Current air quality data is provided from static monitoring stations. Although this is an effective method, it is costly and only provides data from the specific areas the monitoring stations are located. The purpose of this project is to demonstrate an urban crowd sensing application for monitoring air quality through the use of wearable sensors (the Air Beam) and mobile phones (Air Casting App). Air Casting allows for a context-aware and energy efficient collection and filtration of the Air Beam sensor data in a mobile environment. It also ensures proper sensing coverage. The data collected will be used to obtain a real time pollution map for New York City. Having real time pollution data will allow individuals to take less polluted routes to their destination. It can also help identify possible sources of pollution in heavily polluted areas.

MATHEMATICS

OPTICAL VORTEX SOLITONS: EXISTENCE AND COMPUTATION

Through the late ’60s and early ’70s mathematicians and physicists became interested in solutions to nonlinear partial differential equations, or field equations. Many of these field equations possessed solutions which exhibited particle-like properties such as localization in space and hence these solutions were named solitons. Solitons are travelling packets of energy that do not change shape as they move. In this project we study a specific class of solitons known as optical vortices which arise physically from light passing through an optical medium, and mathematically from an analysis of the Nonlinear Schrödinger equation. Optical vortices are a “twisting” of light waves along the axis of travel causing destructive interference at the axis itself. This gives optical vortices their ring shaped profile. This phenomenon occurs when there is a balance between the nonlinear effect of the field equation, and diffraction of the medium. Optical vortices are governed by the nonlinear properties of the medium that they are propagating in, such as pure Kerr nonlinearity, saturable nonlinearity and cubic-quintic model.

In this project we study different nonlinearities to establish the conditions for the existence of stable optical vortex solitons and to numerically compute their solutions which will enable us to further understand the various properties of the medium.

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DNA BREATHERS - EXISTENCE AND COMPUTATION

Deoxyribonucleic Acid (DNA) denaturation is the process in which temperature fluctuations cause DNA strands to unwind and separate. In order to understand this process, physicists have derived various Hamiltonian dynamical models accounting for the thermodynamical splitting of DNA. Understanding the denaturation process is helpful in understanding other DNA processes such as transcription, which incorporates denaturation as a step. It is hypothesized that DNA breathing, the formation of localized finite-amplitude oscillations, is the precursor to denaturation. Hence, our overall goal of this project is to find conditions for the existence of breathing solutions in our models, and to numerically simulate these solutions so as to gain physical insight into our system.

Most of the mathematical models of DNA stem from the Peyrard-Bishop model, which takes into account temperature when analyzing the breathers. Other models use different coordinates and factors to create a more accurate and precise representation of the DNA. For example, there are various models which take into account the helical geometry of the DNA strands, as well as other models which account for environmental factors such as external temperature sources.

Our goal is to use global functional minimization and calculus of variations methods to give conditions for the existence of breather solutions. Once we prove that breathers exist, we will numerically simulate them using constrained minimization tools in MATLAB. This will help us gain both mathematical and physical intuition on our various DNA models.

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MEASURING THE DISCREPANCIES BETWEEN CLIMATE MODELS IN REGARDS TO CURRENT CLOUD DATA

For over 30 years, scientists have known that the inability to accurately model climate change and to quantify the extent of global warming is primarily due to the unpredictable changes in clouds from the anthropogenic influx of greenhouse gases. Clouds provide both positive and negative feedbacks to climate change. While they exert a warming effect by radiating the infrared energy back to the surface of the earth, they also provide a cooling effect by reflecting the sunlight, also known as the albedo effect. The amount in which they provide a positive and negative feedback vary depending on the types of clouds and their altitudes, adding to the difficulty of climate modeling. According to the Intergovernmental Panel on Climate Change (IPCC), the net effect of clouds on the earth's radiative balance is negative with a magnitude ranging from 10 to 20 W/m^2 due to the albedo effect. However, uncertainties in cloud feedback still remain when considering the expected anthropogenic greenhouse forcing. This study will explore a variety of acknowledged cloud models and compare those models using mathematical models.

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CLIMATE MODELING USING THE MAHALANOBIS-TAGUCHI SYSTEM (MTS) FOR SOIL CARBON ANALYSIS

The Earth's carbon cycle is the process by which carbon is exchanged among the Earth's three carbon pools namely the atmosphere, ocean and land. It plays a vital role in keeping the Earth's carbon system in equilibrium and thereby acts as a thermostat, helping to maintain a relatively stable global climate. However, human activities have increased carbon emissions in the past few decades to unprecedented levels and are threatening to disturb the equilibrium of the Earth's carbon system. Soil, a key element of the land carbon pool is estimated to store more carbon than the atmosphere or the ocean surface and can be used as an effective carbon sink in the fight against climate change.

The amount of soil carbon (both organic and inorganic) and the net carbon sequestered are affected by a number of factors. The research project will investigate these factors by applying the Mahalanobis-Taguchi System (MTS), a multivariate data analysis approach, and identify the variables that are most influential in determining the net soil carbon sequestration effects. Existing field data from different government and non-governmental soil databases will be gathered and summarized for this purpose. Since land-use changes substantially alter the soil carbon content, these changes will also be explored using climate models by simulating different land-use scenarios.

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HEAT VULNERABILITY INDEXES FOR URBAN ENVIRONMENTS USING THE MAHALANOBIS TAGUCHI SYSTEM

There is a general consensus amongst the public health community that rising temperatures, due to Climate Change, will correlate to a rise in the number of people being admitted to hospitals for heat related illnesses. Identifying neighborhoods most at risk of suffering from these illnesses will allow public policy leaders to better allocate resources in efforts to mitigate the impacts of Climate Change on the population. Previous studies have been done to assign areas with an indicator of risk, such as heat vulnerability indexes, but none to our knowledge have utilized the Mahalanobis Taguchi System. MTS is a multivariate statistical method with high sensitivity to inter-variable correlations. By separating a dataset into at-risk and not-at-risk samples, MTS can be used to estimate the degree of separation between the two groups via their Mahalanobis distances. Our focus, in this project, is to utilize MTS in an attempt to designate effective heat vulnerability indexes for the five boroughs of New York City.

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INVESTIGATING THE ROLE OF NUCLEAR ENERGY IN CLIMATE CHANGE MITIGATION

Carbon dioxide is emitted in the construction and maintenance of a nuclear plant during its life cycle. This project focuses on calculating the carbon footprint of the entire nuclear power plant life cycle, including uranium mining, extraction of uranium from ores, enrichment, chemical treatment, fuel transportation, construction, operation, maintenance, refurbishments, decommissioning, dismantling, and disposing of spent fuel. The carbon footprint of nuclear power is then compared to other sources of energy, such as coal. Furthermore, the CO2 footprint of building a nuclear power plant in various geographical areas is also compared.

By analyzing the carbon footprint of various energy sources and in different geographical regions, we can better understand humanity's contribution to climate change. This analysis can aid in making energy source decisions in the context of climate change.

Calculating the amount of emitted CO2 from the life cycle of a nuclear plant aids in keeping track of how much CO2 is emitted into the atmosphere. A nuclear reactor does contribute to the atmospheric CO2 levels; however, closing down a nuclear plant has some of the same effects as the burning of fossil fuels, which will create potential private and social consequences.

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CALCULATING CLIMATE CHANGE CAUSED BY SURGES OF METHANE

The radiative forcing of methane is thought to have a strong effect on climate change since it absorbs infrared light that would otherwise leave Earth's atmosphere. Many climate models of the radiative forcing of methane exist today. The models created in this experiment explore the impact surges of methane whose quantities are derived from values existing on Earth today such as total stored methane in US, estimated regional methane leaks, etc. have on Earth's climate. The weight of the methane is converted into the CO2 equivalent in million metric tons in order to calculate methane's increase in parts per million (ppm) in the atmosphere. The details of the results of the simulations will be presented.

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MECHANICAL AND AEROSPACE ENGINEERING

EFFECTS OF GENETIC MODIFICATION ON BONE MECHANOADAPTION AND REPAIR

Human bone tissue has the unique ability to remodel itself based on where it is needed in response to mechanical stimuli. Understanding the regulatory mechanisms behind bone remodeling can allow for manipulation of them in order to yield a higher quantity and quality of bone. In this study, the role of stromal cell-derived factor 1 (SDF1), otherwise known as CXCL12, is under investigation. CXCL12 is a chemokine that is hypothesized to recruit stem cells to an injury site.

This hypothesis is being tested by knocking out the CXCL12 gene in bone and observing its effect of bone homeostasis and repair. The effects of gene knockout will be observed in mouse tibiae under the following conditions: (1) normal ambulation, (2) application of an exogenous dynamic load, and (3) during bone repair. All experimental groups will be compared to littermate wild-type controls. Firstly, the knockout must be confirmed by using immunohistochemical (IHC) staining to identify cells expressing the CXCL12 protein in the mice. The staining will be done on sections of tibia embedded in paraffin. Additional staining will be done for vascular cells using the antibody against PECAM and for proliferating cells using an antibody against PCNA to observe the presence of these species under the three aforementioned conditions. The target species in each staining procedure will be highlighted with DAB and the nuclei of all cells within the sample will be labelled with the fluorescent chemical DAPI. After staining, the number of cells expressing the target in the tissue samples will be quantified using ImageJ. Results from these studies will improve our understanding of the role of CXCL12 in bone metabolism and repair and aid in the development of novel treatment strategies for bone loss and injury.

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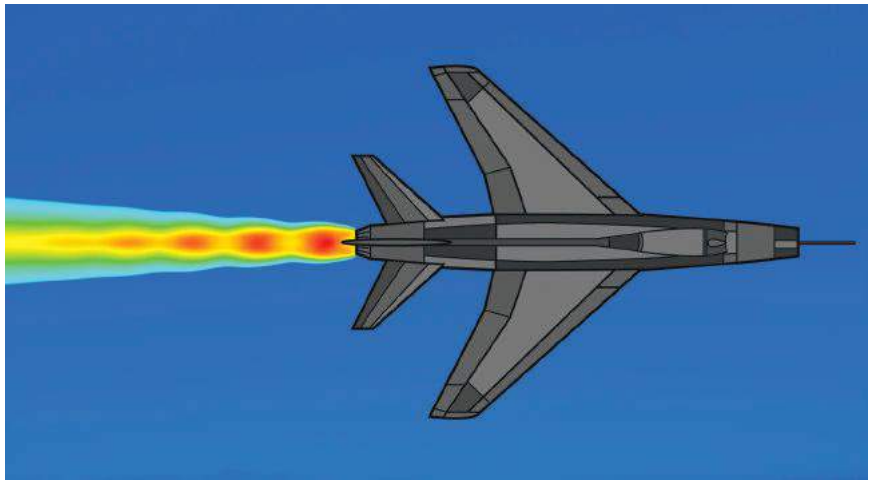
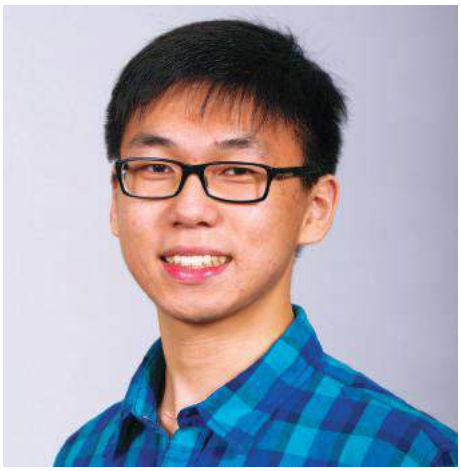
EFFECT OF MICROJET FLUIDIC INJECTION ON COLD AND HEATED SUPERSONIC JETS

Supersonic jets have been of particular interest of many theoretical and experimental studies. Mixing enhancement of the supersonic jets has extensive applications in the operational environment of supersonic aircrafts, such as reducing the jet noise radiation. Various methods have been implemented in the past in attempt to enhance mixing of the supersonic jets with the surrounding ambient quiescent air; among all, incorporating fluidic injection has shown the most promising results. High temperatures of the exhaust jet plum of supersonic aircraft can influence the jet noise radiation. Therefore, examining the effects of varying temperatures on development and mixing of supersonic turbulent jets can improve our understanding of possible jet noise reduction techniques. The objective of the present research is to investigate the effectiveness of microjet fluidic injection in promotion of supersonic jet mixing at varying elevated temperatures, consequently mitigating the jet noise radiation.

For this purpose, quantitative investigations were performed using the CFD code, ANSYS FLUENT to analyze the dynamics of a turbulent supersonic jet originated from a converging-diverging nozzle. In this computational study, the jet was produced by operating the nozzle at underexpanded conditions and the effects of augmented temperatures on the jet flow development were investigated for various temperature ratios. The flow field was solved using Navier-Stokes equations for compressible flow, while Reynolds-Averaged Navier-Stokes equations (RANS) as well as Large Eddy Simulation (LES) were used to model the turbulent flow across the domain. Flow field and turbulence profiles were examined for the heated jet cases and compared to those obtained from the cold jet in order to verify the effects of varying temperature on the jet mixing characteristics which consequently influence the jet noise radiation.





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DYNAMIC MODEL AND ENERGY EXPENDITURE OF ROBOTIC GAIT

With superior physical characteristics and greater resistance to fatigue, robots exceed the performance of humans in various activities, such as repetitive and heavy duty tasks. However, like humans, labor intensive tasks demand high power consumption in robotic systems. In order to optimize the motion for the task at hand, it is crucial to both model the robot's total energy expenditure and measure the power required to actuate each of the robot's degree-of-freedom. An inverse dynamics approach will be utilized to evaluate the energy expenditure of Dynamic Anthropomorphic Robot with Intelligence – Open Platform (DARwIn-OP) humanoid robot. Experimental data such as joint kinematics, physical properties, and ground reaction forces were gathered for a specific manner of walking, governed by a configuration of gait parameters. Through its dynamic model and the results for the generated gait, the actuation torque required to replicate its sequence of movement can be determined. Using this knowledge, the corresponding voltage and current associated with each degree-of-freedom can be used to validate the total power consumption of the robot while generating the gait motion.

▲ To optimize robotic function, Wenjie Chen (pictured left) is developing a system to evaluate the energy expenditure of humanoid robots.

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STATE OF CHARGE ESTIMATION OF MOBILE ROBOT CELL BATTERY THROUGH DUAL EXTENDED KALMAN FILTERING

In order to optimize the efficiency of mobile robots, a battery management system must estimate values and parameters descriptive of the battery pack's present condition. Our estimation mechanism notifies the battery state of charge and provides dynamic error bounds on the estimate. For this application, a circuit model is designed to capture the dynamics of a LiPo Battery cell through cell test data. To identify the dynamic parameters that best suit our model and the cell's state of charge, Dual Extended Kalman Filtering (EKF) is applied. Consequently, by integrating this EKF estimator to our *Dynamic Anthropomorphic Robot with Intelligence—Open Platform* (DARwIn-OP), the available power can be determined and the energy expenditure can be administrated accordingly for each of the robot's 20 degrees of freedom.

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3-D PRINTING PH SENSORS

pH regulation plays an important role on fundamental human activities, such as agriculture, cleaning, and preparation of foods and beverages. pH regulation and sensing is also a common task in biological studies and environmental monitoring of water bodies. To date, pH meters range from litmus paper, pH strips, and digital devices. The development of versatile and customisable pH sensors is still in the works. The aim of this project is to establish a tool for designing and 3D printing free-form pH sensors that would help biologists and environmental engineers meeting specific requirements of their laboratory and field experiments. This effort involves the development of a 3D printing process of soft polymeric materials that embed the Nile Blue A dye. Our results indicate that the intensity of the blue colour changes in response to pH, whereby the blue colour intensifies when immersed in basic solutions as opposed to lightening when in acidic media. These phenomena were further studied through UV-Visible spectroscopy. In our process, the dye is coated onto biodegradable PLA (Polylactic acid) pellets. The pellets are extruded into filaments that were then used to 3D print the pH sensors. The colour change of the 3D printed pH sensors was further studied using a video based detection systems developed at the Dynamical Systems Laboratory. The response time of the sensors was also investigated.

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PROMOTING BONE GROWTH THROUGH A VIBRATION TREATMENT

Osteoporosis, a disease prevalent in the elderly population and women after menopause, causes decreased bone strength due to bone mass reduction, which significantly increases the risk of bone fracture. A method to counter the effects of osteoporosis is to promote bone growth in patients. Studies have shown that exposure to low amplitude, low frequency vibrations can be effective in dampening the detrimental results of osteoporosis.

Current vibration treatments are typically delivered via a vibrating platform. This entails drawbacks, as the patient must make an appointment with a physician to partake in the vibration treatment or purchase expensive equipment to receive the treatment at home.

In this study, a vibration based treatment with the intention of promoting bone growth was investigated. Vibration treatment is delivered via a vibration motor embedded in a dedicated, medical shoe. The damping of the shoe is being characterized across different frequencies and amplitudes generated by the vibration motor. The frequency of these vibrations is modulated by a microcontroller while the amplitude is controlled by added mass to the shoe. Accelerometers, mounted at the sole of the shoe and where the shoe makes contact with the leg, are used to measure the relative amplitude of the induced vibrations. Results from this study will be included in further work characterizing the response of bone to the excitation from a shoe.

▲ Vladimir Pavlov is studying the efficacy of a lower-cost vibration treatment to stimulate bone growth in osteoporosis patients.

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A MECHATRONICS-BASED PLATFORM TO STUDY SYNCHRONIZATION

Synchronization is a ubiquitous phenomenon across natural and technological systems. While several breakthroughs have been made through mathematical models and computer simulations, robust experimental platforms to investigate the principles of synchronization are yet to be established. This project aims to develop a mechatronics-based platform to systematically study synchronization of coupled chaotic units, representing fireflies blinking or neurons firing.

The platform consists of a pair of metronomes connected to a moving base, which will be systematically blocked or released to simulate intermittent coupling. The moving base is blocked by a clamp connected to a microcontroller, enabling fine grained control of when the metronome oscillations are coupled. By investigating different strategies for blocking and releasing the moving base, the conditions under which synchronization of the metronomes occurs is elucidated.

Physical characteristics, specifically internal damping and coupling strength, of the metronomes are being determined by comparing experimental oscillations with numerical simulations validated against published results. Trajectories for the actual metronomes are obtained from video recordings of the metronomes oscillating. The recordings track a large black dot affixed to the end of the metronome oscillating at a fixed frequency of 200 beats per minute. Results from this research are being used to characterize the system of intermittently coupled metronomes.

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EFFECT OF ETHANOL CHRONIC ADMINISTRATION ON SOCIAL BEHAVIOR OF ZEBRAFISH

Zebrafish are becoming an increasingly popular alternative to laboratory mammals for the investigation of several biological processes. Similarities between fish and us, humans, are staggering, opening the door for conducting prospective hypotheses-driven studies on social behavior in a laboratory setting. A deeper understanding of social behavior in zebrafish may help the design of experimental models and protocols, aiding the comprehension of the fundamental mechanisms behind the onset of human neurobehavioral disorders.

This project seeks to understand the role of psychoactive compounds, such as alcohol, on social behavior. Specifically, we are investigating how exposure to chronic concentrations of alcohol influences zebrafish and the interactions between individuals. To isolate the role of alcohol administration on shoaling behavior, control experiments are being conducted alongside experimental trials. Besides representing a valid proxy for social behavior, shoaling behavior in zebrafish constitutes an evolutionary-adaptive response favoring survival and reproduction.

We are conducting experiments on groups of zebrafish swimming together and record their performances. We are using state-of-the-art image processing tools to identify the behavior of the fish and to characterize the locomotion of each individual, the cohesion and degree of alignment of the group and the interactions between subjects.

TINA LI

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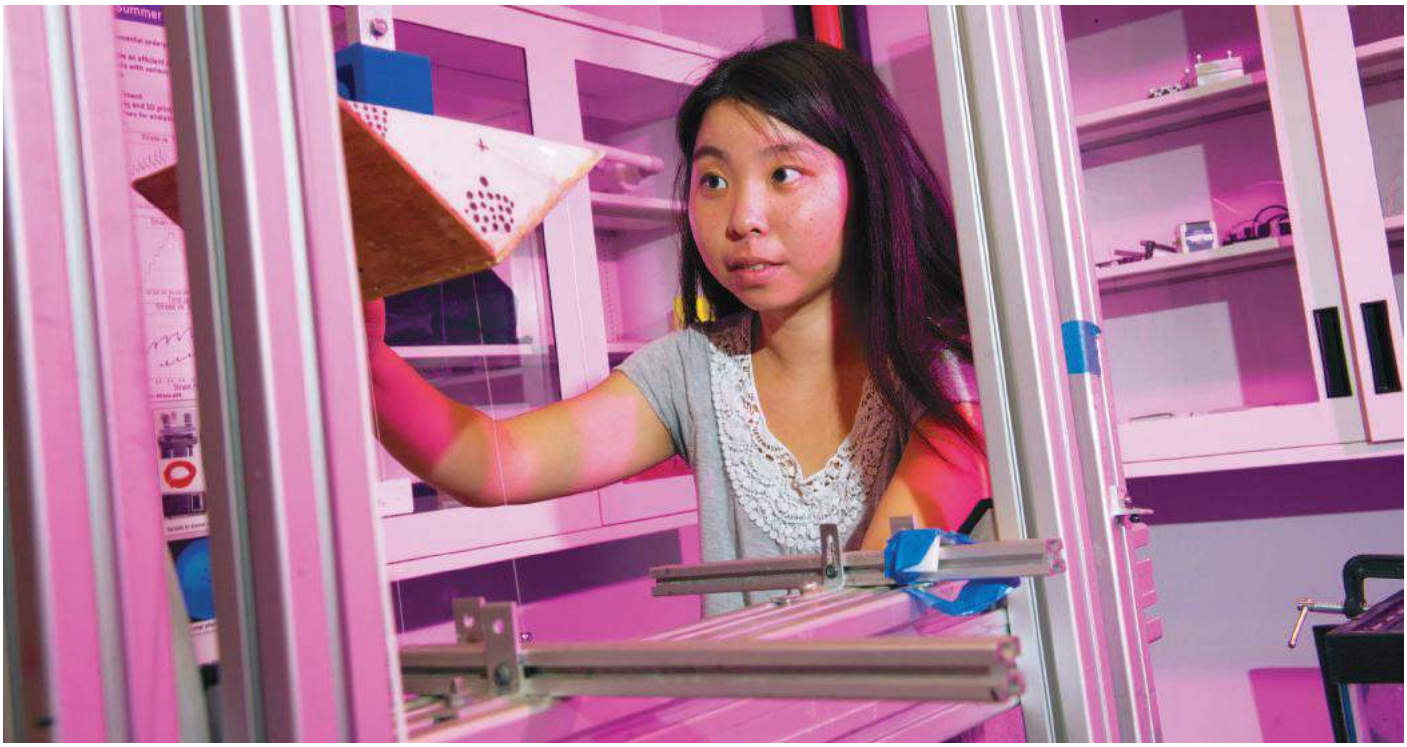
ICE-INDUCED LOADING DURING WATER ENTRY OF MARINE VESSELS

In arctic environments, marine vessels should withstand impact loading from water-ice mixtures. This area of research is becoming more pressing as global warming is changing the polar landscape and is posing new scientific challenges on the mechanics of marine structures.

The goal of this project is to establish an experimental scheme to measure ice-induced loading during water entry of wedges. As a stepping stone toward more realistic studies, water entry experiments are being performed by releasing neutrally buoyant solid bodies in the fluid to comprehend the effect of a solid phase during impact. Particle image velocimetry (PIV) and particle tracking velocimetry (PTV) are combined to experimentally characterize the water entry of a rigid wedge into a quiescent fluid in the presence of multiple solid bodies. The identification of the solid bodies during impact is being performed using PTV, while the velocity field is obtained through PIV.

The pressure inside the disconnected fluid parcels is reconstructed through Navier-Stokes equations by utilizing a spatial eroding scheme that masks out the solid phase. Experimental results are expected to shed light on the effect of the solid phase on the pile-up evolution, flow physics, and hydrodynamic loading experienced by the wedge during water entry. These experiments will provide a basic understanding of the physics behind ice-impact loading.



▲ To address global warming's effects on arctic environments, Tina Li is formulating a method of measuring how well marine vessels can withstand impact loading in icy waters.

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CIRCUIT DESIGN ON GRAPHENE OXIDE PAPER

Technological advances in biomimetic robotics have made it possible to recreate and imitate the locomotory patterns of living organisms, ranging from insects, fish, and even humans. However, biomimetic robots still heavily rely on a construction of rigid body parts or actuators to replicate these motions. To address these challenges, the field of soft robotics seeks to utilize and apply smart materials in robotic designs to accurately recreate the intended motions.

The research objective of this project is to demonstrate the use of graphene oxide paper from various methods to design circuits and actuators through laser scribing directly on paper. The project is part of an international collaboration with KAIST, which has allowed the undergraduate student to perform his research between US and Korea. This work seeks to lay the foundation for future applications in soft robotics, where the capability for designing flexible circuits and actuators may be utilized in creating a completely flexible robotic fish with no internal rigid parts.

For this project, a graphite oxide solution is being used to create both graphene oxide paper through a vacuum filtration systems. Based on preliminary findings, the laser scribing techniques will be utilized to convert these films into usable conductive flexible circuits. Once a graphene oxide paper is laser-scribed with a circuit design, surface mount components can be added to complete the fully flexible circuit. Conductivity and bend tests will be completed utilizing 3D printed testing rigs to characterize this methodology for circuit design.

▲ Miguel Angel Vazquez is applying smart materials to robotic designs to recreate the patterns of motion of living organisms.

RYAN KUBIK

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EXTRACTION DYNAMICS OF RIGID BODIES IN GRANULAR MATERIALS

The need for anchoring systems in granular materials such as sand is specifically present in the marine transportation industry, e.g. to layout moorings, keep vessels and docks fixed in bodies of water, build oil rigs, etc. The holding power of an anchor is associated with the drag force exerted by the granular media. Empirical evidence indicates that the holding power depends on the size and shape of the anchoring structure.

In this model study, we use a two-dimensional geometry in which a rigid body is pulled through a granular media at constant velocity to determine the drag force exerted by a granular medium on a moving object. The method allows measuring the drag force and recording the trajectory of the rigid object through the sand. We systematically vary the size and geometry of the rigid body, the properties of the granular medium and the extraction speed. For different initial positions of a cylindrical object pulled horizontally through the medium, we record large variations in magnitude of the drag and a significant lift force that pulls the object out of the sand.

Using this data, we aim to provide a theoretical model that can aid the design of anchors, as well as on a consumer level, assist in selection of the type and size on an anchor needed for a desired load.

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INFLUENCE OF THE CO-FLOW GEOMETRY ON THE GENERATION OF MONO-DISPERSE EMULSIONS IN MICROFLUIDIC DEVICES

Laboratory microfluidic systems produce emulsions with a very small footprint. Such miniaturization could benefit pharmaceutical, food, cosmetics, and biomedical industries, if parallelized. The Rayleigh-Plateau instability drives this emulsification, destabilizing a jet into droplets. Two capillaries aligned coaxially are traditionally used to generate an inner that jet breaks into droplets while the outer capillary provides the continuous phase. Dynamics of co-flow depend upon the balance of capillary, viscous and inertial forces. In the dripping regime, the inner phase is expected to produce monodisperse drops. However polydispersality presents persistent problems in emulsions, especially when the system is parallelized. Small perturbations in flow rate can result in significant changes in drop volume; the size of droplets varies as the square root of the ratio of flow rates.

Historically, co-flows with parallel outer and inner capillary walls produce the emulsions. Recently, a novel co-flow geometry efficiently reduced polydispersality of the drops: a step-function describes the outer channel. We use numerical approaches to alter the outer flow geometry systematically and determine its influence on the dripping and jetting regimes. More specifically, we investigate the influence of the opening angle of the outer capillary (α), previously either 0° or 90°. We use level-set/finite element axisymmetric numerical simulations of the co-flow. The study suggests novel schemes to produce emulsions in single or parallel co-flow systems.

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INTERACTIONS BETWEEN ZEBRAFISH AND PREDATORIAL STIMULI

Just as zebrafish are attaining an important role in behavioral neuroscience, they are becoming particularly prominent in the study of fear and anxiety. These emotional domains that affect a large proportion of the population and generate remarkable economical and societal costs are often studied in freely swimming zebrafish. The research objective of this project is to characterize from an information-theoretic perspective the fear response of a zebrafish to a predator. The notion of transfer entropy has been shown to offer a valid complement to traditional indicators for the study of fish behavior, revealing the influence of robotic stimuli on animal responses. Building on previous studies conducted at the Dynamical Systems Laboratory, we seek to elicit the predatorial response of zebrafish using a live predator and a dynamic robotic predator.

We have assembled a new dedicated platform to actuate a robotic predator and programmed it to follow live predator locomotory patterns. We are performing experiments on zebrafish and, once completed, we will analyze the gathered data through the use of a custom automatic tracking system to obtain quantitative measures of fish behavior. Transfer entropy will be used to study the interaction between the predatorial stimuli and fish, offering a basis for contrasting live and robotic stimuli, and objectively elucidating the behavioral difference between fish response to conspecifics and predators. This data will provide a compelling basis for further experiments quantifying information flow in fish shoals under a predator threat.

▲ By studying the fear response of zebrafish to various predators, Gabrielle Cord-Cruz is compiling data that can be applied in behavioral neuroscience.

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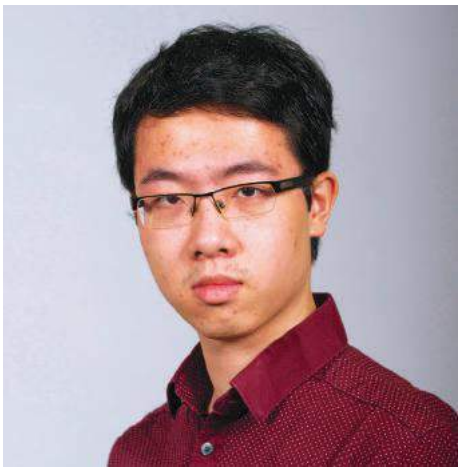
NEW TECHNOLOGIES FOR CONGENITAL HEART DISEASE ASSESSMENTS

Ebstein's anomaly is a congenital heart disease (CHD) occurring in approximately 1 per 200,000 live births and accounting for <1% of all cases of CHD. The anomaly is characterized by a displacement of the septal and posterior leaflets of the tricuspid valve towards the apex of the right ventricle of the heart. This displacement alters the blood flow through the heart as it changes the functional size of the right ventricle and the shape of the right atrium, as a consequence, regurgitation of blood into the right atrium, the patient will have cyanosis at birth and other abnormalities might be manifested in the patient's heart.

Ebstein's anomaly can be diagnosed early in the pregnancy, but severity of this malformation is unpredictable: some patients can grow and lead a normal life, while others have to undergo major surgeries. Adult patients with this congenital disease are monitored using ultrasounds at six months intervals. The severity of the disease varies greatly from patient to patient and is directly related to magnitude of the displacement of the tricuspid valve. The volume of the right ventricle is useful in determining the severity of the disease; however, due to its complex shape, RV volume cannot be calculated easily from 2D ultrasound images. Previous works on this project have defined approaches to extrapolate more accurate RV volumes compared to state-of-the-art methods.

In this research we propose using computational fluid dynamic (CFD) to analyze models generated in previous works as means of improving our understanding of the functional effects of the disease.



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HOMEOSTASIS RECONSTRUCTION OF VASCULAR SMOOTH MUSCLE CELLS

Vascular smooth muscle cells perform a range of functions dependent on a variety of environmental, biochemical, and mechanical factors but little is known about the mechanisms by which it does so. A better grasp of response mechanisms is achieved by examining how vascular smooth muscle cells react to specific forces. Vascular smooth muscle cells were cultured on PDMS micropillars, bound to a microbubble via RGD-integrin binding and subjected to local transient mechanical forces applied by an ultrasound transducer. Traction force microscopy indicated that a self-adaptation process was the response to this stimulation, to return the cell back to a mechano-homeostatic state. A transient calcium influx was also found by measuring Ca^{2+} signals via intracellular OGBI fluorescence, most likely for activating mechanotransduction signaling pathways. Drug experimentation with jasplakinolide, blebbistatin and nocodazole on actin polymerization, myosin activity and microtubule polymerization respectively, confirmed that mechanotransduction pathways and the generation of traction force is reliant on cytoskeletal architecture. This research hopes to model the cell geometrical reorganization mechanism using data from the cell traction forces and strain energy.

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EVALUATING SILICON CARBIDE FOR LOW DENSITY FUNCTIONALLY GRADED BIOMEDICAL IMPLANTS

Silicon carbide (SiC) has received strong attention due to its outstanding properties such as high stiffness, low density and biocompatibility. The synthesis of different shapes of SiC particles and structures can potentially open up a broad range of new applications. This study is focused on evaluating spherical SiC hollow particles for physical properties to determine their potential for use in biomedical implants. The particles have a cavity in the center and also have porous walls. The evaluation methods include optical microscopy, scanning electron microscopy, and pycnometery to determine the real and apparent densities of the spheres. The cell culture cytotoxicity study shows over 90% survival of cell on these particles, which is similar to the level for control cell specimen. The results are valuable in developing new SiC based implants that match with the natural bone in terms of density and mechanical properties.

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MICROSTRUCTURAL EVALUATION OF ADDITIVE MANUFACTURED ALUMINUM-SILICON ALLOY

Additive manufacturing, more widely known as 3D printing, is the process of joining materials layer by layer to make parts from computer-aided design solid model. It has gained popularity among many industries from aerospace, architecture, and automotive to biomedical and dental for its ability for rapid prototyping, customization of components, and production of complex designs that had formerly been difficult or impossible to manufacture. Selective laser sintering (SLS) 3D printing method is used in the present study to print ASTM standard tensile test specimens. Since the specimens are built using a layer-by-layer building process, the possibility of obtaining a directional microstructure is evaluated in this work. The specimens are sectioned along three different axes and then prepared for optical and scanning electron microscopy using standard metallographic procedures. The results show that the as-fabricated specimens have directionality; due to the fact that the fused feed particles are partially melted and resolidified, which creates a layer around each particle, these particles are elongated in the direction of printing. Porosity is also observed in the microstructure, which is uniformly distributed in the specimens. The alloy is heat treated at 550 °C for ten hours, after which it is cooled in the furnace to 200 °C, and then cooled in air to room temperature. It is observed that the heat treatment helps refine the microstructure and results in fine precipitates and smaller grain size. The future work will include tensile testing of as-printed and heat treated specimens.

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PARTICLE IMAGE VELOCIMETRY OF ZEBRAFISH SWIMMING

Collective behavior in biological groups such as fish schools, bird flocks, insect swarms, and bacteria, is attractive for the self-organized and coordinated maneuvers observed with tremendous applications in engineering and science. While most of our data consists of fish swimming in placid waters, fish often swim in dynamic environments where flow cues are central to determine their collective response. In an effort to expand our current datasets for data-driven model development to include fish swimming against a water current, we are conducting a set of experiments to study the hydrodynamics of single and group of zebrafish swimming against a water current in a miniature water tunnel.

Our experiments seek to elucidate the fundamental mechanisms governing collective behavior on the basis of physical proximity. We utilize particle image velocimetry, which is a non-invasive method to quantify flow structures. Based on high frequency videos recording of seed particles illuminated by a laser light, we are studying the wake in the vicinity of fish swimming. Our results are expected to inform the development of mechanical simulators to replicate the wake behind fish swimming along with mathematical models of zebrafish swimming currently undergoing at the Dynamical Systems Laboratory.

▲ Sebastián Romero Cruz is conducting experiments designed to shed light on the hydrodynamics of zebrafish swimming alone and in groups against water currents.

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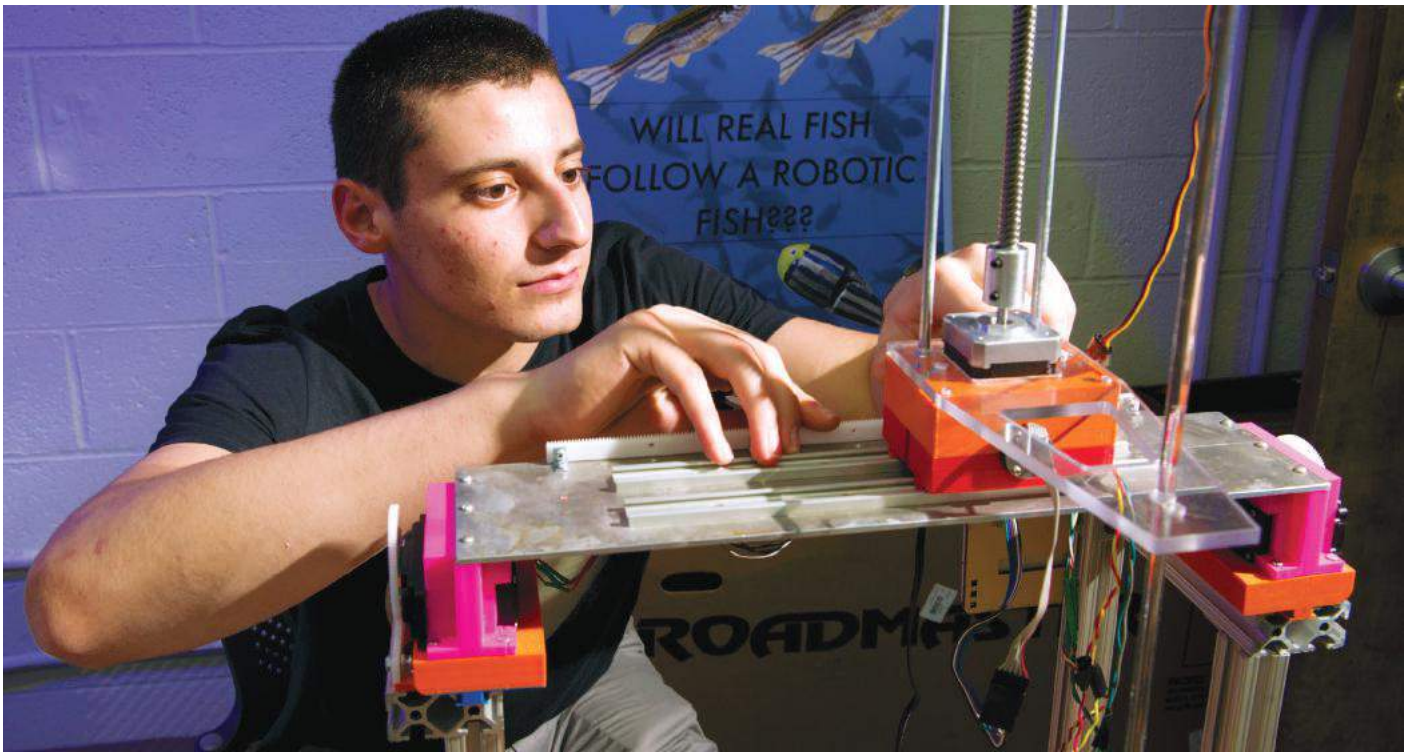
TRAVELING EXHIBIT FOR FISH REPLICA RESEARCH

Informal learning is a type of learning that often occurs outside of the traditional classroom and academic settings. Informal learning often emphasizes the importance of engagements in additional to the learning of the educational content and may typically be found in the interactions from visitors at museum, aquarium, or nature centers.

The research objective of the project is to establish a robotics-based traveling exhibit for understanding the principles of informal learning of the general public, tapping into the local residents in Brooklyn parks. The traveling exhibit will 'pop-up' at local Brooklyn parks, where park goers can explore content through interactive activities, such as playing mini-games (topics on dynamical systems, robotics, and biology), reading summary pamphlets, and watching videos from our NSF-supported work at the Dynamical Systems Laboratory.

There is a twofold purpose for this project. On one hand, the exhibit seeks to inform the general public on the animal behavior research being conducted at NYU Tandon and, on the other hand, it seeks to assess viability of this format for promoting STEM learning and interest. Accompanying the exhibit, interactive activities allow participants using a PlayStation joystick to control a fish replica through a robotic platform, used for conducting various experiments, and to control zebrafish schooling through a custom app. To analyze visitor learning, they will fill out a personal meaning map before and after the activities of the exhibit.



▲ By creating a traveling exhibit for use in local parks, Mitchell Berger is seeking to generate interest among park visitors in robotics-based activities and assess visitors' learning.

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DUAL-LAYER STENTS

Stents, a mesh-patterned tube that is stretched thin and inserted into an artery, come in many different designs, each having its own pros and cons. Some mesh designs have a high porosity, which reduces the radial force exerted on the arterial walls, while other mesh designs have low porosity, which prevents blood from flowing out of the stent and are used to treat aneurysms. Porosity is the measure of amount of gaps the mesh designs have.

The objective of this experiment is the test the idea of a dual-layer stent where the outer layer is comprised of a high porosity mesh while the inner layer is comprised of a low porosity mesh. This design is suggested to combine the pros of both designs while eliminating the cons. For the design to be ideal and safe, blood flow velocity in between the layers must be faster than the threshold velocity for which blood clots. For this project we are developing an experimental setup to study blood flow between the two stent layers and to validate computational simulations.

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DUAL-LAYER STENT MECHANICS

An intracranial aneurysm is a bulge in an artery of the brain that can cause a fatal cerebral hemorrhage if ruptured. Dual-layer stents have recently been proposed as a new option for the treatment of intracranial aneurysms. Each layer serves a different purpose; the inner layer diverts blood flow from the aneurysm and the outer layer ensures that the vessels connected to the main artery remain open and unobstructed. Finite Element (FE) models are a cost-effective and efficient way of testing various stent designs, and studying the interaction between the stent and vessel wall during deployment.

NiTinol is an intermetallic compound of nickel and titanium frequently used in medical applications because of its shape memory effect, superelasticity, and biocompatibility. It can undergo deformation under large strains and then return to its original shape upon unloading. NiTinol is specifically used in dual-layer stents because it is capable of expanding and conforming to vessel walls.

The goal of this project was to create a FE model of a dual-layer stent composed of NiTinol using Abaqus. This work expands upon a previous finite element model of a dual-layer stent composed of Eligloy, a linear elastic material. A user material subroutine was implemented to model the complex behavior of NiTinol in Abaqus. By developing a FE model of a NiTinol dual-layer stent, we expect to be able to optimize flexibility of the stent in the closed configuration prior to implantation, and stability of the stent following deployment in future work.

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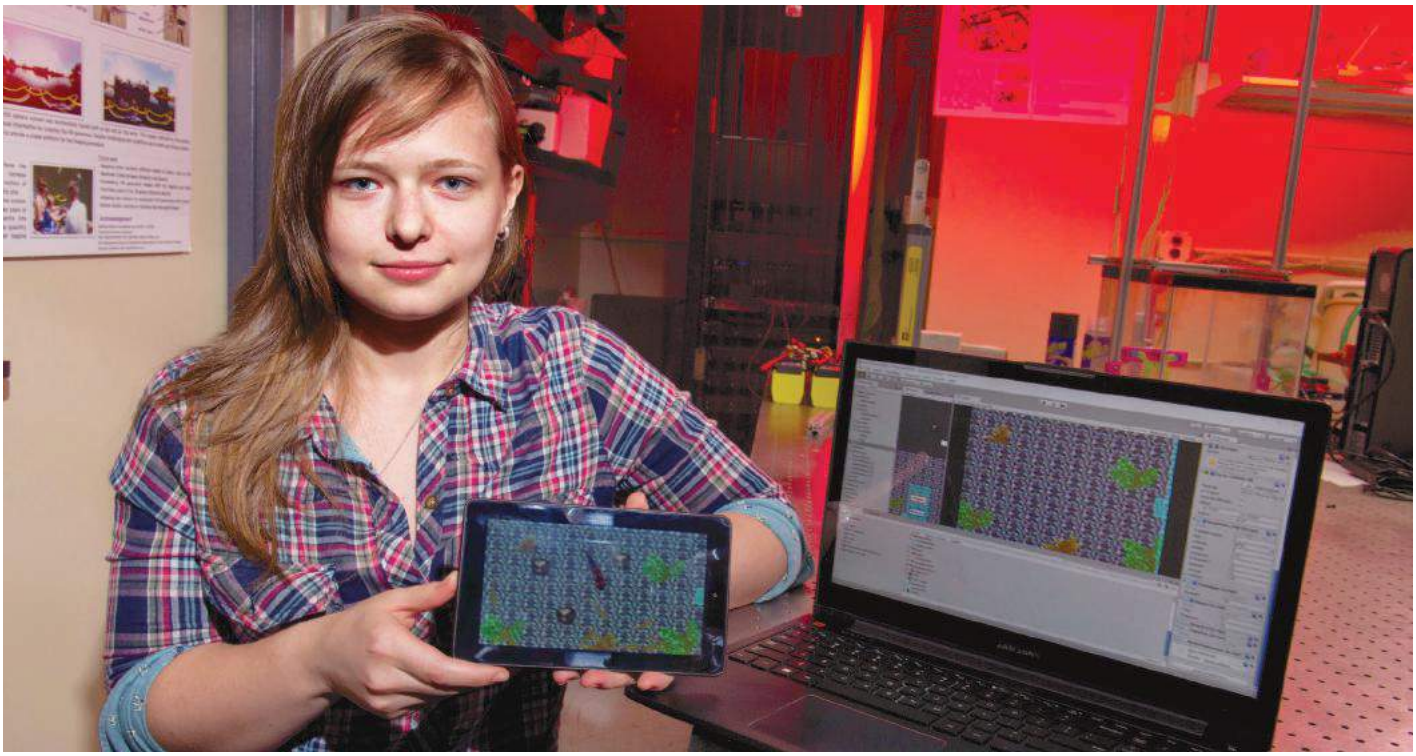
DESIGNING AN ENGAGING APP TO DEMONSTRATE MATHEMATICAL MODELING OF ANIMAL BEHAVIOR TO THE PUBLIC

Visual simulations provide a powerful tool in the development of engaging informal science learning tools. Mobile apps, in particular, can be used to display concepts in some of the most accessible and flexible ways to users of all age groups. In this project, we seek to implement the zebrafish modeling framework developed at the Dynamical Systems Laboratory within an app which could be used to promote STEM concepts to K12 students and to the general public. A freeware game engine is being utilized to code and build the synthetic zebrafish swimming in a two-dimensional tank domain. Modeling of fish swimming was inspired by stochastic models proposed for zebrafish locomotion.

The app incorporates an educational module on noise and uncertainty and illustrates a bottom-up approach where local interaction rules between animals are enforced, toward the emergence of collective patterns. Specifically, the app demonstrates basic principles of fish individual locomotion and social behavior by allowing to select parameters related to specific fish behavior, obstacle avoidance, and repulsion toward a predator or attraction toward a conspecific. The users can also select among different local interaction rules or define their own rules toward the visualization of collective dynamics. The app will be tested to assess the effectiveness of the educational module on a sample high school students.



▲ Veronika Korneyeva is developing an interactive app for promoting STEM concepts to students and the general public through a game based on zebrafish swimming.

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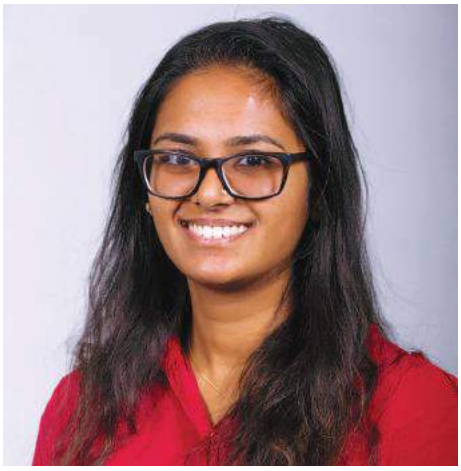
DEVELOPMENT OF LIGHTWEIGHT ZINC-BASED COMPOSITES

Zinc has a density of 7.1 g/cc (versus 1.9 g/cc for a typical magnesium alloy) but is often required for its excellent corrosion resistance in applications such as galvanic protection of steel and in batteries. In this project, lightweight zinc-matrix syntactic foams are developed and studied for their mechanical properties under quasi-static and dynamic loading. Hollow glass microspheres of approximately 50 μm diameter and 1 μm wall thickness are coated with nickel and dispersed in the zinc alloy matrix. Various processing methods, including powder compaction and vacuum assisted melt infiltration, are explored as means of producing such foams. The resulting syntactic foams are observed to have higher strength relative to their density than blown Zn foams and those made using fly ash hollow particles recovered from thermal power plants. The strength of the syntactic foams is observed to increase by up to 40% at high strain rates compared to the quasi-static strength. Success in developing these materials can help in reducing the weight in ships, where zinc is used in many structures.



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ANALYZING THE RESPONSE OF POLYMER MATRIX COMPOSITES ACROSS TEMPERATURES, FREQUENCIES AND STRAIN RATES

Ever increasing demands for higher fuel economy and reduced emissions for automobiles and aircraft requires the use of lightweight materials. Hollow particle filled composites called syntactic foams are useful in such applications because of their tailorable density, stiffness, and thermal properties. This project focuses on high-density polyethylene (HDPE) matrix syntactic foams containing fly ash hollow spheres, which are recovered as a byproduct of coal combustion in thermal power plants. Compared to engineered glass hollow spheres their reinforcing ability is lesser, but they can be used to reduce the consumption of expensive polymers and improve the stiffness of the material. The syntactic foams for this study were injection-molded with up to 60 wt.% cenospheres. Polymeric materials and their composites are strongly viscoelastic, meaning that their response to load is highly dependent on the loading rate and history, as well as temperature. In this study, the viscoelastic response of the syntactic foams was determined using dynamic mechanical analysis (DMA). A frequency-time inversion was used to determine the sensitivity of the material response to loading at widely varying strain rates.

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IMMUNE DISEASE DIAGNOSTICS: DETECTION OF IMMUNE CELL SECRETED CYTOKINES WITH AN OPTO-MICROFLUIDIC BIOSENSOR

Immune disease diagnostics and monitoring inflammatory diseases including cancer, sepsis, and lupus require the detection of immune cell secreted cytokines in a small volume blood sample. Monitoring slight changes in the complex immune system by identifying the presence and concentration of various cytokines requires a highly accurate and sensitive system. Conventional immunoassays, like ELISA, can be time consuming and require large sample volumes. Localized surface plasmon resonance (LSPR) optical biosensing can detect molecular binding on a gold nanoparticle surface by measuring the intensity shift of scattering light from the gold nanoparticle with high sensitivity. Integrating the principle of LSPR biosensing into a microfluidic chip allows for high throughput and low sample volume consumption while detecting cytokine biomarkers. A laser-generated optical tweezer is developed and incorporated into the opto-microfluidic device to further increase the sensitivity of the system by concentrating the cytokines in the optical trap. The device was fabricated by patterning gold nanorods (AuNRs) array onto a microfluidic chip and functionalizing the AuNRs with antibodies. Binding of the cytokines to the antibody-functionalized AuNRs in the optical trap produces a quick shift in scattering behavior from the resonant oscillation of conduction electrons at the surface of the AuNRs, which can be measured using dark field imaging. This technique will provide a highly sensitive and rapid detection of cytokines for immune disease diagnostics and monitoring.

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3D IN-VITRO ANGIOGENESIS MICROFLUIDIC MODEL FOR BONE REPAIR

Bone is highly vascularized for skeletal repair processes such as bone growth and remodeling. To initiate bone repair, vasculature serves as a permeable interface for biochemical signals between bone tissue and microenvironment. This requires angiogenesis, the sprouting of endothelial cells, such that pre-existing blood vessels invade and extend into their microenvironment for forming new blood vessels. It is understood angiogenesis is coupled with bone repair, since nutrients, oxygen, growth factors, cytokines, osteoblast and osteoclast precursors require a vascular route to reach the injury site. However, the governing mechanisms for angiogenic bone repair by its microenvironment are not well understood.

To investigate bone repair under angiogenic conditions, we have designed a bilayer microfluidic platform of 2 parallel 3D channels in a scaffold, derived from Type 1 Collagen, to mimic in-vivo bone vasculature and microenvironment. In one channel (engineered vessel), C166-GFP endothelial cells are seeded confluently to develop an in-vitro blood vessel. The parallel channel serves as a reservoir of 3 different biochemical parameters to perfuse through the collagen matrix to the engineered vessel. These 3 biochemical gradients consist of the following: (1) C166-GFP culture media loaded with Vascular Endothelial Growth Factor, VEGF; (2) mechanically-stimulated secretions, isolated from mesenchymal stem cells (MSCs); (3) direct secretions of seeded MSCs. By performing these experiments, the aim is to elucidate the effects of these biochemical gradients on bone-related angiogenesis for bone repair. This platform plans to model the in-vivo bone repair microenvironment for high-throughput screening, bone fracture therapies, and other future skeletal repair work.

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MICROFABRICATED TOPOGRAPHIC SUBSTRATES FOR STUDY OF MESENCHYMAL STEM CELL OSTEOGENIC DIFFERENTIATION

Controlling osteogenic differentiation of mesenchymal stem cell (MSC) holds great significance for the success of artificial bone implant. Failure of implants often occurs when MSCs in bone marrow do not differentiate into bone tissue due to the unsatisfied implant biomaterial properties. Nanotopographic surface has attracted much attention as a physical cue for controlling the differentiation fate of stem cells. Human MSCs cultured on different substrates with nanoscale topographies can differentiate into varied cell types such as adipocytes, chondrocytes, and osteoblasts. In order to promote the osteogenic differentiation of MSCs, we investigated the effect of nanorough glass substrates with varied surface roughness on MSC osteogenic differentiation. We introduced reactive ion etching (RIE), an accurately- controlled microfabrication method to generate defined roughness in glass substrates so as to investigate the sensitivity of MSC to topographic signals from cellular environments. In this study, we explored how the cell-topography interactions affect MSC behaviors including cell morphology, cell adhesion, cell spreading, and differentiation. The study is aiming to provide a novel biomaterial mimicking *in vivo* nanotopographic cues in the stem cell microenvironment for tissue engineering. Additionally, due to the understanding of the differentiation mechanism of stem cells, the study also shows a great potential for future development of regenerative medication.

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TECHNOLOGY, CULTURE AND SOCIETY

HUMANITIES SCHOLARLY DATABASE SEARCH

Searching for scholarly resources in humanities fields and interdisciplinary topics naturally differs from traditional web searching. While web searches require all of the most directly meaningful information to appear first, humanities scholars often want to find resources that focus on minority opinions or information that lies in the middle ground between two disciplines. Nevertheless scholarly database search engines follow the same model as web search engines.

Web searching is based around the idea of hubs and authorities. Hubs are pages containing links to other pages, and authorities are pages pointed to by hubs. Overall rankings for a page, which determine where in the results it will appear, are determined by a combination of a page's hub score (how well it points to authority pages) and authority score (how well it is pointed to). With this system, web search engines have made great strides in optimizing general web searching.

However, the traditional hubs and authorities model is not ideal for humanities searching, which demands more than directly meaningful results. Current search engines for scholarly databases thus do not fully satisfy their users. The goal of this project is to determine the needs of humanities and interdisciplinary researchers in conducting successful searches. To do so, we are using JSTOR as a platform to analyze the methodology behind humanities researching so that we can gauge and take preliminary steps to design the tools and improvements that would best benefit them.

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PUBLIC DIGITAL HUMANITIES

This project aims to visualize Poly's history so a visual analysis of the data is possible. By applying visualization to the Public Digital Humanities, it allows for a deeper and more insightful analysis and dynamic representation of significant historical events that would otherwise only be available in static form.

To do so, the project modifies the augmented reality interface, Layar. Layar's framework allows modifications to be made by PHP and MySQL. Therefore, the first step taken was to collect and sort through data to be put into a database. To develop this prototype, data involving Poly's early history was collected. Data collected included history of: Poly's numerous campus changes, the many buildings the university acquired for various purposes, information of old and future plans for renovations, and more. The data was then plotted on Layar's interactive map using PHP. Each entry is hyperlinked to another page, where pictures of Poly's history in that location can be found.

The goal of this project is that anyone in the public can view and analyze the data to interactively learn about Poly's history. What makes this project stand apart from reading a Poly's history book is intuitive, simple graphics that displays the location of any Poly-related historical events and how far away the user is away from such a location.

By visualizing Poly's history in such a fashion, it creates a platform of interaction and discovery for the average person and allows connections to be made from anywhere by anyone.

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TOPOLOGICAL ORDER AND EMERGENCE

In 1989, the Chinese-born American physicist Wen Xiao-Gang first introduced the concept of topological order to describe certain condensed matter systems. Those systems, which include quantum Hall liquid, topological insulators, and topological superconductors, are found to display a new type of order that cannot be described by classical Landau-Ginsburg theory of matter. Topologically ordered systems now play a prominent role in the research in condensed matter physics. For instance, the phenomena associated with fractional quantum Hall (FQH) systems have been proposed as a way to encode information non-locally using qubits, which can serve as the basis for the construction of topological quantum computers.

Recently, some physicists and philosophers have suggested that certain types of topological order can be understood in terms of a holism that is underwritten by the mechanism of long-range entanglement (LRE). This means there might be a notion of emergence that is applicable to all condensed matter system that exhibit topological order. In this project, our goal is to articulate such notion of emergence by studying the relationship between topological order and entanglement. To achieve this goal, we aim to provide an explicit definition of emergence and identify the necessary and sufficient conditions in the physics literature for a system to possess topological order. We are also going to examine the mechanism of LRE in order to distinguish topologically order systems from systems that possess classical symmetry-based Landau-Ginsburg notion of order.

TECHNOLOGY MANAGEMENT AND INNOVATION

HUMAN COMPUTER INTERACTION AND PERSONAL GENOMICS EXPLORATION

Human genome sequence reports have greatly decreased in cost but exponentially increased in scientific research. Such information is paramount in accessing precision drug effects on different individuals, ancestry and human migration mapping, and screening for hereditary disease and other biological risks. Human computer interactions methods were implemented for direct consumer genetic reporting. Genetic reports were programed to be D3 visualizations along with analyzed data on the genomics reports from the Open Humans project out of the Harvard Personal Genome Project, and funded by the National Science Foundation. Data in JSON and CSV were analyzed into further stimulated user interfaces and given easy and comprehensible visualization reports to the users. The different gene variants from VarExplore were then compiled for this year's experiments. The genomics research hopes to facilitate long-term engagement of non expert users with their personal genomic information by supporting the curation of resources relevant to one's personal genomic results; and establish support for Genomix and the tool 23andMe, along with fully deploying Genomix on the Open Humans Project servers.

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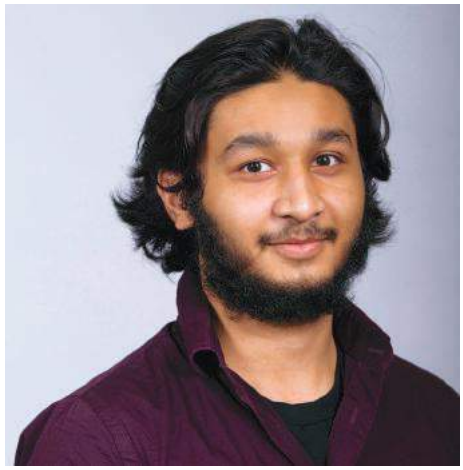

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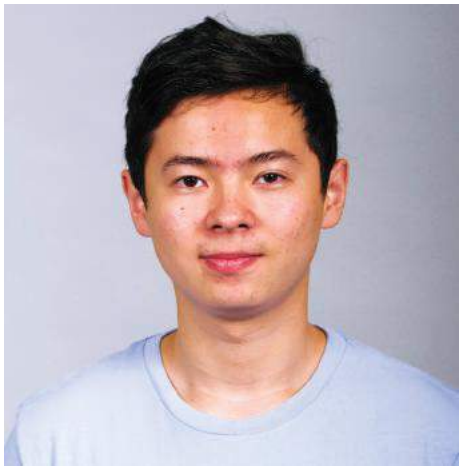
HUMAN-COMPUTER INTERACTION AND FINANCIAL DECISION MAKING

Long-term saving can be a daunting and difficult task for any person without prior experience. Human Computer Interaction has attempted to alleviate this task with interface features that will allow the user to make informed financial decisions for their future. The behavioral changes of users influenced by modified interface features can have varying results thus encouraging further research into human-computer interaction.

The subject of behavior change for long-term saving has been a compelling study and this project serves the development of a long-term saving simulation applying theory from behavioral economics and human-computer interaction to encourage individuals to think about the implications of short-term versus long-term saving. More specifically, the retirement simulation drew upon behavioral economic theory dealing with intertemporal choice and hyperbolic discounting. These theories were applied in the context of a long-term saving simulation with a financial information label that expressed the concepts of risk and reward in an easy to understand way. The long-term saving simulation will be tested on users in the coming months. Past research has examined long-term saving in the context of retirement with applications of theory from behavioral economics such as endowment effect and loss aversion applied to human-computer interaction design.



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