2019

THIRTEENTH ANNUAL

SUMMER RESEARCH PROGRAM UNDERGRADUATE ABSTRACTS

NYU TANDON SCHOOL OF ENGINEERING

2019 SUMMER RESEARCH

NYU Tandon School of Engineering's Undergraduate Summer Research Program provides a unique opportunity for undergraduate students to engage in research over the course of the summer term. This program offers students far more than the traditional classroom experience; it allows them to work alongside faculty mentors and research staff as well as PhD and masters students on cutting-edge research projects. In addition to the work they do in labs, students attend seminars focused on both academic and career development. They participate in a poster session in collaboration with the NYU CAS Department of Chemistry's MRSEC Program, in which they present their work to other members of the research cohorts, faculty, staff, peers, and other outside attendees. Throughout the program, students get to interact with numerous people of different levels from various areas and fields of study both within and outside of NYU, promoting an educational experience that advances Tandon's i2e model of invention, innovation and entrepreneurship. Undergraduate students are afforded the opportunity to conduct this research during a 10-week period, aiming to enhance and broaden their knowledge base by applying classroom learning to solve practical and contemporary problems and to better prepare them for lifelong learning.

Tandon's faculty participation in this program is essential, as is the financial support provided by faculty mentors and the Tandon School of Engineering. The gifts from several alumni donors have also propelled the program's success. This year marked the 8th year of the Thompson Bartlett Fellowship, in which 10 of this summer's female researchers were graciously supported by Mrs. Dede Bartlett whose father, Mr. George Juul Thompson, was a graduate of the Electrical Engineering program at 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. 2019 marked the 2nd year in which students were given the opportunities to explore the entrepreneurial world of startups by working in the Tandon Future Labs with partial support of the institute for Invention, Innovation, and Entrepreneurship, the IIIE@Tandon, sponsored by Dr. Kurt Becker.

A special thanks also goes to Nicole Johnson, Assistant Dean for Opportunity Programs, who volunteered her time to mentor the TB Fellows, providing them with additional programming and engagement throughout the summer. She remains in contact with these students over time and often brings them back to engage with younger Fellows. I would also like to acknowledge Sara-Lee Ramsawak, Director of Undergraduate Academics & Global Programs, who has coordinated the Undergraduate Summer Research Program and ensured that the program's daily operations run seamlessly since 2013. Jen Piro, Assistant Director of Undergraduate Programs, joined in on the coordination efforts for the first time this year and assisted with all of the programs enhancements and developments. She also coordinated all of this summer's participant placements.

Summer 2019 marked the 13th year of the program. Since its inception, over 900 students have participated, and a large number of faculty members from a variety of departments have contributed. The abstracts published in this year's volume are representative of the research done over the summer and celebrates the accomplishments of the undergraduate researchers. Congratulations to all of the student researchers who participated in the 2019 Undergraduate Summer Research Program. I look forward to future summers of more intellectual and scholarly activities.

Peter J. Voltz

Peter Voltz
Associate Dean for Undergraduate and Graduate Academics

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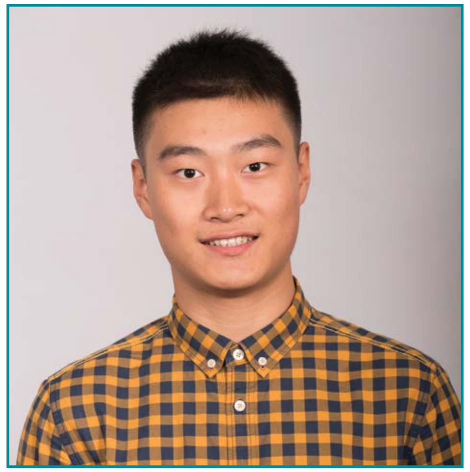

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Improved Iterative Closest Point Algorithm for Registration of Dense Urban Laser Scanning Point Cloud

Terrestrial laser scanning (TLS) is an effective means to generate accurate, high-resolution, three dimensional (3D) models of the urban environment. To capture a 3D scene, a TLS scanner must be deployed at multiple stations around the object of interest. Multiple scans are needed since data captured at each station is often incomplete due to occlusion. The 3D data derived from the separate stations are aligned and combined together to create a complete model of the scene through a process called registration. Amongst many existing solutions, Iterative Closest Point (ICP) is one of the most commonly adopted point-based registration algorithms. This iterative descent algorithm performs fast, fine registration of two overlapping point clouds given that the datasets to be registered have a good priori manual alignment already. Thus, this project aims to further automate ICP-based point cloud registrations by performing a coarse registration step prior to the fine ICP registration. The coarse registration is based on several abstract representations of the complex point cloud, including the surface normal vector distribution and the coordinate histograms of the data. The algorithm is developed based on analyses of multiple real TLS datasets collected around Washington Square and several subway stations in New York City.

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Graphical User Interface Design for Retrieving and Viewing Massive Remote Sensing Data Sets

Light Detection and Ranging (LiDAR) is a method which uses light pulses to obtain a digital representation of an object, location, or region. Laser beams emitted from a source are reflected off the targeted surface. The coordinates of the points of reflection are determined by a combination of the scanner's position and the return characteristics of the laser beam. Data sets gathered from this technique contain billions of points making their storage, processing, and visualization highly demanding.

Retrieving and visualizing large LiDAR data sets are challenging. Strategies have been undertaken including gridding and subsequently tiling the data to make it more manageable. However, such strategies introduce discontinuities and/or redundancies at tile boundaries and become problematic when features beyond the data of a single tile are sought.

To overcome such difficulties, this project focuses on developing a Graphical User Interface (GUI) for LiDAR data retrieval and visualization. The GUI is an access gateway to a distributed spatio-temporal database system Ariadne 3D. The particular functionality being developed will support selection of a projected two-dimensional region and visualization of all data in three dimensions, for the selected area. The goal is an efficient GUI for retrieving and visualizing LiDAR data which avoids processing irrelevant points.

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Statistical Distribution of Large-Scale Aerial Laser Scanning Data

Light Detection and Ranging (LiDAR) remote sensing data are instrumental in a wide range of urban mapping, planning, engagement activities. The current generation of equipment allows multi-pass data sets of 100s of points per square meter generating unprecedented densities and quality. Computing the statistical distribution of such datasets is a convenient way to gain preliminary understanding of the data and perform a basic quality assurance, as well as providing insights for future data storage and post-processing strategies. While manual analysis is easy to perform to derive statistical distributions and related insights, such approaches are highly limited in their scalability.

In this work, algorithms are devised and implemented to determine the relevant statistics and histograms. The approach is applied to increasingly larger groups of data determine the scalability barriers with respect to time and memory bottlenecks. These insights are then used to develop a distributed computing solution based on MapReduce.

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Autonomous Occlusion Detection in LiDAR Data

Light Detection and Ranging (LiDAR) is a remote sensing method to collect highly accurate and precise shape data of an object or a surface. LiDAR is used to detect different landscapes or project sites. The data can be collected by aerial sensors mounted on planes or helicopters so that a large area can be covered efficiently from a high elevation. They can also be collected by terrestrial scanners based on the ground or mobile platforms. A common form of LiDAR emits a laser beam towards a surface of interest and measures the time for the reflections to come back to the sensor.

However, water reflections, glass refractions, and low albedo surfaces results in laser pulses either being absorbed or reflected in an incorrect position. These missing laser pulse returns can lead to void regions in LiDAR data. The goal of this project is to generate an algorithm that can automatically extract the outline of occlusions caused by water bodies, including rivers, pounds, and roof top puddles. The output generated by this algorithm can be used to help with rooftop maintenance and city maintenance.

CHEMICAL AND BIOMOLECULAR ENGINEERING

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Engineering Personalized CAR T-Cell Immunotherapy Through Leukemia-On-A-Chip

B-cell acute lymphoblastic leukemia (B-ALL) is the most common cancer in childhood and the leading cause of cancer-related deaths in children. Adoptive CD19 CAR (Chimeric Antigen Receptor) T-cell transfer has emerged as a successful FDA-approved therapy for B-ALL patients. Despite this, the durability of patient remission remains unpredictable largely due to CAR T-cell immunological resistance and insufficient target engraftment from the dynamic, immunosuppressive and protective leukemic bone marrow (BM) niche/microenvironment. Herein, we engineered a three-dimensional microfluidics-based, "biometric" niche model (termed "Leukemia-On-A-Chip") that contains key immune populations and essential tumor-immune-stroma intercellular communications. This "Leukemia-On-A-Chip" platform allows visualization between the interactions of B-ALL leukemia blasts with the bone marrow microenvironments ex vivo. Preliminary investigations are necessary before in-depth analysis of the microdevice. Therefore, we have deeply studied the relationship between the genetic-specified B-ALL subtypes and immunophenotype of tumor-associated macrophages, which could be further interrogated to elucidate the immunosuppressive cues in regulating CART-cell therapy. We believe this leukemic BM niche model can be applied to optimize and screen efficient CAR T-cell therapy, which will finally improve disease-free long-term survival in pediatric and adult B-ALL patient.

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Smart Fingerprint: Optical Imaging of Latent Fingerprints through the Detection of Glucose in Human Perspiration

Fingerprints consist of patterns of ridges and furrows that is an inverse of the pattern on the fingertip. Fingerprints also consist of natural secretions from the pores in the skin. Using the glucose secreted in the human perspiration a fingerprint pattern can be optically visualized. Moreover, a correlation between the blood glucose levels and the amount of glucose in the secretions from the pores of skin also exists indicating blood glucose levels can be deduced from a fingerprint.

Using polydimethylsiloxane (PDMS) gel on a glass substrate as a chip, a pattern of silver nanoplates was created. When incident light was shone onto them, the conduction band electrons oscillated to give a characteristic initial light intensity detected by the camera. When a sample solution containing glucose was loaded onto the channel on the jell, along with the enzyme glucose oxidase a spike was observed in the light intensity. Current research is looking for a correlation between the glucose concentration and the change in light intensity to detect different amounts of glucose in the perspiration and hence in the blood.

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Spatial Signaling and Mechanical Sensing facilitates Sweat Gland Development

Sweat glands play an important role in body temperature regulation. Congenital diseases like Hyperhidrosis (excessive sweating) and injuries like major skin burns, result in damaged sweat glands. Inadequate thermoregulation can lead to high body temperature that may also result in death. Currently, we do not have any treatments available to repair damaged sweat glands. Our aim is to understand the underlying mechanisms of sweat gland development and establish a reliable ex-vivo regeneration system using bioengineering technologies.

The structure of a sweat gland consists of a duct that forms in the skin's epidermis and grows inwards into the dermis where it differentiates into the coil. Using skin samples from mice footpads, we observed sweat glands at different developmental stages and identified that the skin's varying stiffness environments can impact sweat gland formation by altering its dermal thickness. It was found that the thickness of the dermis decreases with increasing stiffness. The duct of the sweat gland grows longer in stiffer substrates while the coil only grows in softer substrates. Using this information, we are studying the effect of different gene signalling pathways on sweat glands. Taken together, our research integrates mechanical and biological perspectives of sweat gland formation.

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Crystal alignment during laser-induced nucleation of supersaturated solutions using pulsed lasers

Nucleation is the initial step of the formation of a new thermodynamic phase, and has significant economic value. It is often used to produce high-value solid materials, such as laser crystals and pharmaceuticals. Common methods for inducing nucleation involves applying external perturbations, such as ultrasound and mechanical shock. Non-photochemical laser-induced nucleation (NPLIN) is a relatively unexplored technique which allows the nucleation process takes place at a specific time and location as well as at a much faster rate. Such high speed control might lead to a refreshing prospective of crystallization in various industries, and more characteristics of this phenomenon are yet to be examined. The goal of this project is to explore the alignment of the urea crystal during non-photochemical laser-induced nucleation. Urea is a needle-shaped crystal, which is ideal for studying the crystal alignment as it well illustrate its orientation.

The backbone assumption of the project is that during NPLIN the orientation of the initial crystallite that nucleates is directly related to the polarization of the laser. The process of nucleation would be recorded and the image of the initial crystallite would be analyzed to study the correlation between the crystal alignment and laser polarization.

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Catalyzing Suzuki-Miyaura Reactions Using Cyclodextrin Supported Palladium Complex

This project aims to evaluate the performance of a cyclodextrin-supported palladium complex (DACH-Pd-β-CD) in catalyzing Suzuki-Miyaura cross-coupling reactions in a continuous-flow micro-reactor. A Suzuki-Miyaura reaction uses a palladium catalyst to combine organohalides and boronic acids. Using DACH-Pd-β-CD to catalyze these reactions is desirable since it uses environmentally friendly solvents, can be reused multiple times, produces excellent yields, and has low catalyst loading. All of these qualities show its potential applications in green chemical synthesis. Previous research has shown that DACH-Pd-β-CD is extremely effective at catalyzing Suzuki reactions in batch systems. This project evaluates its performance in a continuous-flow system.

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Inhibition of amyloid aggregation

Parkinson's disease (PD) is the second most widespread neurodegenerative disease, affecting a significant portion of the world's population over age, where the combined cost of PD is estimated to be nearly $25 billion per year in the United States alone. The aggregation of a-Synuclein (aS), a 140 residues protein naturally found inside of neurons, plays a key role in the pathogenesis of PD. aS is a primary component of abnormal neuronal aggregates called Lewy bodies, which are the hallmarks of PD. As an amyloidogenic protein, aS monomers aggregate to form toxic soluble oligomers that further develop into fibrils that are rich in b-sheet structure.

There have been many studies on the effect of metal ions on neurodegenerative diseases, primarily focused on their role for redox cycling and initiating oxidation stress. Metal ions, such as Cu^{2+}, act as mediators of neurotoxicity and provide a suitable pharmacological target for the treatment of neurodegenerative diseases. In this study, the effect of Cu^{2+} and resveratrol and AM17 on aS aggregation has been characterized using Thioflavin T fluorescence, TEM, native-PAGE, SDS-PAGE and circular dichroism spectroscopy. Resveratrol is a chemical compound naturally found in berries and grapes, and AM17, is an ionophoric derivative of resveratrol. Reservatrol is known to act as an anti-amyloidogenic and fibril-destabilizing polyphenol and its derivative, AM17, is hypothesized to interact with Cu^{2+} to enhance this inhibitory effect.

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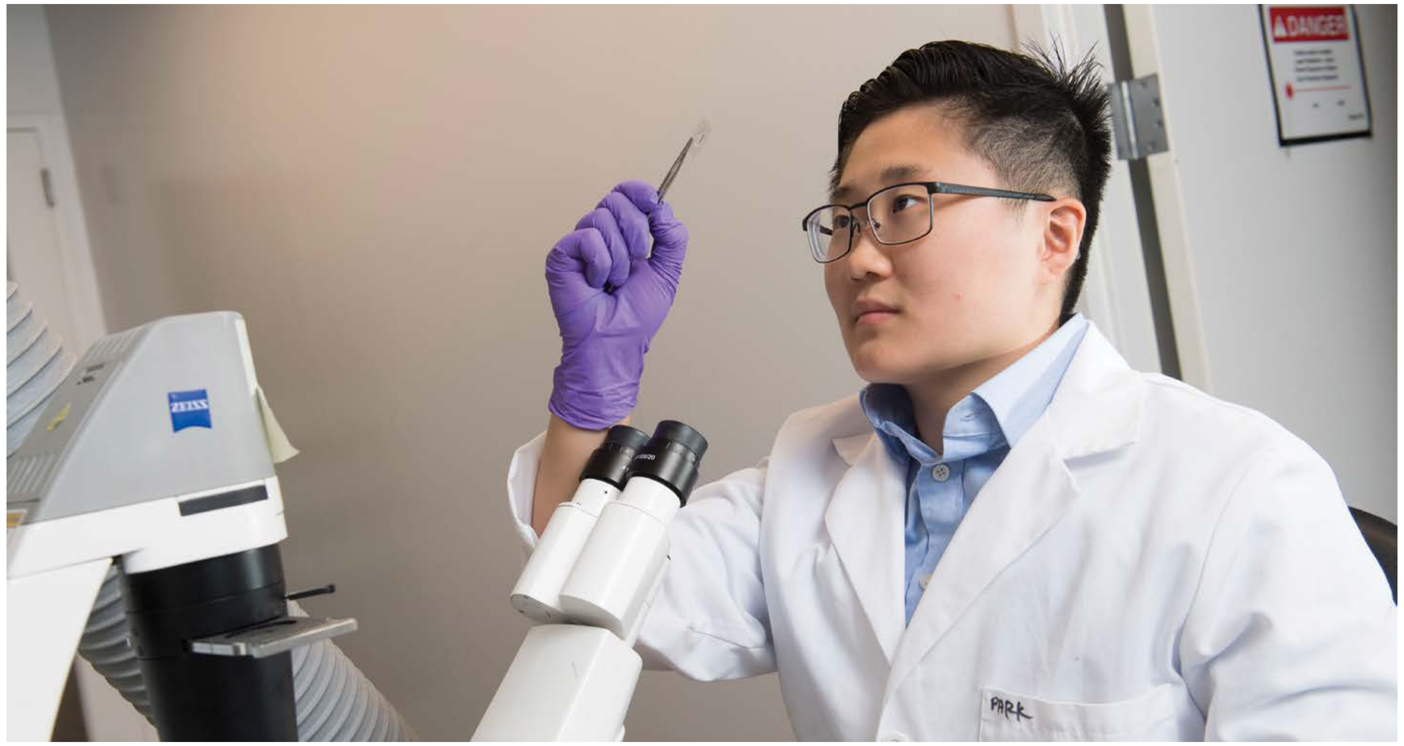
Amyloid Aggregation

Many globular proteins are structurally well-ordered and functionally essential to many biological processes such as enzymatic activities, transportation of materials as well as other uses. Unlike intrinsically disordered proteins such as α-Synuclein and β-Amyloid which are natively-unfolded with their amyloidogenic sequences being relatively more exposed, the hydrophobic and potentially amyloidogenic sequences of globular proteins tend to be buried inside as a result of protein folding. Through an amyloid aggregation prediction algorithm, TANGO, we surveyed various globular proteins for their amyloid aggregation potential, which was also experimentally examined. A functional activity of a selected globular protein and its amyloid aggregation propensity under native conditions were examined.



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Unravelling Immune Cell Mechanobiology through Force Measurement

Macrophages are essential to the immune system and perform various defensive functions in the body such as phagocytosis of bacteria, and are crucial to inflammation and healing. These macrophages present themselves in different phenotypes which arise from the differentiation of macrophages through various chemical and metabolic signalling pathways. We study the phenotypical differences of RAW 264.7 and Bone Marrow Derived Macrophages (BMDM), which are murine macrophages. Macrophages have shown to be mechanosensitive, as they perform differently under different physical environments. Hence, we study the differences between the various phenotypes by using home-made micropillars to measure differences in cell forces. Micropillars are force sensors that are made using polydimethylsiloxane gel in the lab. The deflections on these pillars caused by cell movement can be measured and the cell force can then be calculated by taking into account the stiffness and size of those pillars. Differences in macrophage phenotypes are also studied using various immunostaining techniques in order to visualize the various genes expressed in each phenotype.

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Plasmonic-based Microfluidic Biosensor for Immune Cell Phenotyping

During the progression of immune-related diseases, rapid and precise monitoring of the state of the immune system has a crucial role in personalizing a patient's treatment protocol. By tracking the secretion of cytokines, small proteins secreted by specific cells in the immune system, from frequently sampled human blood, the course of a disease can be monitored. The current gold standard in immunoassay technology is the enzyme-linked immunosorbent assay or ELISA, which is a plate-based immunoassay that measures the quantity of a specified antigen in a sample. However, ELISA relies on fluorescent labeling, large sample volumes, long-term sample incubation, and time-consuming manipulation processes that make real-time, multiplexed cytokine measurements impossible. Given ELISA's limitations, immune monitoring for clinical decision-making is made impractical. In recent years, localized surface plasmon resonance (LSPR)-based microfluidic biosensing has gained popularity as a promising approach for the real-time refractometric detection of binding events between an antigen and antibody. LSPR offers a label-free solution to the multiplexed analysis of cytokine concentration and even offers potential for sensor miniaturization. This project focuses on the development of a highly-sensitive LSPR-based biosensing interface that, when integrated with a high-throughput microfluidic platform, can measure the concentrations of secreted cytokines in real-time.

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Nucleation of glycyl-glycine dipeptide using optical tweezers

Optical tweezing is a method that uses laser trapping due to radiation pressure generated by a tightly focused laser beam. It is a useful method of trapping and manipulating micrometer and nanometer sized particles in solution without mechanical contact. Previous research using the optical tweezing method with glycine (a peptide) and heavy water (deuterium oxide) has been conducted and shows crystallization upon tightly focusing a continuous wave (CW) laser at the air/solution interface. However, a dipeptide has yet to be studied. Glycyl-glycine is the dipeptide of glycine and is the simplest dipeptide. A continuous wave (CW) laser will be used in this experiment to observe crystallization and nucleation of a gly-gly solution after tightly focusing the beam at the air/solution interface. Both saturated and supersaturated solutions of gly-gly will be nucleated to compare the results to those of glycine. Crystal structures will be determined using XRD.

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Understanding and Optimizing Organic Electrosynthesis of Hexamethylenediamine with Membrane Electrode Assemblies (MEA's)

Nylon 6,6 is a widely used synthetic polymer found in textiles, plastics, and automotive parts. Its main precursor, hexanediamine (HMDA), is industrially produced by hydrogenating adiponitrile (ADN). This is done in unsafe processes requiring not only high pressure but also temperature. The electrohydrogenation of ADN to HMDA has a wide potential to provide safer and more efficient production routes for this important Nylon precursor. However, several challenges need to be addressed, including mass and charge transport limitation as well as problems with low energy efficiencies.

MEA's are innovative reactor configurations that eliminate the use of inorganic electrolytes and metal plate electrodes while avoiding the undesired mix of product streams and reducing mass and ionic transport limitations. This research studies the formulation of how to setup catalyst inks and the fabrication of the MEA's and their potential use for the electrohydrogenation of ADN to HMDA. Studies on the effect of operating cell conditions and ink formulation are carried out to develop a better understanding of the limitations of the system which will help optimize its performance levels.

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Analysis of Silica Microsphere Fabrication for use in Whispering-Gallery Mode Biosensing

Since the late 20th century, the idea of label-free biosensing through the use of whispering-gallery mode (WGM) biosensors has allowed for the resonant detection of various biomolecules. When a microsphere is placed onto the surface of a shaved optical fiber—with a laser tuned into the fiber—, resonant modes with corresponding resonant peaks were formed due to light coupled into the microsphere by frustrated total internal reflection (TIR), forming a circumnavigating wave known as the WGM. The near-field light-matter interaction allows for the detection of said biomolecules via a resonance wavelength shift.

Generating optimal resonant peaks is the most critical factor in determining the overall functionality of a microsphere. Factors such as the size and sphericity determine whether an integer number of wavelengths is fitted inside the microsphere, which is required in order to produce WGM resonance. We will analyze how manufacturing of the microspheres affect their physical properties and their functionality during biosensing. These properties include the quality factor (Q)—which determines the sharpness of peaks—, the separation and depth of the resonant modes, and the sensitivity of the resonances to binding of biomolecules, with the ultimate goal of discovering the optimal specifications needed for biosensing.

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Photocatalytic Hydrogel Reactors for Removal of Organic Contaminants from Aqueous Solution

In this study, a technology to remove and degrade contaminants from wastewater is presented. A photocatalytic hydrogel was created to overcome reactor design limitations in existing light-driven treatment methods. It is made of titanium dioxide (TiO_2) as a photocatalytic nanoparticle, acrylic acid, hydroxyethyl methacrylate, ethylene glycol dimethacrylate, and DMPA molded to form a channel with an inlet and outlet, allowing continuous processing of wastewater. Methylene blue was employed as a model contaminant. The properties of this continuous flow reactor allow for the diffusion of organic molecules through the reactor walls and degradation of those molecules by encapsulated photocatalytic particles. The removal of contaminants is determined by the diffusion (previously studied) and the UV-driven degradation of contaminants. Since the degradation rate depends on UV light, TiO_2, and methylene blue concentration, the amount of TiO_2 in the hydrogel was changed in order to further understand its effect. To quantify the effect of direct photolysis, without the effects of contaminant absorption and degradation, impermeable PDMS was used as a flow reactor. Finally, a solution containing a real organic contaminant, Norfloxacin, was used to asses device performance in more relevant conditions.

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Investigating the Influence of Solvent for the Use of an Activated Aluminum Alloy for Birch-like Reductions

There is a growing need in the chemical industry for alternative pathways to novel chemical reactions used for organic synthesis, as they often require toxic reagents and dangerous environmental conditions. For instance, the Birch Reduction is useful in the chemical and pharmaceutical industries due to its novel mechanism that reduces stable conjugated aromatic systems, like benzene, into unconjugated systems. However, its most common procedure requires sodium metal and liquid ammonia, which are considered dangerous reagents due to their reactivity and toxicity. Prior research has shown that Birch reductions can be performed without ammonia using silicon-stabilized sodium particulates. Inspired by successful alternative pathways to the Birch Reduction, this work explores the reducing capabilities of an activated aluminum powder on varying functional groups including alcohols and carboxylic acids, and on unsaturated and conjugated systems. Variations in reaction duration and proton source for the tested reductions were also studied. The demonstration of successful reductions with Al particles would constitute the first recorded use of aluminum-based heterogeneous organic reductions, opening opportunities for the development of novel and safe pathways for organic transformations.

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Conductivity Effects of Methanesulfonic Acid on a Cerium Redox Flow Battery

As fossil fuels verge on the edge of depletion, renewable energy sources, like solar and wind, are suitable replacements to fossil fuels— with limitations. For instance, solar power can only be utilized until sunset. In order to supply energy around the clock, energy storage devices are essential. Factors considered when evaluating a grid scale energy storage device include high energy density, affordability, scalability, and lengthy cycle life. One of the main forms of energy storage, lithium-ion batteries, excels in some aspects, but is not scalable or affordable. An upcoming form of energy storage, redox flow batteries, fulfills much of the criteria mentioned, like having a lengthy cycle life and being scalable. A redox flow battery is an electrochemical cell where redox species dissolved in electrolytes react at electrodes, with the two sides separated by a membrane. This study concentrates on optimizing a promising flow battery that uses Ce(III)/Ce(IV) and H_2 as the redox pair, methanesulfonic acid as the electrolyte, Nafion 117 as the membrane. One of the factors affecting the system's performance is the proton conductivity of the membrane. This will be studied under different environments using techniques such as electrochemical impedance, FTIR, and solution uptake experiments.

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Self-Assembling Protein Biomaterials for Ocular Drug Delivery

Photochromic ligands, such as diethylamine-azobenzene-quaternary-ammonium (DENAQ) bearing an azobenzene moiety, have been shown to treat degenerative blinding diseases caused by the progressive loss of rod and cone photoreceptors. DENAQ photoisomerizes from *trans* to *cis* in picosecond upon exposure to visible light and impacts the biological activity of transmembrane channels of the retinal ganglion cells. DENAQ can restore light sensitivity on voltage gated ion channels in retinas, but needs to be re-administered consistently. To enable this drug to persist longer in retinas, we introduce a protein engineered biomaterial, Q, in which its design is based on the coiled-coil domain of cartilage oligomeric matrix protein (COMPcc). Using DNA recombinant technology, we have designed Q so that the homopentamer has an optimal surface charge distribution that contributes to its ability to self-assemble into nanofibers at pH 4 and further assemble into microfibers upon binding to small hydrophobic molecules. We have demonstrated that Q successfully binds DENAQ into the hydrophobic pore to produce microfibers of 19.23 ± 7.01 Qm size, protecting DENAQ. The impact of DENAQ on the protein conformation is evaluated via circular dichroism spectroscopy. Sustained release of DENAQ from Q fibers will be studied for its potential application in photopharmacology.

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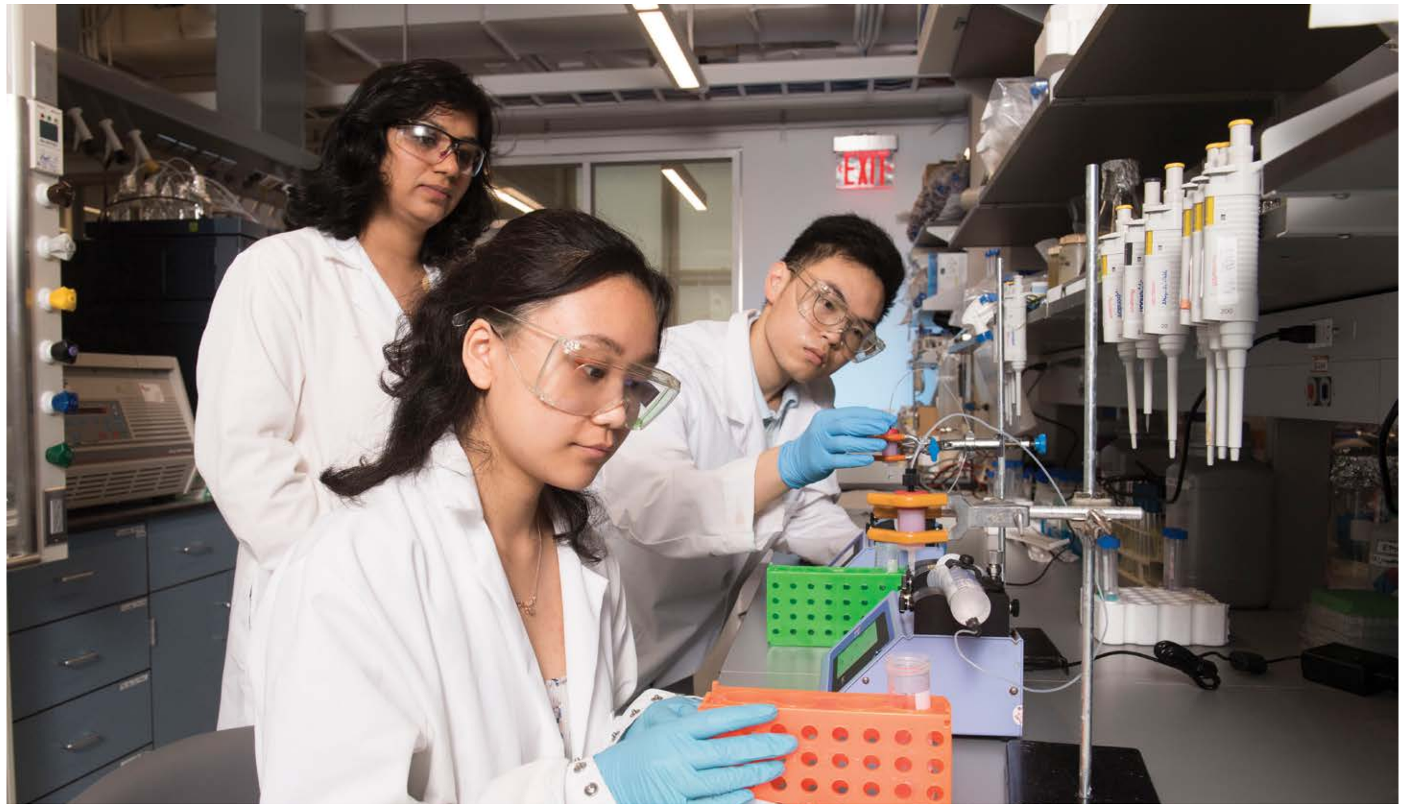
Exploring the Effect of pH on Protein-Engineered Coiled-Coil Hydrogels

Self-assembling biomaterials have proven to be useful in various fields including drug delivery, gene delivery, and tissue engineering. More recently, self-assembled hydrogels exhibiting thermoresponsive sol-gel behavior have been gaining traction as carriers of small hydrophobic molecules. Our lab has previously designed Q, which is an engineered variant of the coiled-coil domain of cartilage oligomeric matrix protein (COMPcc). The surface charge of the parent protein was re-distributed by swapping the N- and C-termini of COMPcc, allowing for lateral fiber assembly. Here, we demonstrate that Q nanofibers can undergo physical entanglement to form hydrogels at low temperature. Additionally, we are examining the effect of pH on the self-assembly and gelation of Q. The secondary structure, fiber assembly and gelation properties of Q will be characterized through the use of circular dichroism spectroscopy, transmission electron microscopy and rheology, respectively. Future studies will focus on investigating the encapsulation and release of a small hydrophobic molecule.



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Micropatterned, Highly Conductive, Solution-Processed MXene Foils

Two-dimensional Titanium Carbide (MXene) has gained increasing attention in research this past decade, demonstrating outstanding performance in electrochemical energy storage and other applications. MXenes, synthesized by hydrofluoric acid etching from precursor MAX phase, is generally processed using vacuum-assisted filtration or spin-casting into transparent conducting films, supercapacitor electrodes, and high-strength composites. In this work, MXene films are fabricated by drop-casting onto polystyrene; this hydrophobic substrate causes MXene-MXene interactions to be stronger than MXene-substrate interactions, producing foil-like films that can be removed from the substrate. Sheet resistance, thickness, and thus conductivity, depend greatly on concentration of MXene dispersion. At concentration of 3 mgmL-1, film thickness is $4.2\,\mu m$, and conductivity is 26,500 Scm-1, surpassing standard measurement for MXene film conductivity.

Despite numerous studies on MXene free-standing films, not much attention is directed at patterning films due to limited versatility of vacuum filtration methods. For this project, we design and prepare micro-structured polystyrene substrates with highest microscale resolution possible, resulting in films that exhibit mirror-images of substrate structures. Using this technique, we can envision introducing a new approach in MXene micropatterned film synthesis that is scalable and allows greater accessibility and throughput for preparing MXene-based materials in a diverse range of applications.

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Quantifying the Transition from Pristine to LiTFSI-doped Spiro-OMeTAD using Space-Charge-Limited Current Measurements

Though perovskite solar cells (PSCs) have reached efficiencies comparable to silicon solar cells, these have only occurred with lab-scale devices. To further improve performance, researchers must understand the different layers in PSCs. Spiro-OMeTAD is an organic semiconductor used as a hole-transport layer due to its non-reactivity and relatively high conductivity when doped with a lithium salt, LiTFSI. While Spiro-OMeTAD has been thoroughly characterized in its pristine state, LiTFSI-doped Spiro-OMeTAD is not well understood. Spiro-OMeTAD has been characterized with space-charge-limited current measurements to determine its charge-carrier mobility and doping density—its data often fitted with over-simplified analytical models. When LiTFSI is added, both charge-carrier density and the apparent mobility increase. This seems contradictory as the mobility of semiconductors usually decrease as doping increase, a possible artefact from fitting with simple analytical models. Using a drift-diffusion model, we will characterize the transition between different doped states in Spiro-OMeTAD and investigate the effect on its mobility and charge-carrier density. Ultimately our goal is to compare results found from using the drift-diffusion model with other simple models to determine whether both mobility and charge-carrier density truly increase as the semiconductor is doped and how this relates to PSCs performance.

Synthesis of Novel Two-Dimensional Graphene-like Nanomaterials for Catalysis and Energy Applications

Recent studies have shown that commonly used industrial catalysts have the potential to be improved through colloidal synthetic methods and doping to produce a low-cost, highly active hybrid material. Current industrial processing methods are expensive and are imprecise at targeting harmful chemicals that are produced in refining processes. Working in the nanoscale is promising since we are able to create a more active catalyst with more control over the end result, giving rise to the possibility of fine tuning catalysts to selective industrial processes. The key to unlocking the full potential of these hybrid materials lies in maximizing the available active surface area to influence important reactions to occur such as hydrodeoxygenation, hydrodenitrogenation, and hydrodesulfurization. With the potential to produce powerful catalysts at a fraction of the cost, our group has targeted molybdenum disulfide (MoS2) and has been working on producing single nanosheets of MoS2 through colloidal synthesis with Cobalt and Nickel as our tested dopants. Our approach has been to create said nanosheets through colloidal synthesis and to characterize our samples via X-Ray Diffraction, Atomic Force Microscopy and Linear Sweep Voltammetry in hopes of producing cost-effective, consistent, and alternative catalysts that could optimize current processing methods in chemical manufacturing.

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CsPbCl3 nanoparticles as x-ray scintillators for early stage cancer detection

Cesium Lead Chloride nanocrystals ($CsPbCl_3$) with perovskite crystal structure have shown high conversion efficiency (80%) in converting ultraviolet photons into visible photons. This property to convert high energy into low energy photons makes these nanocrystals a potential candidate for scintillators. A scintillator is a section of indirect flat panel photodetector that converts X-rays (20 KeV) into low energy visible photons, which are then detected by a photodetector and are electrically read out in the Integrated Circuit. This indirect photodetector is very crucial in medical applications to image in real-time and improvement of this device increases the chance of early-stage cancer detection. The current state-of-the-art scintillator (CsI:TI) suffers from low quantum efficiency due to the spectral mismatch with the photodetector (amorphous-Selenium (a-Se)). That is, a-Se lacks effective absorption of photons emitted by CsI:Tl at 550 nm. Thus, our focus is on $CsPbCl_3$ owing to its spectral match with the a-Se photodetector at 400 nm. We proceed with a facile colloidal synthesis technique to synthesize $CsPbCl_3$ nanocrystals and treat the samples with $CdCl_2$ to increase their stability. The crude $CsPbCl_3$ and the stabilized-$CsPbCl_3$ are further structurally, and optically characterized followed by the measurement of quantum efficiency and spatial resolution of the overall device.

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Colloidal Synthesis and Characterization of Metal Phosphide Nanoparticles

Nanoscale semiconductors exhibit a variety of size-dependent optical, electronic, and structural properties that make them highly beneficial for use in optoelectronics, charge storage, and other electronic applications. To date, a large number of multicomponent semiconductor nanocrystals with various stoichiometries (I-III-VI, I-V-VI, etc.) have been synthesized through numerous methods. Unfortunately, existing systems rely on use of materials that are expensive to process, such as GaN. Such issues have motivated the exploration of II-IV-V_2 (II: Zn; IV: Sn, Ge; V: P) semiconductor materials. In this work, we emphasize the development of zinc tin phosphide ($ZnSnP_2$), a p-type semiconductor consisting of environmentally benign and earth-abundant elements that has shown promise as a solar cell material due to its high carrier concentration and ideal direct band gap. At the moment, synthesis of stable zinc tin phosphide remains elusive, as thermodynamics preferentially favors formation of binary compounds such as zinc phosphide and tin phosphide. The goal of our research is twofold: develop an understanding of the reaction kinetics and thermodynamics underlying binary and ternary phosphide syntheses, and employ tunability of the material's optoelectronic properties via composition, size, and phase for practical use. We present x-ray diffraction, transmission electron microscopy and preliminary optoelectronic characterization.

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High-Performance Solution Processable Silver Selenide Thin Films for Optoelectronic Applications

Thin-film optoelectronic devices fabricated from colloidal quantum dots (CQDs) represent a promising avenue to sustainably achieve new levels of performance and scalability. CQDs are studied for advantages such as size-tunable bandgap transition, the availability of low-temperature manufacturing methods and mid-IR absorption. The advantage of the mid-IR spectral response is that detectors do not require an illumination source for imaging and can see through airborne obstructions. Previously, Hg chalcogenides were studied for mid-IR absorption. However, there exists a potential threat to the environment and public health through improper use and disposal of Hg-containing CQD devices. Recent research has adopted Ag2Se nanocrystals, an alternative to toxic Hg-based materials, as they share similar surface chemistry with Hg chalcogenides.

In the project, Ag2Se NCs were colloidally synthesized using silver and selenium precursors in trioctylphosphine and oleylamine. NCs were deposited as thin films on silicon substrates by spin coating. Colloidally synthesized Ag2Se nanoparticles have long carbon chain ligands that are electrically insulating. Exchanging these long-chain ligands with shorter, more polar ligands improves charge transport through the film. Fourier Transmission Infrared Spectroscopy and ultraviolet-visible-near-infrared spectroscopy were used for optical characterization and X-ray diffraction for structural characterization.

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Synthesis of Tin Phosphide Quantum Dots

Semiconductor nanoparticles, also known as quantum dots, have wide potential applications in many fields, such as medical imaging, quantum computing, and energy storage. Their potential comes from their display of quantum confinement, a phenomenon by which we can manipulate their optical and electronic properties by changing their size. This phenomenon is unique to nanoparticles and impossible for bulk materials and simple atoms. While a number of synthetic techniques exist to generate nanoparticles, we use bottom-up colloidal synthesis in our lab. Colloidal synthesis provides better control and precision of the final product compare with other nanoparticles synthesis techniques, such as plasma synthesis. By changing parameters such as temperature, concentration and the growth time, the synthesis stages can be optimized. SnP (tin phosphide) is one example of semiconductor nanoparticles. However, due to its challenging synthesis, its applications and properties remain unknown. One potential application of SnP scientists are looking for is anode materials for Na-ion batteries. The goal of this study is to find the optimizing condition to grow phase pure SnP and to explore the application of SnP as an anode of Na-ion battery.

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Efficient $CsPbBr_3$ Scintillators for Mammography Application

According to the American Institute for Cancer Research, more than 2 million cases of breast cancer were reported in 2018. Mammography is an X-ray imaging technique used to detect breast cancer. However, increased harm from high energy X-rays (20 KeV) and the high mortality could be effectively reduced through early detection of tumors a need which has been unmet by existing photodetectors. The state-of-the-art scintillator (CsI:Tl), an X-ray photodetector section, converts X-rays into visible photons which are then detected by a photodetector and electrically read out. However, the quantum efficiency (QE) is low requiring a high dosage of X-rays to obtain a better resolution. In a recent study, $CsPbBr_3$ scintillators have been reported to exhibit high radioluminescence for amorphous-silicon photodetectors (five orders of magnitude higher than bulk scintillators), but they lack in achieving high spatial resolution (SR). Therefore, we proceed with a facile colloidal synthesis technique to synthesize $CsPbBr_3$ and SiO_2 - coated $CsPbBr_3$ nanocrystals. Compact films are drop-cast as scintillators for amorphous-selenium photodetectors and tested their QE and SR. Preliminary crystal and optical characterization techniques are employed after synthesis. In the future, we will be measuring QE, and SR to compare the results with existing technology and optimize their efficiency.

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Silver Selenide for Use in Infrared Detectors through Ligand and Cation Exchange

Quantum dots (QDs) are semiconductor nanoparticles with size and shape dependent properties that differ from their bulk counterparts. We are interested in Ag2Se QD's because of their use in infrared detectors. Infrared detectors that absorb in the mid wavelength-infrared (MW-IR) can resolve an image through low visibility because they do not require an illuminant for imaging. There are devices that do this already, but they are made of toxic materials (HgTe). Being able to optimize Ag2Se with MW-IR absorption would allow for a safe material to replace a toxic one. In the Hybrid Nanomaterials lab, quantum dots are made through colloidal synthesis, which uses hydrocarbon ligands to stabilize growth. When synthesized, Ag2Se has long hydrocarbon chains attached at its binding sites. Although these hydrocarbons are beneficial for stability, long ligands are electrical insulators. The long ligands must be exchanged for shorter ligands that allow electrical conductivity. Previous experiments show that when Ag2Se is directly ligand exchanged, the nanoparticles conglomerate and are no longer useful in their desired application. We are attempting to make Ag2Se with short chain ligands through a "backwards approach". There have been previous experiments that have converted CdSe with long ligands into CdSe with short ligands. There have also been experiments that have converted CdSe to Ag2Se through a thermodynamically favored cation exchange reaction. By combining both of these processes, we hope to make Ag2Se with short ligands to replace the use of HgTe in MW-IR photodetectors.

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From Skin Care to Medicine: Anti-Inflammatory and Wound Healing Properties of Calendula Officinalis Flowers Grown In A Vertical Farm

Aquaponic vertical farming is the practice of growing food in soilless culture in vertically stacked layers, and it integrates hydroponic and aquaponic technologies. This significantly reduces the need for space and water to grow plants and is a much more sustainable alternative to traditional farming. We go beyond growing food and demonstrate that vertical farming can be used to create medicine and skin care products.

Calendula Officinalis Flowers has long been used in traditional medicine to facilitate wound closing and healing. Calendula contains triterpenoids, which has anti-inflammatory properties, and topical application of the extract increases collagen-hydroxyproline and hexosamine, two bioindicators of wound healing. It also increases the concentration of Glutathione when used in burns, which indicates it plays an important role in detoxifying free radicals. These properties of Calendula makes it suitable for not only skin care but also medicine as it can help heal acne, wounds, and burns. In this proof of concept project, we demonstrate an aquaponic farm›s capacity for farm to pharmacy or farm to cosmetic in-house sourcing of raw materials.

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Bacteria Analysis in an Urban Aquaponic Vertical Farming System

In an urban aquaponic vertical farming system, the waste product of fish, ammonia, can be converted to nitrates in a two-step nitrification process to provide a nutrient source for the plant. In the first step of nitrification, ammonia-oxidizing bacteria oxidizes ammonia to nitrite. In the second step of the process, nitrite-oxidizing bacteria oxidize nitrite to nitrate. Therefore, quantifying the nitrifying bacteria by measuring the pH and nitrate concentration at various concentrations will contribute to the construction of a more productive farming system. In addition, in order to maintain a safe environment for the vertical farm, there must be an early detection system developed for pathogenic bacteria such as streptococcus to eliminate possible bacteria outbreak inside the vertical farm.

CIVIL AND URBAN ENGINEERING

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Two-Sided Market Operational Policy for Real Time Public Transit Route Deviation

Traditional Fixed-route services are becoming inefficient due to their rigid routes and schedules. In the last decades ridership in transit services has progressively declined. Between 2017 and 2018 the NYC bus ridership decreased 5.1%. Hence the urgent need for transit planners to adjust to the changing urban environment and travel patterns. Different mobility-on-demand alternatives such as car-sharing and ride-hailing have become available on the market. However, these services are not an efficient city level solution due to their high costs. Studies have shown that flexible transit services under specific demand and deviation constraints result in a lower cost. Planning for these flexible routes is complex as very different route spatial distributions can be derived depending on the cost constraints and distribution between users and providers. In this research, we propose to develop a flexible bus route using a two-sided market framework in order to guarantee the maximum benefit for both users and transit service operators. The existing NYC bus route B63 was used as a reference. From this benchmark, a demand specific route alternative was derived using a dynamic station model. This method could potentially be used by public agencies to engage with transit operators and travelers at a city level to assure a social optimum cost.

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Brooklyn Queens Connector Evaluation Through a Multi-agent Virtual Simulation

The introduction of large scale data informatics allows for the computation and prediction of different modes of transportation. The developed program allows for policy makers to predict how changes in transportation infrastructure will affect traffic flow. The project specifically tackles the proposed Brooklyn Queens Connector(BQX). The BQX is an above ground light rail system that is expected to be fully implemented by 2029. The proposed route runs along the East River. The tracks for the BQX are designed to replace roadways and allow for shared traffic. The baseline model generates an artificial population and determines the usage of available modes of transportation(automobiles, bikes, walking, heavy & light rail, etc.). The test model incorporates the BQX and allows for the synthetic population to choose between the BQX and other modes of transportation. This allows for an accurate determination of the expected volume the BQX will experience and the effects it will have on other modes of transportation.

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Recommender system development and deployment for elderly mobility in NYC

The lifestyle and mobility pattern of many seniors change as they grow older. Their criteria for a good place to solve their shopping, dining and socializing needs are largely different from young people. Although recent technologies based on smartphones provide services including route planning, ride hailing, and destination recommendation, elderly people have not adjusted well to them and it is challenging for them to utilize the benefits from the current public transportation system. There are limited smartphone applications that serve to assist seniors with their specific mobility constraints. This research project aims to cater to the needs of mobility applications for seniors by incorporating an algorithm that can learn seniors' preferences and make recommendations accordingly. Contextual bandit algorithm makes use of context and user information to make personalized recommendation from dynamically changing pool of candidates. It sequentially selects destinations for users and receives feedback to adjust its selection strategy, which both exploiting and exploring their preference. A synthetic dataset is generated by simulating certain groups of people's preference, and an offline evaluation is conducted. This algorithm will be extended to a mobility application designed for elderly people and will recommend destinations for them according to their preference.

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Building Baymax with Machine Learning in Soft Robots

Building Baymax, a humanoid soft robot in Big Hero 6, in real life faces a universal challenge as all soft robots do. Soft robots, made from compliant materials, are appropriate for performing diverse tasks with their high flexibility and degrees of freedom. These characteristics, however, challenge the traditionally analytical techniques such as Finite Element Method (FEM). Existing methods for proprioception, the self-sensing of body movement, of soft robots incorporate the use of stretchable sensors embedded in their bodies to capture local deformations, having limited accuracy of measurement and adaptability to other soft robots.

In this project, we focused on assisting human-computer interaction of soft robots, specifically through building a real Baymax. We proposed a framework to accurately measure and reconstruct the real-time 3D shapes of soft robots, by employing vision-based sensors, training a Convolutional Neural Network (CNN), and then recovering 3D shapes with point cloud decoders like FoldingNet. This method addresses those problems, in which the resolution for real-time proprioception is enhanced and the setup is applicable to various soft robots. The design will lead to a Baymax and its virtual avatar that synchronizes its motion with the real one and therefore enable closed-loop control in the future.

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Portrait Painting with Neural Networks

The area of generative machine learning has made great improvements in recent years. Models are able to create realistic reconstructions of various types of images. Many of these neural networks construct new images by creating a new pixel representation, a bitmap image. Our method, inspired by human artistic methods, recreate images digitally by generating virtual “paint strokes” as represented by Scalable Vector Graphic (SVG) instructions. Vector graphics store data as a set of mathematical instructions which are interpreted by graphics software to create an image. An image in vectorized format lends itself well for data compression, which has implications for smaller data storage and transfer volume. Our model uses an autoencoder, which takes a rasterized image as input. Using a convolutional neural network, our image is first encoded into a smaller dimensional latent space. We then decode using a multilayer perceptron, the results being a tensor of SVG instruction parameters. These instructions are lastly run through a neural renderer, which translates back into a pixelated image. This image is compared to the original input image to calculate loss, which will be used for backpropagation and training.

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Machine learning for Structural Engineering

Designing structures that are both strong and cost effective is a difficult task in many engineering applications. Architects must make the best use of limited resources to create designs that are both cost effective and compliant with safety regulations. Even though structural analysis tools exist, techniques to create structures are mostly empirical and time consuming.

Recent advances in machine learning provide promising solutions to various optimization tasks like optimal control for robotics and production optimization in manufacturing. We explore various machine learning techniques to aid in computer generated structural design, specifically in the realm of bridge building. In complex environments like irregularly shaped terrain, optimal structure designs may not be obvious. The generated designs can be used by architects as inspiration or starting points for bridge building projects, saving time and providing useful insights. To simplify the simulation environment, we focus on generating truss bridges (wire-frame structures), optimizing for maximum strength and minimal material usage.

Deep Learning for Traffic Video Analysis

Traditional high-way transportation systems are monitored based on traffic counters. Such sensors provide much less information compared to traffic cameras and make the system less secure/resilient to attacks/disasters. Thanks to the success of deep learning for object detection/segmentation on images and the publicly available large-scale image datasets with object labels, fusing the information from both traffic counters and traffic cameras has the potential to improve the security and resilience of existing highway transportation systems. The purpose of the project is to investigate such a potential by developing a deep-learning-based highway video monitoring method that can reliably estimate the fine-grained (car/truck/motorcycle) traffic flow of a high-way network. First, we need to collect a large-scale traffic video dataset with traffic flow estimations from corresponding traffic counters. Then, we need to find efficient deep learning methods for extracting fine-grained local traffic information from individual traffic videos. At last, we need to correlate this information with traffic counters for sensor fusion and detection of defective counters.

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Large Scale Mobile Robotic 3D Printing

While useful, traditional gantry-based 3D printers have a few significant disadvantages. The printing scale is strictly confined to the printer platform, and the printing process has relatively low efficiency. Using mobile robots for 3D printing can be one potential solution. However, highly accurate localization of these robots is the key challenge to this new possibility. Accurate 3D printing requires millimeter level accuracy of the printhead, but traditional cost-effective localization methods are at most of centimeterlevel accuracy. Our research will use deep neural networks to fuse laser sensors and cameras, leading to a new method of localization suitable for mobile robotic 3D printing. Such a method will also be able to incorporate other sensors such as odometry from IMU/wheel-encoders, to further increase the accuracy and efficiency of localization. We are working on both the hardware and software platform for testing and improving the localization accuracy and expect to demonstrate a large-scale 3D printing (at least 1m by 1m size) by the end of this project.

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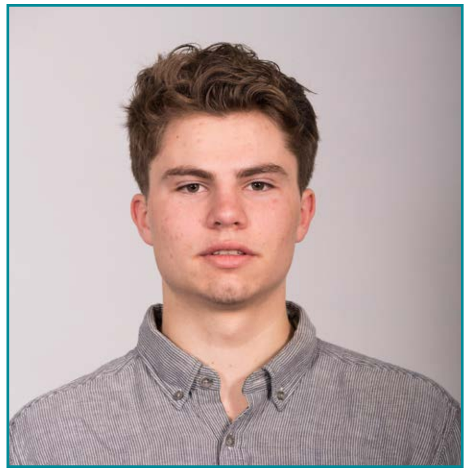

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Resilience of Dynamic Routing over Parallel-Link Networks against Recurrent and Random Sensing Faults

Road traffic is already a great problem around the world. When traffic networks are down, they pose an even greater problem. These network links are also prone to attacks which can induce significant congestion and accidents. The flow and stability of transportation links are crucial to having running but these failures and their implications are still not well understood. Google Maps, WAZE and other route engines track traffic flow to produce the most efficient route to get to your destination. This research develops algorithms to enable the routes to be effectively calculated even when links are down or producing inaccurate results. The inflow and outflow of vehicles are analyzed through the capacity and number of possible links that are down to develop trends of accuracy through the network system. With these mathematical representations, even if the links are down or corrupted and effective route guidance would still be available. This has implications to create better GPS systems as well as creating a system in which automated cars could use to create the most efficient networks.

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Development of data-driven models for highway traffic flow: A case study on Interstate 210

Highway traffic is a major challenge around the globe. Much of our road network operates at- or over-capacity and is often faced with severe congestion. For this reason, it is essential to better understand the behavior of traffic and how to optimize flow within existing infrastructure.

Using actual traffic data from Caltrans PeMS, several data-driven models (including linear regression, tree regression, and neural networks) were constructed in MATLAB to predict future traffic in this freeway section. The models were used iteratively, and their outputs compared to true values. This way the relative precision of each one could be assessed and improved, and then used to compare the prediction power of data-driven models with more traditional physical law models.

The trained models are also useful to obtain insight of cause and effect relationships in traffic flow, and to simulate flow under different traffic conditions. The solutions developed can later be used to optimize traffic using tools such as ramp metering and HOV lanes.

Coordination of Connected and Timeless Vehicles

Platooning of heavy-duty vehicles (HDVs) is a key component of smart and connected highways and is expected to bring remarkable fuel savings and emission reduction. This project focuses on studying the coordination of HDV platooning on a highway junction. The goal is to develop an algorithm that can characterize the optimal platooning pattern that leads to minimal cost (time plus fuel). Forming platoon, i.e., merging, is done by accelerating the following vehicles to catch up the leading ones, which increases oil consumption. On the other hand, platoon structure saves fuel through reducing wind resistance of vehicle driving. Here, we develop a threshold value as the fine line to balance two contradictory factors out. Three major random variables are considered as part of the equation: (i) platoon size, (ii) headway between platoons, and (iii) travel time increment due to platoon formation. We formulate and solve the optimization problem through utilizing some established models.

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Interventional Radiology Life Cycle Assessment

The United States healthcare sector contributes to, among other pollution impacts, over four million tons of waste yearly and 10% of the nation's greenhouse gas emissions. Measures to reduce such impacts of US hospitals could save an estimated $15 billion over one decade, in addition to improved environment and public health outcomes. However, information is scarce on the environmental impact within the scope of a single hospital operating suite, where changes directly impacting clinical outcomes take place. Life-cycle assessments (LCAs) are used to calculate the environmental emissions of a product or system due to raw material extraction, manufacturing, transportation, product use, and end-of-life treatment. This study will evaluate the total emissions per procedure from the vascular interventional radiology (IR) inpatient and outpatient suites of one hospital by using a process LCA, based on quantity of equipment manufactured, electricity consumed, and waste produced, and an economic input-output LCA, based on purchasing data for the equipment used. Procedures are also qualitatively observed to identify staff practices that may contribute to emissions. Future LCA studies could introduce changes to the vascular IR suites and estimate differences in emissions.

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Decay of Antibiotic Resistance Genes in the Environment

Antibiotic resistance is a growing issue, in which the use and overuse of antibiotics positively select for resistant bacteria, causing them to be more prevalent. Infections caused by antibiotic resistant bacteria cannot be treated with commonly used antibiotics. Current wastewater treatment methods rely heavily on chlorine disinfection which inactivate ARB, but has a reduced effect on antibiotic resistance genes (ARGs), the genes that code for resistance, which persist in effluent waters. In the environment, ARGs may undergo horizontal gene transfer (HGT) in which genetic material is shared between microorganisms, leading to the propagation of antibiotic resistance. Sunlight becomes an extremely important environmental stressor which is capable of inactivating bacteria, viruses, and potentially ARG2.

This study focuses on E. coli SMS-3-5 which is resistant to the antibiotics tetracycline and sulfonamide; the corresponding ARGs are tetA and sul2 respectively3. In this study, the sunlight inactivation of ARB as well as the intracellular and extracellular sunlight decay processes of the ARGs were monitored. While ARB inactivation was monitored using plating methods, DNA extractions were conducted to monitor ARG decay using qPCR. Preliminary results suggest that the tetA gene is susceptible to sunlight disinfection.

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Life Cycle Assessment: Whole Hospital

The United States spent 3.65 trillion dollars on healthcare in 2018, with 31% allocated solely to hospital expenses. As a result of such hospital spending, the healthcare sector contributes to the production of 10% of the country's greenhouse gas emissions (GHG's) and 9% of Clean Air Act criteria air pollutants, like carbon monoxide and particulate matter.

The purpose of this study is to quantify the resource and energy input and output flow of a typical hospital in order to determine its entire carbon footprint. Input streams from multiple departments such as pharmaceuticals, engineering (utilities), central sterile, finance, etc. and corresponding output waste streams will be identified through previous literature, site tours, meeting with hospital staff, and pre-recorded measurements and records maintained by the hospital. Resource and energy data will then be subject to a life cycle assessment (LCA), which calculates the total environmental impact of a product or service at each stage in its life cycle, from raw material extraction to usage and ultimately disposal.

Analysis of the data would reveal which hospital departments and expense categories contribute most to its entire carbon footprint. A working hypothesis pins the operating room (OR) and its abundant waste generation, single-use-item policy, and demanding HVAC usage as the primary contributor in generating the hospital's entire carbon footprint.

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iWASTE (Intelligent waste auditing system for OR)

Approximately 1.8 billion kg of waste is produced by healthcare facilities annually in the US, among one-third of which comes from operating rooms. While the safety and quality of patient care should be the priority, efforts to ensure efficient and sustainable resource practices in healthcare facilities, through waste auditing, are equally important. Auditing helps define the characteristics of the residual waste generated by hospitals and offers insight to determine ways to reduce the total amount of waste. Unfortunately, the current waste auditing methods are inaccurate, time-consuming, and places the auditor in close contact with hazardous materials.

This project aims to create a waste receptacle, *iWASTE*, which is an automated waste auditing system that is efficient in tracking material flow before and after procedures. This summer, students will redesign the *iWASTE* prototype, and collect 60 images and videos of general medical tools as they are disposed to help gather data for machine learning concepts. Using the training data, *iWASTE* will be used in operating rooms to help identify the types of waste produced after each surgery. This data will provide healthcare professionals with information about the quantity and type of medical waste generated in their facilities and enable them to work towards a more environmentally and economically sustainable option.

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Holodeck/VR/AR, and Sensing

The Holodeck is a collaborative mixed reality environment tool that connects across multiple locations through the use of Corelink, a dedicated network solution developed for the project. The Holodeck is intended to have a flexible infrastructure, allowing it to host diverse applications ranging from the collaboration of cross-disciplinary groups to human-agent or human-robot interactions in simulation settings. By integrating electroencephalography, heartbeat, motion capture and other sensor data in the Corelink network, the research aims to obtain an in-depth understanding of the moment by moment psychological and physical states of individual participants within the interactive environment. Data gathered in the Holodeck environment can be utilized for further analysis and drawing informed conclusions depending on the environment setting and objectives. Further research and development in the integration of new sensors through the implementation of sensor-specific modules and Corelink libraries will allow for further insight regarding the state of participants interacting within the Holodeck.

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Dress Assistant for Individuals with Dementia

Dementia is a state of cognitive decline that can interfere with daily activities. Symptoms include memory loss, confusion, and inability to perform familiar tasks. Like most disabilities, dementia causes strain on both personal relationships and psychological well-being. While there are medical treatments for dementia, there are also untreatable impacts such as a loss of independence. Individuals diagnosed with dementia begin to face challenges performing familiar activities, such as getting dressed every day. For many of the approximately 50 million individuals around the world diagnosed with dementia, donning clothes in the morning becomes a daily frustration. This research directly addresses the demand for more disability-friendly applications to assist individuals with dementia by creating technologies that help those individuals to live more autonomously. The Dress System utilizes LED strips to prompt action for specific drawers, and cameras using computer vision to track movement and provide auditory feedback on the dressing process. With various sensors, caregivers are able to avoid conflict that may arise with from the private nature of dressing, while tracking individual progress and anxiety levels, and providing intermittent assistance as needed. Future research into sensing and emotional feedback can provide new ways to develop friendly applications for dementia.

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Tangible Activities for Geometry (TAG)

Using robots is always a powerful tool for students with STEM contents, improving their comprehension of the fields and constructing their confidence in their skills. Our TAG project, Tangible Activities for Geometry, aims to bring potential benefits to middle school students interacting with a teachable robot to learn mathematics and computational thinking in geometry.

We first built our robot with Lego Mindstorms EV3 components and installed python on the brick to control the robot with the program. Next, we used an MSI VR One Backpack PC as a broker to run MQTT, a protocol that can send and subscribe operations to exchange data between the robot and the computer. An iOS application was built to send simple commands such as forward and turn with pre-programmed codes in python.

After that, we utilized the OptiTrack motion capture system to capture the position and orientation of the robot in the field. Therefore, we developed several applications such as make the robot "yell" "put me down" when it was lifted and control the robot to steer accurately. The next step is to use the robot to do simple geometry problems.

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Preventing Compiler Backdoor Attacks with Reproducible Builds

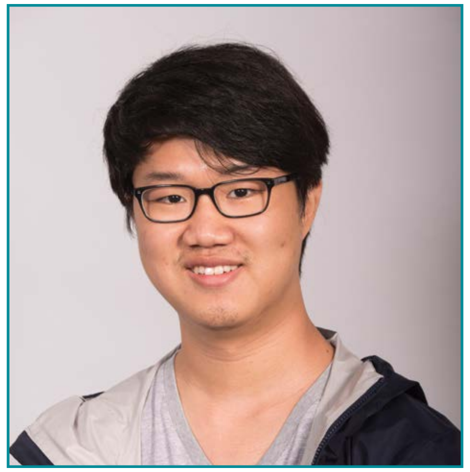
In the software development process, code is first written in a human-readable format and then translated to machine language, where machine language is what our computer reads and understands. A compiler is used to translate a high-level language into machine code. But what happens if an attacker intercepts the compilation process, and the machine code produced isn't what you originally instructed your high-level language to do? A compiler backdoor attack potentially allows an unauthorized third party to inject code as software is being compiled, thus resulting in machine code which includes malicious scripts. Since machine code cannot be understood by humans, this attack is virtually invisible and undetectable.

To prevent compiler backdoors, reproducible builds are used. We are currently using the Debian OS hosted on a virtual machine to create a trusted rebuilder of our programs to ensure that the corresponding builds on our local machine are identical bit by bit.

Indra Agent-Based Modeling System

Agent-based modeling (ABM) is a class of computational models for simulating interactions of multiple agents acting independently, but whose interactions produce an emergent outcome. For example, an agent can represent a person in a certain economy, and by creating thousands of these agents with different income levels, buying habits and more, we can model how the economy could change. Currently, we are refining Indra's Net, an existing ABM system that was built using Python, Javascript, Awk, Bash, and YAML. Our team is focused on three main tasks: developing new models and refining current models, building a RESTful API web server, which communicates with users through JSON messages, and creating a new web front end. The ultimate goal of Indra is to simplify ABM creation so that a model can be specified in only a few lines of code or, for non-coders, simply by modifying a few parameters based on default models. Indra's Net provides an easy solution which supports parameter sources including terminal input, prebuilt property files and environment variables.

A description of our system can be found here: https://gcallah.github.io/indras_net/index.html (along with links to our working components), and our Github repository is here: github.com/gcallah/indras_net



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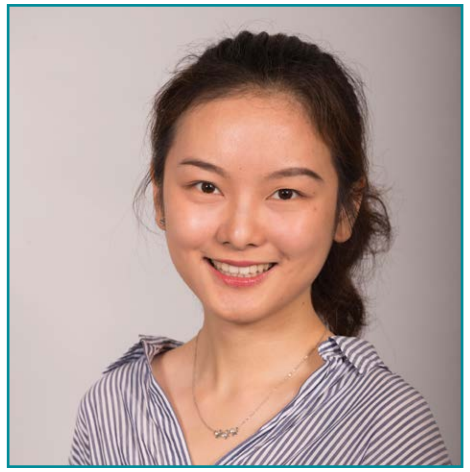

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Crash Simulator

A common problem for developers is applications exhibiting new bugs after deployment. Many of these bugs can be traced to unexpected network, operating system, and file system differences that cause program executions that were successful in a development environment to fail once deployed. Preventing these bugs is difficult because it is impractical to test an application in every environment. So, we create an implementation of Simulating Environmental Anomalies (SEA) technique, which is called CrashSimulator. CrashSimulator provides a framework by which the checkers and mutators constructed by its users can be used to test an application using the anomalies they represent. CrashSimulator operates on system call level, which is a good fit for simulating the file system, network, and operating system anomalies in which we were interested. An application normally queries these entities using system calls, so we simply had to return modified responses in order to simulate an anomaly. We have created mutators and reconstructed the tool. Now we are updating this tool to a better user interface and making it faster and more powerful when testing large programs.

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U•Start – Build Website and Connect People Around You

U•Start is a creation platform where college students can highlight all their skills, portfolio, and past projects in a modern, sleek way that does not require going to multiple different sources. Users can also share ideas for new projects with others on the U•Start network in hopes of finding people with the necessary skillsets to develop the project. It will also allow students without ideas to browse through projects and contact other users about joining the projects that interest them. The platform provides opportunities for real-world experience and projects with a worldwide impact.

For the Undergraduate Summer Research Program, we intend to build a networking database system that maps and analyzes existing data, connects users with similar backgrounds and past project experiences, and recommends possible acquaintances and potential project partners. We are trying to achieve this comprehensive Internet-scale graph database through Neo4j, a graph platform embodying complex algorithms and various libraries that allows us to visualize traditional user information and create dynamic relationships within our system. On the backend data side, we are working on adding new microservices such as emailer and uploader features, written with Golang and Elasticsearch.

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Load Balancing and Query Routing in Large Search Architectures

Billions of search requests are addressed daily to major search engines. In order to handle such an extensive workload while staying customer-friendly and satisfying service level agreements (SLAs), agreements that establish limits for the quality and latency of the results delivered, search engines parallelize execution of queries among a large number of machines. To achieve this, the set of documents is split into shards, and shard replicas are assigned to specific machines. Every query then gets routed to many machines in parallel to cover all the shards. Thus, the system of machines can be modeled as a hypergraph where every hyperedge connects replicas of the same shard and has a certain workload that is distributed among the replicas.

In this project we aim to explore local distributed algorithms that repeatedly perform elementary rebalancing steps to converge to an optimal load balanced state. We explore different load rebalancing techniques by creating models in Python and analyzing their results, by comparing the results to the output of a linear solver for the same problem, as well as defining and calculating potential functions that converge to zero when the system is balanced.

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An interactive visual explorer for error detection in machine learning models

With today's machine learning models, machine learning is capable for making relative accurate decisions. However, in order to help domain experts to validate model decisions and end users to trust and use the model, it becomes more important for model developers to further understand the model behaviors and then improve the model. The project is intended to build an interactive visual explorer for users to detect potential model errors by visualizing the distribution of model predictions. For example, a histogram of every class's accuracy and a t-SNE projection of data. Furthermore, by selecting specific class of interest, the visual explorer can give further details on the performance of the model prediction by giving confusion matrix and histogram of prediction score. By these visualizations, users can get a better understanding on model's prediction on dataset and therefore find potential problems of dataset or choose other models according to the specific trait of data. For now, the project started with MNIST dataset and convolutional neural network model to visualize the the model's accuracy on image classification. For future work, this interactive visual explorer can allow user to input other datasets and select different models for other accuracy analysis and error detection.

ELECTRICAL AND COMPUTER ENGINEERING

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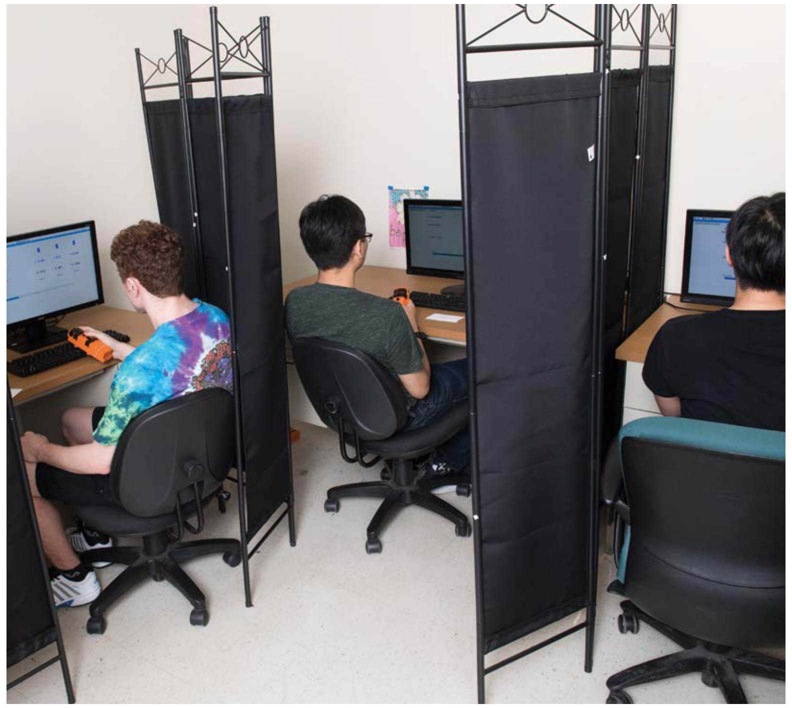
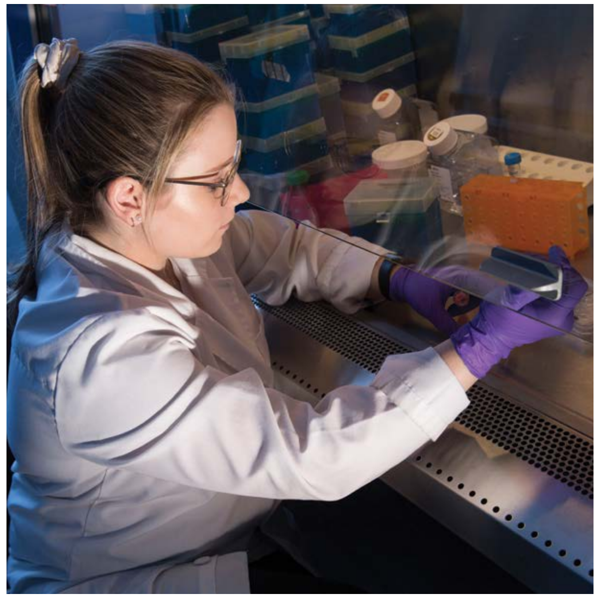
Exploring Indirect Attack Angles to Protect Power Grids against Demand-Side Cyberattacks

Since the cyberattack on the Ukraine power grid in December 2015, cybersecurity researchers have investigated numerous grid-end vulnerabilities. However, due to the growing penetration level of residential internet-based high-wattage appliances, there is an emerging threat of indirect attacks on the US power grid. The goal of this project is to explore the multiple indirect attack vectors, e.g. heating, ventilation, air conditioning (HVAC) and electric vehicles (EV). Each attack vector will be examined for the steps in order to execute the attack, as well as the effect of these demand-side cyberattacks. From each attack vector, data specific to executing the attack vector will be collected. Finally, the data collected will be evaluated using data analytics in order to contribute to improving privacy-aware defense mechanisms.





Low Delay Congestion Control Protocols over 5G mmWave Links

Congestion is a state that takes place in a network whenever heavy traffic exists, thus, slowing down the overall network response time. Conventional congestion control algorithms aim to utilize the available bandwidth while avoiding network congestion. Recently, many congestion control algorithms are proposed for reducing the end to end delay. Most adopted protocols have been developed with stable links in mind (i.e generic internet or conventional 4G wireless links).

Having different characteristics than pre-existing 4G links, the 5G mmWave links are known for rapidly varying capacity, intermittent outages and short channel coherence times. Considering the commercial rollout of 5G, the compatibility of the existing congestion control algorithms and protocols over 5G links should be questioned. Low delay congestion control protocols have not yet been evaluated in this environment, and may not work as efficiently with 5G. As a result, we must revisit conventional congestion control protocols over 5G links.

In this project, we will evaluate different congestion control algorithms on a test bed emulating a 5G mmWave channel. Through studying several congestion control protocols, such as TCP BBR, PPC, Remy, Sprout, Copa and Verus, the project would test if the experimental results match the expected outcome for each protocol.

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A Game-Theoretic Approach for Reducing Queuing Delay in Communication Networks

Many applications of 5G networks, such as Internet of Things, self-driving cars, VR etc. require very low network delay for their functionality to perform as desired. Since delay on the air link has been reduced with the development of 5G networks, now queuing delay due to congestion becomes a major contributor to end-to-end delay. As a result, we must revisit well-established results that do not consider queuing delay.

The strategy of “selfish” senders in a network who seek to achieve high throughput is well studied over the past decade. But this strategy can lead to excessive queuing delay. In this project, we extend the previous work in this area to understand the behavior of senders who seek to achieve low delay, as well as high throughput. Results and conclusions from this project may help us develop new protocols realizing this strategy which can be used on 5G links to reduce overall delay.

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Identification of relevant diffusion MRI metrics impacting cognitive processing using a novel feature selection method

Mild traumatic brain injury (mTBI) is a significant public health issue with millions of civilian, military, and sport-related injuries occurring every year. Moreover, 20-30% of patients with mTBI develop persistent symptoms months to years after initial injury. Cognitive complaints are important among the most troubling of symptoms due to their significant impact on the quality of life. In this study, we examine the specific cognitive subdomain of working memory in relation to the underlying tissue microstructure by accessing diffusion MRI and predict performance on working memory. Defining specific imaging biomarkers related to cognitive dysfunction after mTBI would not only shed light on the underlying pathophysiology of injury leading to cognitive impairments, but also help to triage patients and offer a quantitative means to track recovery in the cognitive domain as well as track efficacy of targeted cognitive therapeutic strategies.

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Improving 360-Degree Video Streaming Via Deep Reinforcement Learning

With the advent of virtual reality (VR) technologies, effective solutions for the streaming of 360-degree video have become increasingly important. These videos are typically produced in high resolution, thus requiring a great deal of bandwidth to stream. However, only a fraction of the video is viewed by the user at any given point in time. Current systems divide the video into multiple non-overlapping tiles, which may then be allocated independent rates. For higher quality of experience, we would like to predict the user's field of view (FoV) with a high degree of accuracy, and then allocate high rates to tiles which fall inside the FoV, and low rates to others. As this problem is a sequential decision making problem, where decisions taken in the present affect states and rewards available in the future, we use deep reinforcement learning (DRL) to maximise the quality of experience. We experimented with various state compositions and deep learning models such as multilayer perceptrons, convolutional networks and recurrent neural networks, for the components of a popular DRL algorithm called A3C (Asynchronous Advantage Actor Critic), and obtained improvements over previous work done in our laboratory. The system was based on a two-tier system with separate buffers for high and low quality video, which helps prevent black spots, minimizes rebuffering and is robust to variations in bandwidth and FoV prediction accuracy.

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A Kinetic-Based, In-Home Exercise System for Lymphatic Health and Lymphedema Intervention

Kinect sensors have been an upcoming trend in healthcare because they can monitor and provide feedback to patients performing intervention or rehabilitation exercises. Kinect measurements for joints are noisy and unreliable and the motion sequences are not temporally aligned. This research develops algorithms to solve the problems of noisy Kinect data and alignment. Firstly, this research contributes the clustered Gaussian Process regression model that de-noises the Kinect data. Secondly, it contributes the modified dynamic time warping algorithm that detects the end of each exercise subsequence while aligning the subsequence data with a reference subsequence. The current focus is on effectively integrating the algorithms into the prototype system that provides real-time feedback to patients performing lymphatic exercises and on improving the exercise algorithms. As of now, the prototype system integrates these algorithms effectively and gives instantaneous feedback to patients during the exercise through a friendly user interface. Further tests with patients is needed to improve user interface and to test the precision of the exercise algorithms. A database is also needed for storage and maintenance of patients' data and privacy.

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Exploring Adversarial Phenomena in Deep-Learning-Based Autonomous Driving Applications

Autonomous driving has been a highly popular area of research in both academia and in corporate R&D. Just last year, Waymo, a subsidiary of Google's parent company Alphabet, started implementing self-driving taxi services in the US, Apple purchased the startup Drive.ai, and Renault and Nissan have started developing autonomous vehicles for Europe and East Asia. While such vehicles have enormous potential, a lot of phenomena are still left to be fully explored.

One such phenomena are adversarial examples, input data that cause machine learning algorithms to misclassify them. They raise cybersecurity and validity questions about the physical world implementation of deep learning algorithms, such as in autonomous vehicles. Our research investigated the three main methods of generating these physical world adversarial examples as outlined by Goodfellow et al. Prior to this, we developed training and testing algorithms for both discrete/classification and regression problems, one of which includes predicting Parkinson's disease stages based on voice recording data. The final phase combines the generation of adversarial examples with a new idea called VisualBackProp, and thereby using masks to make our algorithms more flexible in the face of targeted misclassification data.

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Concealment Charm: Generating Steganographic Sequential Data using Generative Adversarial Nets (LeakGAN)

A constant exchange of essential information through social media, email services, and other virtual means raises a concern about the extent to which our data is protected. Steganographic systems have enabled people to have an additional layer of protection for their data. However, so far steganographic systems using sequential data as cover data, such as textual data or scripts for software, have not seen noticeable advances. Improving steganographic systems for sequential data has positive implications in enhancing privacy in social media, especially under regime with strong censorship, and reducing software obfuscation cases, thus protecting intellectual property.

The main challenge with reproducing sequential data is that it is difficult to generate cover data that would look and sound as authorized data, i.e. read like a human-written message or script. With this issue in mind, this project aims to build a system that enables an exchange of sequential data (Twitter messages and emails as case studies), so that passive adversary who has the encrypted data can determine neither the original content nor the fact that this data has been encrypted. This improved steganographic system is trained using Leak Generative Adversarial Nets (LeakGAN), which has shown state-of-art results in generating long textual data.

INSTITUTE OF INNOVATION, INVENTION, & ENTREPRENEURSHIP

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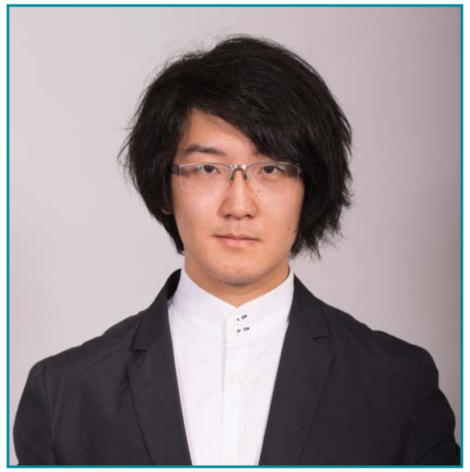
Internship with Future Labs Start-Up (Eureka)

Eureka is a start-up developing on-boarding software that improves how engineering organizations scale their teams by automating and optimizing all aspects of the on-boarding process. It analyzes data from the tools a team is using (like project management, chat, calendars, source control and others) and transforms that information into a dynamic team knowledge base and personalized on-boarding plans for new team members. Eureka also streamlines on-boarding operations like scheduling introductions, assigning tasks to the right people and gathering feedback from your new team member and others around them. As part of my project, I developed algorithms that will be used to personalize on-boarding plans by adding several unique features to the online application. This involved doing research into a variety of subjects including recommendation systems, data modeling, API integration patterns and building out an API that allows for the ingestion and extraction of data from the data layer.

MATHEMATICS



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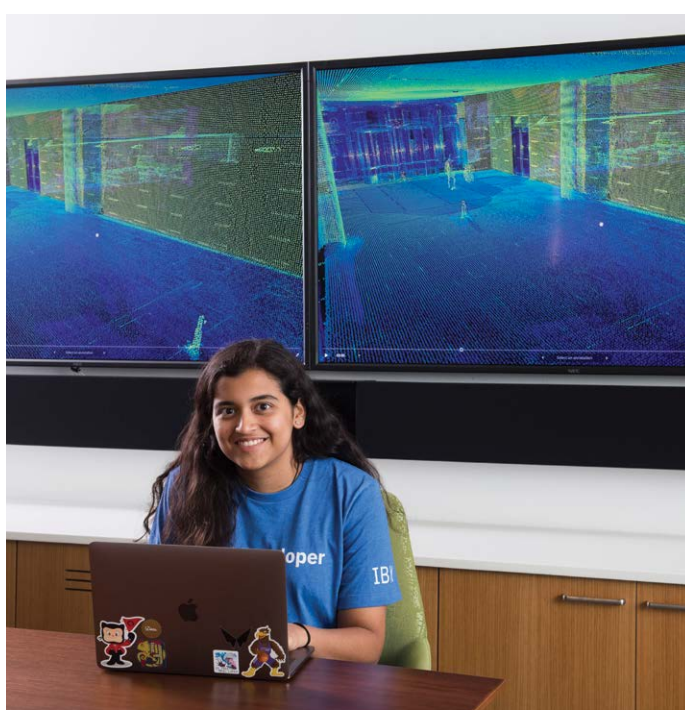
Geometric Properties of Lipid Vesicles Membrane due to Bending Energy

The Canham-Helfrich bending energy is an important topic in differential geometry and biophysics proposed to essentially answer the question of why are some components of life, namely red blood cells or lipid bilayers the shape they are. Its core idea is that it takes energy for membranes to bend; therefore, objects will naturally appear in certain shapes that obey the principle of minimum energy.

Researchers have demonstrated that the biconcave shape has smaller Canham bending energy compared to a sphere with the presence of an anisotropic bending rigidity of the material; thus, biconcave shapes are more efficient. Our research aims to show a genus-1 axisymmetric shape's geometric dependence on anisotropy and volume-area ratio due to Canham energy as well as Helfrich energy. Our approach uses both numerical and analytical methods to determine the profile curve with the least bending energy.



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The Doping Modified Multiband Bardeen-Cooper-Schrieffer Gap Equation in the Theory of Superconductivity

In the late 1960s the Bardeen-Cooper-Schrieffer Theory of Superconductivity was discovered; it accurately modeled the onset of superconductivity of materials that are of a single band. There exist bands on the fermi surface of a superconductor that interact with one another in order to create a superconductive energy gap. If a fermi surface of a certain material has only one band, we consider it a single-banded material. In reality however, the onset of superconductivity at reasonable temperatures in single-banded materials is quite rare. Many mathematicians over the past 30 years have worked to extend this equation to substances that contain overlapping of unfilled bands.

To date, we understand a material's superconductive properties if we assume that the coulomb and phonon interaction between electrons can be simplified into a constant, or even positive, kernel. However, through research in condensed matter physics, it is universally accepted that a compilation of coulomb and phonon interactions into one constant kernel is a detrimental assumption.

The goal of our research is to bridge the gap between multiband theory and the nonconstant kernel. We hope to establish conditions on the kernel that allow us to prove the existence of a gap solution below a certain temperature.

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MEMS Actuator Subject to Casimir Force Analysis

Mircroelectromechanical systems (MEMS) as one of the most promising technologies for 21st century is a process technology using techniques of microfabrication. MEMS benefits from coupling between different energy domains in micro- and nanoscale levels. The physical dimension of MEMS features it to create integrated electronics that involves mechanical and electrical components and its application can range from micromachined Scanning Tunneling Microscopes to inertial sensors such as accelerometers and gyroscopes. To study MEMS devices, we need to carefully analyze dynamics of undamped parallel plate electrostatic actuators governed by several forces including electrostatic and elastic forces. The main point of the present work is to incorporate the Casimir Force on nanoscale as one of the considerations and reach a higher level of understanding of its electromechanical dynamics. The Casimir Force is the effect arising from quantized field in quantum theory. The purpose of the paper is to analyze the motion of the movable plates of the actuator subject to Coulomb and Casimir Force. Here we need to introduce the normalized equation which rules the behavior of the plates. If we denote x1 and x2 as two single roots, a pull-in curve will be defined when 2 single roots form one double root. When Casimir Force equals to zero, the pull-int curve will attain its maximum value.

The Dynamics of Mass Dilation in a Black Hole Model

Black holes, celestial objects known for their high density, were first theorized early in the 20th century as a consequence of Einstein's general theory of relativity. Since then, the existence of black holes has been confirmed and has become the source of significant research in many disciplines, such as math, physics and astronomy. In the context of Einstein-Maxwell-dilaton theory, a hairy black hole is characterized by being scalar-charged through couplings both to electromagnetism and gravity. We consider a fully nonlinear differential equation governing the scalar-field-dependent mass in a hairy binary black hole model. We are interested in the dynamics of the discretized form: in particular, the system's period points, sensitivity to initial conditions, and its potential to be chaotic. The permutation of the two iterative maps, which are derived from the discretized blackhole model, provides us a method to find fixed points in future periods. We attempt to identify and analyze the properties and conditions of this chaotic dynamical system.

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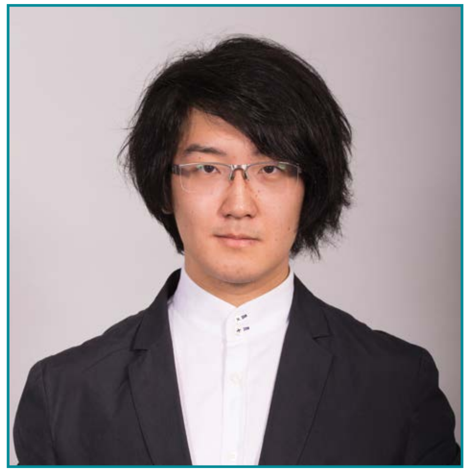

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Direct Simulation Monte Carlo (DSMC) Modeling of Rarified Gases in the Upper Atmosphere

Rarefied gas dynamics is the broad field of study concerned with the analysis of gas flows at pressures significantly below atmospheric pressure. The fundamental difference between such gas phenomena and those at higher pressures is that in rarefied flow regimes, it is seen that a molecule's mean-free-path becomes significant compared to the size of either the test chamber or the flow-field being considered. In other words, the flow regimes of rarefied gases cannot safely ignore the behavior of discrete molecules of the gas. The presence of such flows can be estimated via the dimensionless Knudsen number, which is defined by the ratio of molecular mean-free-path to the representative length-scale of the particular phenomenon being considered.

The Direct Simulation Monte Carlo (DSMC) method is a probabilistic simulation which solves the Boltzmann equation for flows with Knudsen numbers greater than one. In this project we use the open-source toolbox OpenFOAM and the built-in solver dsmcFoam to model rarified gas dynamics in the upper atmosphere. An application of particular interest is that of spacecraft re-entry and we attempt to construct a flow regime to best model this scenario.

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Vortex Flow Modeling over a Delta Wing

A common problem for wind turbine systems is that of a lack of a dilute supply of wind energy. In the same way that lensing may be used to focus solar energy, could it be possible to 'focus' wind energy into a smaller space, thereby augmenting its natural speeds?

The flow over a sharp delta wing type plane has been shown to roll up into cone-shaped fields of rotating flows at its leading edges, which holds even for relatively low angle of attacks. Such cone shaped fields are real manifestations of an ideal aerodynamic flow field known as a vortex, that results in fields with strong flow densities. If we can construct such vortices in a consistent, reproducible manner, they would make ideal candidates for a wind speed augmentor prototype.

The vortex flow field above a flat rectangular plane was simulated using the open-source CFD software OpenFoam, and compared to analytical solutions of the same. Then, the flow over a flat delta wing under different inlet conditions and angle of attacks was also modelled.

The effect of delta wing width and inlet velocity magnitude on the vorticity and velocity of the final flow field were also studied and compared.

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Robot Motion Visualization for Balance Stability Analysis Using Kinematic Structure

The goal of this project is to aid in the robotic balance and gait research. It primarily focuses on creating an animation of motion data from different simulation platforms. Animation is a good way to validate the simulated data because it provides a visual aid of the data. If an animation looks unnatural, there is a good chance that the simulated data is wrong. The solutions that are animated in this project are from in-house developed balance stability code, DARWIN OP I Gazebo simulation, and walking experiment data. Using MATLAB and the Robotics Toolbox software, a model of a two-legged system was created. In creating the 3D animation, standard Denavit-Hartenberg (DH) convention, a notation widely used in robotics, is strictly followed to model robots. Using the DH conventions, frames and links are used to describe the joints of a robot . Forward kinematics, which calculates the position and orientation of each link of a robot from given joint variables, is then calculated. By inputting the calculated kinematics data, the animation is completed. By the end of the project, any robot that is modeled using standard DH convention can be animated in 2D and 3D space.

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Artificial Neural Networks for Materials Design Applications

Viscoelastic materials are characterized for their mechanical properties under a range of strain rates and temperatures through tensile tests and dynamic mechanical analysis (DMA). These methods tend to be costly and time consuming. In previous work in the literature, an artificial neural network (ANN)-based approach was successfully used to predict the elastic modulus of composites over a range of temperatures and strain rates. By extending this approach to the materials design field, we are applying different ANNs, mathematical transforms and optimization methods to predict the weight percentage of polymers required to achieve specific mechanical properties. This is accomplished by collecting data of the mechanical properties for different weight percentages of a material, specifically polymers, to predict the elastic modulus by using an ANN to get the storage modulus and transforming it to the elastic modulus. More data are then generated by methods of optimization to use for another ANN which predicts the weight percentage of material needed from the elastic modulus and temperature range needed. This work can be significantly utilized in the industry in order to determine the most suitable material for an application in a less costly and a more time efficient manner.

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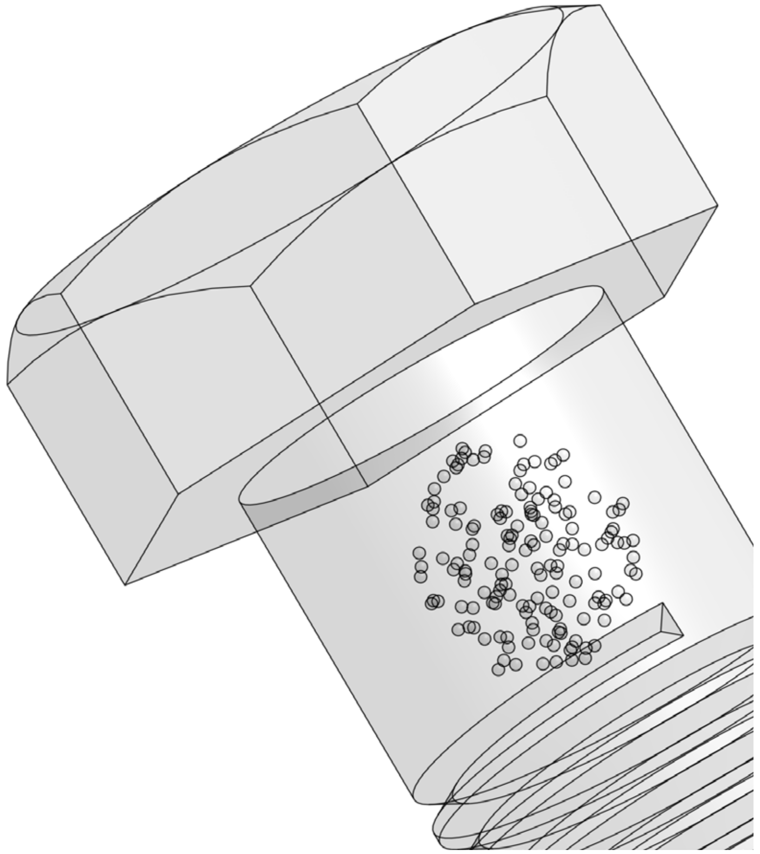
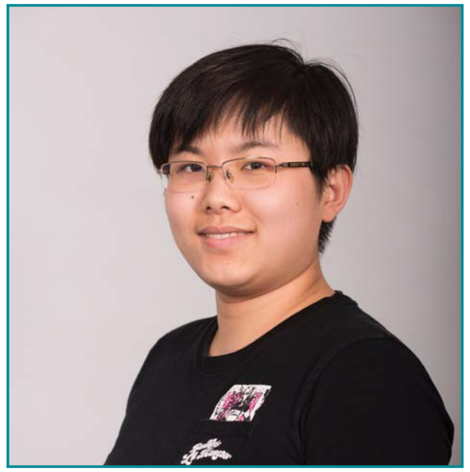
Geometric Obfuscation and Encryption as a Means of Self-Authentication in Models for Additive Manufacturing

The additive manufacturing supply-chain has increasingly decentralized, giving rise to several vulnerabilities, allowing bad actors to inject themselves and tamper with designs. Previous work was done on embedding an authentication code in 3D models. This was taken a step further to introduce geometric obfuscation and encrypted data, allowing a part with an embedded code to act as a self-authenticating component with dual-layer security. The obfuscation prevents a third party from easily detecting and reading a code from the component. In the event in which this is bypassed, the encrypted data, if discovered, is meant to be unusable by an external party. Only the manufacturer is capable of verifying the authenticity of the code, requiring no additional information outside what is provided in the file itself. The verification process involves corroboration of its present state against its untampered state. The system is designed to detect tampering during the computer-aided design (CAD) stage as well as after tessellation (STL); further, the embedded code maintains the ability to act as a unique signature to an authentic product even once the part is additively manufactured.





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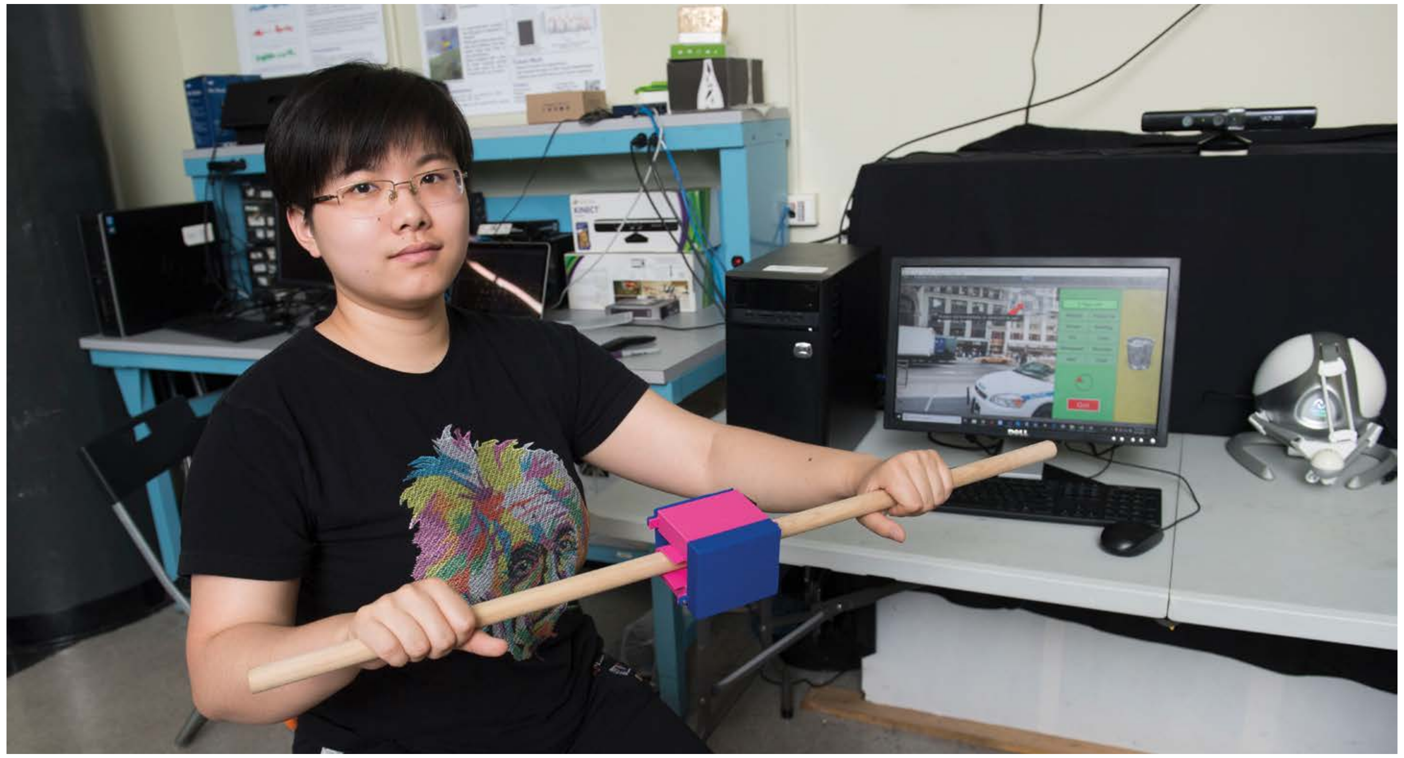
Integrating environmental citizen science into bimanual upper limb therapy through a natural user interface

Neurological diseases often lead to hemiparesis, muscle weakness on one side of the body which severely encumbers the performance of activities of daily living. Recovery from hemiparesis requires adherence to a long rehabilitation regimen, consisting of intensive and repetitive exercises. While the process of rehabilitation is often perceived as tedious and boring, embedding citizen science content in the exercise can motivate patients to adhere to their prescribed regimen.

In this project, a platform is developed to enable hemiparetic patients to participate in an environmental citizen science project while performing bimanual training with the upper limb using a lightweight wooden dowel. A Microsoft Kinect sensor captures skeletal data and an inertial measurement unit measures the rod's orientation. These data are utilized to implement a natural user interface where users control the cursor and in-game functions by manipulating the dowel. A pre-clinical usability study is conducted with 25 healthy individuals, whose motor performance is scored. The results will be compared against the motor performance of hemiparetic stroke patients, using the same platform.



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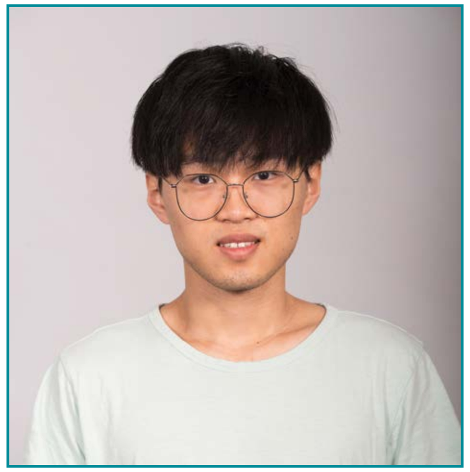
3D Printing Simulation

The aim of this project is to simulate Selective Laser Melting (SLM), which is a distinct Additive Manufacturing process for metals, by Finite Element Method (FEM). Theoretically, the laser is used to melt certain regions of the metal powder layer, which is repeated one by one until a full assembly comes to life. In practical, performing SML is a challenge; complicated parameters such as phase changes and heat transfer must also be taken into account, which make it difficult to obtain the desired parts with the required geometry and properties. Also, melting process is transient, which may also lead to the failure. In this project, the APDL script supported by the commercial FEM software ANSYS is used to simulate the transient thermal loading and phase change as well during the SLM process. The result would give a better understanding of the different parameters affecting SLM method.



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Topology Optimization of Hip Replacement

Around senior years, people usually encounter arthritis in the hip, resulting in ineffective function or failure of the hip joint coupling with extreme pain and mobility hinderance. Hip joint malfunction, however, can befall teenagers, adolescents, and middle-aged people due to unfortunate accidents or diseases. In such occasions, non-surgical treatments are first considered, but as soon as there appears no sign of recovery, hip replacement emerges as the most practical solution. In replacement surgery, the damaged or diseased portion of the femur bone and its head that connects to the upper body skeleton are removed. Then, the femoral stem, such as titanium or stainless-steel hip prosthesis, is inserted in the vacated place. In general, the titanium one is a primary option due to its strength-to-weight ratio, lightweight characteristics, corrosion resistance, cost efficiency, durability, non-ferromagneticity, biocompatibility, and like elasticity and flexibility to those of human bones. Despite titanium's qualifying traits, hip replacement, though not commonly, is still followed by periprosthetic osteolysis. The risk of periprosthetic osteolysis can be eliminated by devising a stem structure with density and porosity approximating those of human bones, thereby tricking the host bone into remaining alive. This is the call for the implementation of topology optimization theory.

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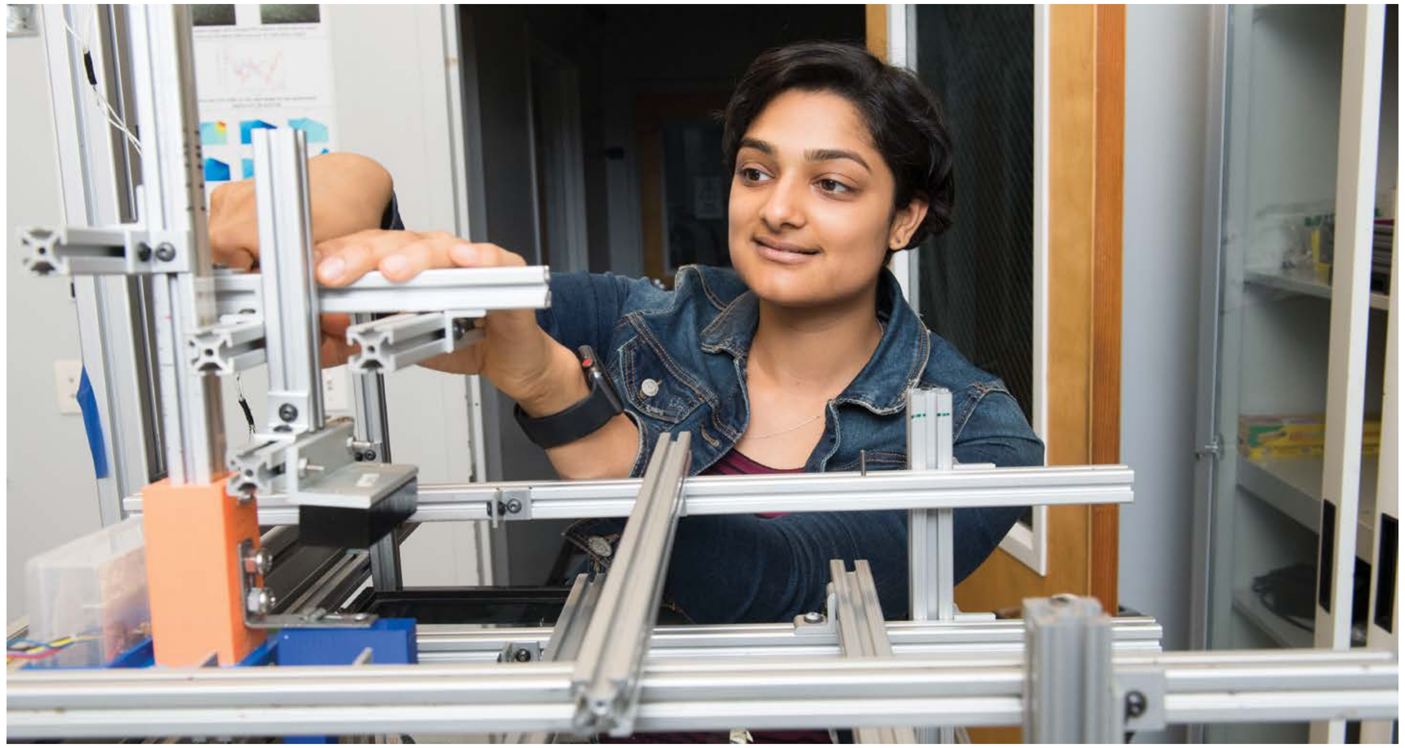
Applying Machine Learning in Material Science

Machine learning algorithms are ways to process and "learn" patterns of a dataset, resulting in a well-fitted model which can be used to analyze and solve related problems. Applications of machine learning algorithms include recommendation systems, email filtering, and smart virtual assistants. One of the most commonly used machine learning algorithms is neural networks, which imitate the biological neural network of the brain. It has been proved that the fitting ability of neural networks is so strong that they can fit almost any model by adjusting the structures. In most cases, a neural network is composed to three layers: an input layer, an output layer, and a hidden layer in between which has one layer or more, depending on the complexity of the dataset. In this research, the neural network algorithm is applied in the study of material science. Through collecting data and designing a database, we aim to organize the experimental data. By building a neural network with the organized data as inputs, we analyze the properties of syntactic foams. Further analysis of this experiment is expected to increase the understanding of syntactic foam properties.



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Applying Machine Learning to Structural Design Process

The stages of the structural design process include the conceptual stage in which the form of the system is selected, as well as the preliminary stage in which the shape of the structure is decided before the detailed or final design. Among these stages, the topology optimization process is applied to help the designer decide the preliminary and final models. In general, the conceptual stage mostly requires the designer's experience instead of an algorithmic basis. Nowadays, the development of machine learning in general or artificial neural networks (ANNs) particularly would improve this stage. The aim of this work is to create an ANN model that can give the suggestion to the designer after "knowing" the necessary boundary conditions of the design. In order to do so, the ANN model is trained with optimized shape data under specific boundary conditions that are calculated by the contemporary topology optimization method.

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Fluid-Structure Interactions During Water Loading on Air-Backed Structures

Marine vessels operating in extreme environments are constantly exposed to impulsive hydrodynamic loading. Understanding material responses under impact loading is essential for the design of marine structures. However, interactions between the structure and water have not been fully understood due to a lack of full-field, simultaneous measurement techniques. In this project, we design a series of experiments to systematically quantify the dynamic response of an air-backed panel under hydrodynamic loading. Specifically, a flexible panel is positioned at an air-water interface, and loading on the panel is induced by the motion of a solid structure in the water. The interaction between the panel and water is studied through a combined visualization technique based on particle image velocimetry (PIV) and digital image correlation (DIC). The velocity field is quantified through planar PIV, from which the hydrodynamic loading is reconstructed. The deformation of the panel is simultaneously measured through DIC. The response of the panel will be systematically studied for a range of hydrodynamic loading conditions. This experiment will help quantify fluid-structure interactions induced by water loading and elucidate the role of air-backing.

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Optimizing group performance through network intervention in a virtual reality-based game

Resource sharing and coordination is a complex social phenomenon where individuals need to make decisions based on network topology and dynamically changing resources to achieve a common goal. In this study, we use a network framework to investigate the influence of group topology on the performance of a collaborative task. To entice emersion, we developed a game in virtual reality (VR), in which three players work collaboratively and can help their peers by sharing their resources. We measure the cognitive load individuals experience through behavioral and physiological metrics to infer behavioral implications of the network topologies. We use the information-theoretic construct of transfer entropy to infer a causal relationship between instances of sharing and cognitive overload, and we compare it across topologies.

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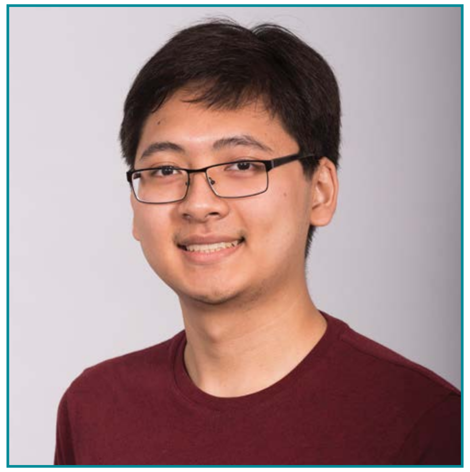
Contact Voltage Drop Measurement for Energetics Characterization of MX-28 Servo Motor

Currently, many papers estimate the energy usage in their robotic experiments to be the integral of work squared, but no one has taken a closer look into where exactly all this energy is being lost. To create a better understanding of the locations and severities of energy loss within a motor, the MX-28 motor, the main motor in the DARWIN-OP robot, was analyzed. Two main tests were conducted. The first test used a brake motor to apply various torques to the MX-28 test motor to generate data about the current and voltage the test motor was drawing. This was used to create a graph of voltage versus amperage which produced the values for the motor's resistance as the slope of the graph, and for the contact voltage drop as the y-intercept. The second test consisted of attaching a pulley to the MX-28 motor, then hanging masses from it to determine static, dynamic, and viscous friction at zero and non-zero currents. While the results are still pending, the generation of precise energy loss data will hopefully allow for more energy efficient motor designs in the future, which would result in robots being able to last longer without any additional energy capacity.



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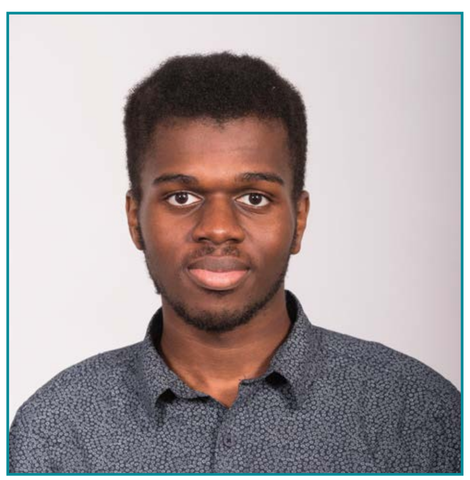
Controlling individual responses through a prisoner's dilemma game

Our study aims to understand how individual's decision-making process may be influenced by the responses made by others in context of a social coordination game. Among many possible coordination games, we opt for the popular "prisoner's dilemma" which has been subject of numerous research studies.

The prisoner's dilemma is game where two prisoners (or participants) have the binary choices of either cooperating or defecting. Depending on their decisions, they individually receive a different punishment in terms of jail time. Prior studies reveal that the optimal choice is to defect even if a reciprocated cooperation would correspond in a lower jail time.

In our experimental study, this game has been modified by having the players receive virtually monetary reward. Additionally, we consider a group of three players who choose to cooperate or defect for several rounds. The goal of each individual is to maximize their own cumulative reward across the entire experimental session. In order to do so, the individuals' choices are likely to be influenced by the peer decisions. We will apply tools from graph theory and statistics to analyze the data and pinpointing what are the factors that determine the individual decision-making process.



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Rheotaxis in adult zebrafish

The ability of a fish to detect flow and swim against it is known as rheotaxis. This behavior is important for animal survival since it allows the fish to optimize energy expenditure and localize food sources. The mechanisms underlying this behavior and the sensor information, however, are not completely known. In this project, we study rheotaxis on zebrafish, a freshwater species widely used in different scientific disciplines and known to exhibit complex social behavior. The overarching goal is to help elucidate the underlying mechanism allowing adult zebrafish to perform rheotaxis and how the presence of a conspecific might provide further information to enhance this behavior. To do so, we conduct an experiment consisting of recording single and pairs of zebrafish swimming in a water tunnel with adjustable flow speed.In order to understand and isolate the complex interplay between the sensor mechanisms needed for rheotaxis, two main conditions are considered: (1) light condition: in which there is illumination and the fish can use both visual cues and mechanosensation to orient against the flow and (2) dark condition: where there is no light and an infrared camera is used to record the fish activity. The data collected is then analyzed through different metrics for assessing rheotaxis such as; heading angle towards the flow, speed, position holding, turn rate, and spatial preference. The results of this project are expected to help understand how zebrafish perform rheotaxis, which may be useful in robotic applications where robots can be equipped with decentralized navigational strategies that allow them to self-locate and move toward a desired location.

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Piezo-based Vibrotactile Actuators For Haptic Stimulation On The Abdomen

Worldwide, approximately 285 million individuals suffer from some form of visual impairment. This number is expected to further grow with the aging and increase of human population. Technological advances in the fields of computer vision and smart materials may substantially improve the autonomy of the visually impaired in navigation and obstacle avoidance. Previous studies have investigated vibrotactile stimulation as a possible method to convey information in a rapid and reliable way. In this project, we build upon these previous efforts, perfecting a belt consisting of an array of piezoelectric-based composite actuators, allowing us to apply haptic stimuli to several points on the abdomen. The actuators are driven by a high-voltage amplifier, whose input signal is generated by a variable-frequency astable multivibrator commanded by a microcontroller. To tune the resonant frequency of the double cantilevered actuators, we add a variable mass at their center, in order to adjust the resonance in the range of frequencies to which skin is most sensitive. We collect preliminary data on the actuators to verify the effect of the mass at different frequencies, and we perform discrimination tests with human subjects to verify the efficacy of the belt in providing vibrotactile stimuli.

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Information-theoretic investigation of human response to a navigation assistive vibrotactile device for the visually impaired

The number of people affected by visual impairment is approaching 300 million globally. With impaired vision, spatial navigation is arduous, but it may be facilitated by novel technologies. Various electronic travel aids (ETAs) have been developed to supplement remaining sensory channels while increasing the mobility and safety of users. Vibrotactile stimulation is used in many ETAs, addressing challenges such as obtrusiveness and relatively low redundant sensory transduction, while offering a plethora of potential contact points. However, the extent to which users can discriminate relayed information remains elusive. In this work, we seek to clarify the effect of multiple obstacles and their positions on the discrimination of a vibrational cue sent from an array of piezoelectric actuators, mounted on a belt worn on the abdominal region. The belt is driven by a computer vision system, which identifies obstacles and maps them onto a grid, such that the corresponding actuators in the array vibrate with an intensity dependent on the proximity of an obstacle to the user. We utilize an information-theoretic framework to quantify the information relayed to the user from the system about the position, distance, and distribution of obstacles. The proposed framework will inform improvements in the device and the design of closed-loop control systems.

MECHATRONICS AND ROBOTICS

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Bioinspired robots to fight invasive species: when technology inspires nature and not vice versa

Invasive alien species threaten biodiversity worldwide, providing intense competition for native species. Robotics is emerging as a promising tool to address this problem. Previous experiments have demonstrated that short-term exposure to a robotic predator fish erodes the energy reserves of invasive mosquitofish and potentially reduces their survival. However, whether the presence of such robotic stimuli reduces the aggressive behavior of mosquitofish and benefits the survival of native tadpoles is still unknown.

In this study, we use a biomimetic robotic predator fish to modulate the highly disruptive behavior of mosquitofish in the presence of tadpoles of the motorbike frog, a common species in Western Australia where invasive mosquitofish are present. The appearance and locomotion of the robotic predator is inspired by natural mosquitofish predators. Previously proven to elicit a robust antipredator response in mosquitofish, a closed-loop control scheme is used to maximize its degree of biomimicry. By comparing the behavioral and life-history responses of mosquitofish exposed to the robotic predator, and those who are not, we test whether bioinspired robotic tools can provide an effective solution to protect harmless native species. This project may open the door for future endeavors utilizing a robotic predator to combat invasive species in the wild.

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Elucidating the physical underpinnings of back-relaxation in ionic polymer metal composites (IPMCs)

Ionic polymer metal composites (IPMCs) are a novel class of electroactive materials that hold promise as actuators, sensors, and energy harvesters. Specifically, due to their low compliance, low driving voltage, and biocompatibility, they have been considered for applications in biomedical devices, soft robotics, and artificial muscles. Despite great improvements in IPMC manufacturing, the understanding of their transduction mechanisms remains marginal. Particularly elusive is the phenomenon of back-relaxation, whereby, under a step voltage applied across their electrodes, IPMCs bend toward the anode, and then slowly relax toward the cathode. In this project, we investigate this phenomenon building upon previous efforts on contactless actuation of ionomer membranes in salt solution. We seek to expand previous results by testing IPMCs and 3D-printed membranes in the same setup. By utilizing IPMCs instead of electrodeless ionomer membranes, we will elucidate the effect of electrodes on actuation, possibly identifying differences at the interface between the membrane and the solution. By tailoring the shape of additively manufactured ionomer membranes and exploiting dual extrusion, we put forward hypothesis-driven experiments to tease out the underpinnings of IPMCs' chemoelectromechanical coupling. This work will contribute to the understanding of IPMC actuation, toward a more accurate physically-based modeling.

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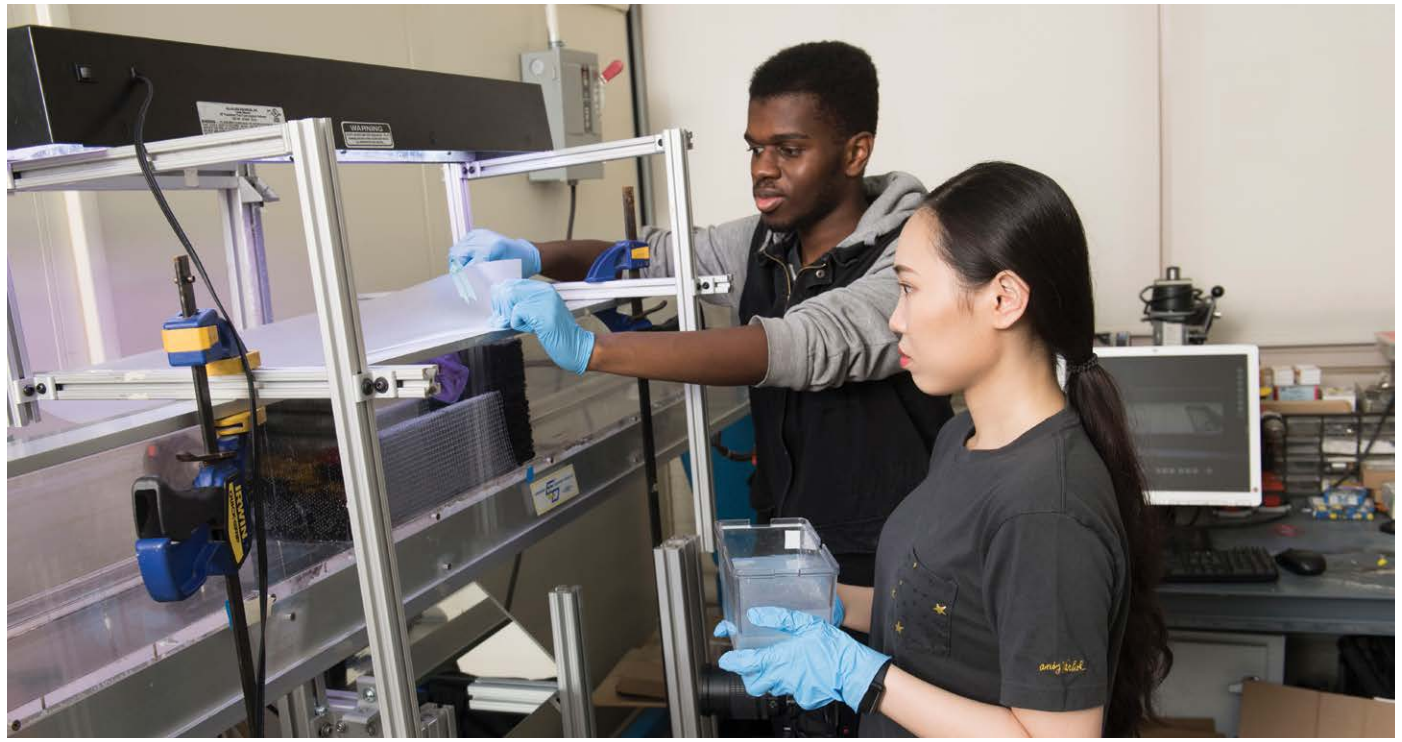
Utilizing Robotics for the Rehabilitation of Stroke Patients

The World Health Organization reports that annually 15 million people worldwide suffer a stroke, resulting in the permanent disability of five million people. Our research is focused on using robotics technology to help rehabilitate stroke patients who struggle to move their arm on their affected side, preventing them from performing simple activities of daily living. We have specifically investigated the motion entailed in lifting a cup. A stroke patient seeking to perform this motion can be assisted using a developed 3-D printed mechanism connected to a servomotor, which rotates to allow the mechanism (and the patient arm) to transition from a "rest" to a "drinking" position. The commands to the servomotor driving the mechanism are generated using an electromyography (EMG) sensor that detects electrical signals from the muscles and transmits this information to a microcontroller. This allows the device to detect the intent of the patient and assist the patient in the process of lifting the cup, with the objective of having the servomotor work progressively less as the patient improves.



TECHNOLOGY, CULTURE, AND SOCIETY

Spacetime and Entanglement

This project seeks to investigate proposed solutions to the discontinuity between the well tested theories of the Standard Model of Quantum Physics and Einstein's classical theory of General Relativity by understanding questions relating quantum entanglement to the geometry of spacetime. One goal of the project is building a conceptual analysis of differing notions of entanglement (quantum entanglement, topological entanglement), non-locality, and entropy and how they relate to measurements of entropy (von Neumann entropy, black hole entropy, thermodynamic entropy). We then use this analysis to assess Mark van Raamsdonk's entanglement/connectedness hypothesis, which proposes that quantum entanglement is the geometric glue that holds spacetime together, and Juan Maldecena and Leonard Susskind's ER=EPR hypothesis, which proposes that quantum entangled particles are linked by wormholes in spacetime. Another aspect of our project concerns a conceptual analysis of how representations of symmetry groups act on state vectors in a Hilbert space; namely, under what conditions do these representations turn non-entangled states into entangled states?

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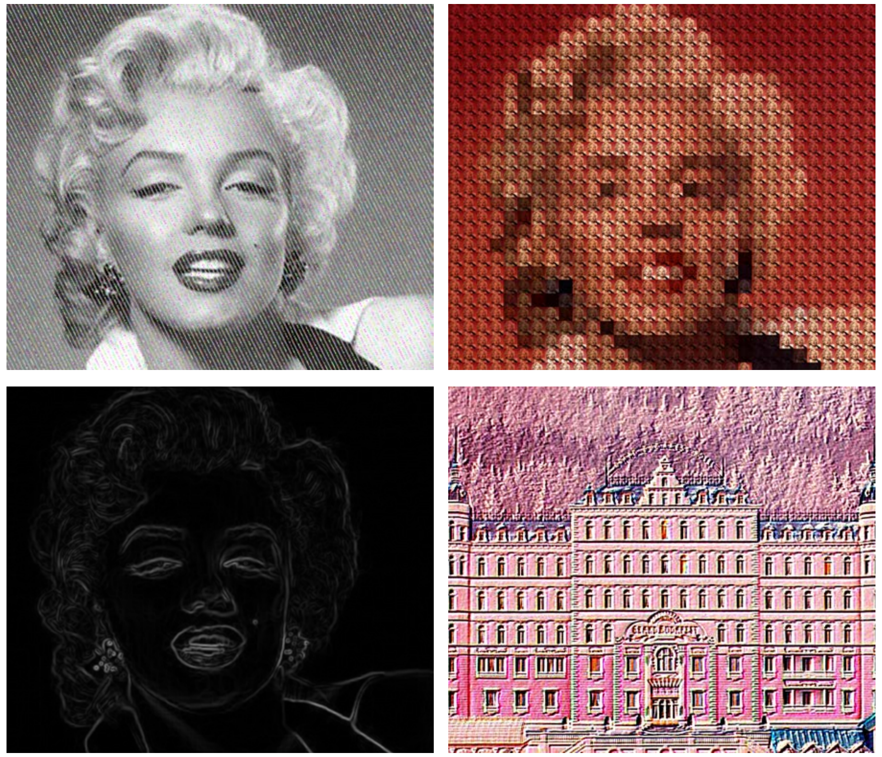
p5.js

With the increase in time people spend looking at screens, comes the necessity of better understanding how to deal with digital images and graphics. Knowing how to manipulate images through programming is an emerging way of digital design, which is why the p5.js team decided to focus its efforts on effective ways of performing Image Processing. This project experimented with image manipulation in p5.js with the intention of creating example sketches and laying out a beginner friendly way of performing Image Processing. Using OpenProcessing, the team was able to generate easy to follow coding examples that are open resources to anyone interested in learning more about the subject. In addition to that, in-depth tutorials were published using GitHub pages so that students could have access to the back-end logic of Image Processing and apply that knowledge as their creativity desires.

Using the knowledge acquired through researching Image Processing, the team moved on to assist in the development of a Risograph Library for p5.js, with the intention of creating a platform, within p5.js, in which people could code while having the logic of Risograph Printing in mind.



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Tech for Teens

The Tech for Teens project at the Rusk Rehabilitation Center seeks to aid teens with severe motor impairments in learning computer skills. Specifically, they are working with teens who have motor impairments that lead to limitations in muscle control or cause muscle weakness or paralysis, and teaching them how to access a computer with access technology. In connection with this, the Tandon team will develop a curriculum to teach different types of technical skills such as coding, creating websites, and 3D modelling. Class sessions will be observed and tech skills will be taught to the instructors at the rehabilitation center. We hope that the teenagers will eventually gain enough confidence in these skills and use them for their own benefits-whether it be for a hobby or potential career. We are planning to investigate several questions like: What is the difficulty of web development?, What are the pros and cons of learning 3D printing? and Will the skills learned in this program benefit them in the future?

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DIY Assistive Technology

As the Internet and web-enabled technologies become ubiquitous and there is greater need for web-related jobs, there is a lack of diversity and representation by persons with disabilities. One factor contributing to this is that the production of web technologies presents various accessibility barriers for individuals that are blind or low vision. CSS and visual styling are areas of particular stumbling blocks that lacks easy, accessible, and comprehensive tools for nonvisual CSS validation. CSS is a core language and component of the web used to describe visual representations and due to the visual nature of CSS nonvisual developers struggle to with its use: often time relying on sighted third party member to assist with validating their CSS. In order to striving for a more diverse participation, better accessibility support, and greater independence of blind or low vision web developers we evaluated existing CSS tool to aim for creating a accessible CSS validation tool that would allow blind and low vision web developers to build, test, and produce websites and web applications with greater confidence and independence.

Sunbots: Robotic-based Design Interventions for Houseplants

The Sunbots project is an exercise in speculative design, centered on crafting robotic appendages for houseplants. The robotic base, recharged by solar panels, gives the plant autonomous motion to search for sunlight. As an open-source project, a core objective is to create a simple yet robust design that is both accessible for design changes, and easily replicable. Wireless communication was added to enable the robotic base to report light levels in order to facilitate group communication and collaboration. This network may facilitate future explorations of robot behavior that more closely emulate chemical communication among organisms in dense forests.

Further, specific high-humidity plants have been chosen for the robots' terrariums, allowing the plants to be theoretically self-sustaining. A smaller, simplified version of the bots has also been designed, to allow lower-cost replication, as well as facilitate exploration of low-impact materials, such as mycelium, and wax made from recycled plastics.

With global climate change, the accumulation of electronic waste world-wide, and the decline of biodiversity, *Sunbots* are an active exploration of our ecological future and changing relationship with both autonomous robotics and our environment. By situating the project within the DIY community, a broader audience is invited to participate in the conversation.

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Data Responsibility

Collaboration is starting to grow between the private sector and the public sector in terms of using private-sector data for public good. Therefore, it has become necessary for data stewardship to arise as an important position at private companies and organizations. One of the GovLab's goals is to create a network of these data stewards from various parties in order to come up with a set of guidelines for sharing and providing access to this data responsibly, decreasing the cost, time, and energy currently needed to establish data collaboratives. For this project my responsibilities included finding events where these data stewards convene and coming up with outreach strategies. I also assisted with the 100 Questions Project, which seeks to bring together "bilinguals", or experts in both data and the domain that they primarily work in, to come up with a list of the 100 currently most pressing questions that can be answered using private-sector data.

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Communications Strategy and Operations

The Governance Lab (GovLab) is an action research lab based at NYU Tandon that studies how technology and data-driven decisions can be used to improve the way public institutions govern. To inform and educate about the important work being done at the GovLab, the communications team develops strategies and campaigns to amplify our messaging. This includes strategic communication through print and digital media coverage, social media, and other mediums. As part of this effort, research is needed to better understand how social media can be leveraged to increase exposure and awareness. Specifically, a comparative study of how our peer organizations are using various social media platforms - including Twitter, Facebook, and Instagram - was conducted. Looking into how often an organization posts, the level of engagement that each post receives, and the type of content an organization chooses to post on a platform will help to inform whether the GovLab should pursue the expansion of its social media presence, what content should the GovLab be posting, and who is our target audience.

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Public Entrepreneurship

Despite advancements in modern technology and quantitative thinking, there is still an existing lack of technology-enabled problem-solving skills among our civil servants from the local level all the way up to the state and national levels. We see methods such as design thinking, agile, and human-centered design being applied in the private sector, however, these practices are not as apparent in the public sector. The Public Entrepreneurship project aims at developing methods through which government officials can leverage data analytical methods and modern technologies to become more effective problem solvers and fill the technical skills gap between the public and private sectors. This involves teaching a combination of methods that include data analysis, crowdsourcing, open innovation, and problem definition. Moreover, this project seeks to ensure these practices transcend learning into action and application to ensure 21st century public leaders are not only tech-literate but also utilizing these learned methods in everyday practice. This is particularly important as through performance, governments can both gain and retain the faith of their constituents in their ability to solve problems.

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Collective and Artificial Intelligence

This project is part of a larger research investigation on collective intelligence, which can be defined as the ability for collaboration between groups or individuals for separate information to be shared, resulting in the creation of new information and/or solutions. We found and sorted through past cases where primarily public institutions have leveraged data analytics mechanisms and artificial intelligence tactics such as machine learning with citizen engagement and crowdsourcing. The objective in identifying these cases is to better understand how collective and artificial intelligence can reinforce one another. Simultaneously, through a literature review of publications on AI, CI, and the combination of the two, we have mapped and defined the possible relationships between collective and artificial intelligence, and the potential institutional data digestion processes. This analysis is then tested and illustrated through the case studies previously collected. Upon completion of this analysis, a small summary essay of this work will be published at the GovLab website, blog, and newsletter. After concluding this study, I will continue to work on GovLab's new collective intelligence projects.

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Evaluating the Impact of Recipe Guided Layout and Design on the Effectiveness of DIY Tutorials

Do-It-Yourself (DIY) culture is gaining popularity in entertainment, education, and hobbyism, and has been heralded as having the potential to democratize technology and empower individuals. Research within STS and Accessibility Studies has contributed to the emergence of Critical Making, a field which seeks conceptual grounding within DIY practices. While DIY culture has been widely interrogated in a philosophical context, more can be learned in the area of evaluating DIY content. This research focuses on the authorship of DIY physical computing tutorials, pertaining to how authorship may be improved, through qualities such as design, layout, and presentation of information. Our experiences with successful and unsuccessful tutorial completion aligns with existing literature, which finds incomplete, disorganized, or inaccurate information to be common barriers to tutorial completion. In our efforts to improve tutorial authorship, we identified recipes as a historically tested, robust format. We identified tutorials which were consistently rated as difficult to follow on knowledge-sharing platforms, and created iterations of these tutorials following the recipe-format. We then ran a preliminary study to evaluate this design based on user-comprehension and rate of tutorial completion. Our results may offer useful suggestions for tutorial authors and provide insights for future research in DIY education.

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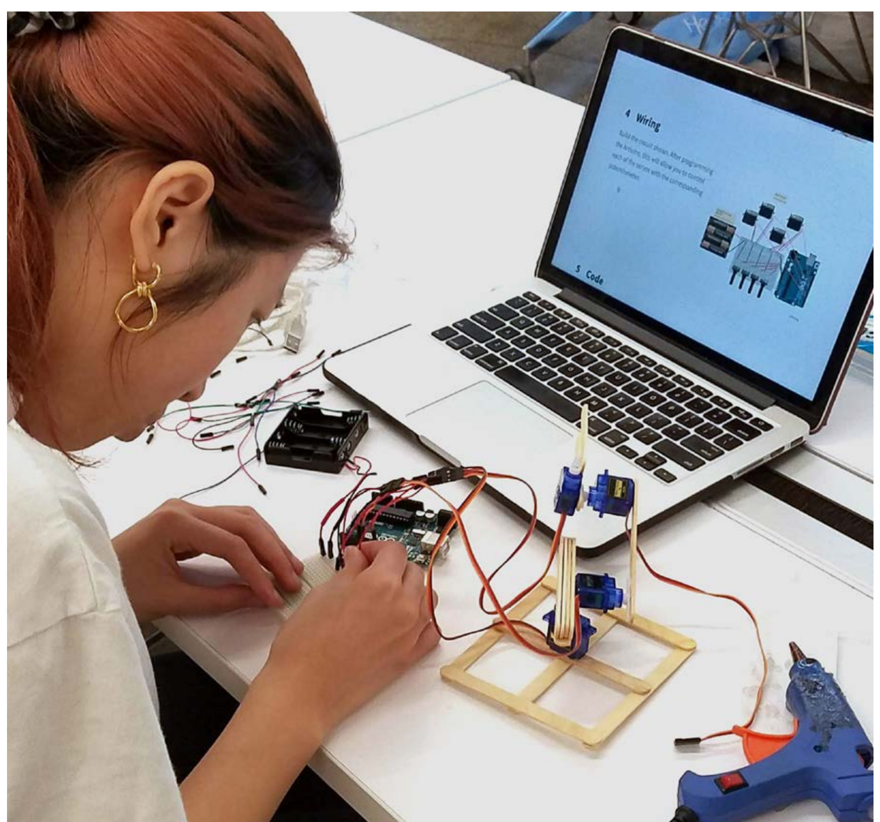

TECHNOLOGY MANAGEMENT AND INNOVATION

Annotation of sound without visual input

Noise pollution is a large quality of life issue for US urban residents. It is estimated that 9/10 adults in New York City are exposed to excessive noise levels. This issue can be mitigated by city agencies taking information-driven action, targeting problematic noise sources. Sensors placed around the city can be used in tandem with machine listening methods to constantly provide rich descriptions of acoustic environments. Given some sample data recorded from around the city (from construction sites, busy roads, etc.), citizen scientists can annotate this data to form a labeled set for ML training.

Anecdotally, participants have found annotating audio with video easier than audio alone, which may be because they can visually verify the sound sources. However, it must be determined how this affects the accuracy of annotation of off-screen sound sources. To verify the effect of the presence of corresponding visual cues, an experiment must be performed, asking paid participants to annotate a series of video clips that include both on-screen and off-screen audio. Steps must be taken to make sure the results maximally illustrate the discrepancy, or lack thereof, between the accuracy of annotations with and without a corresponding video cue.

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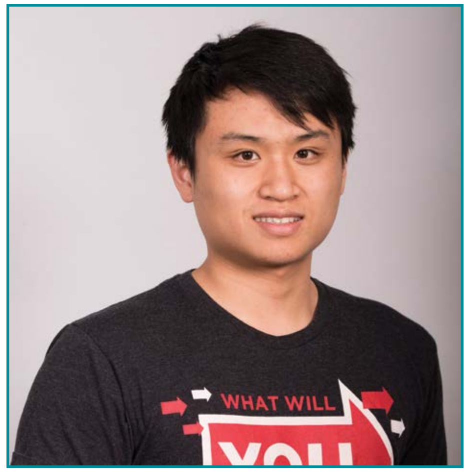
UNDERGRADUATE AND GRADUATE ACADEMICS



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NICOLE REBATTA

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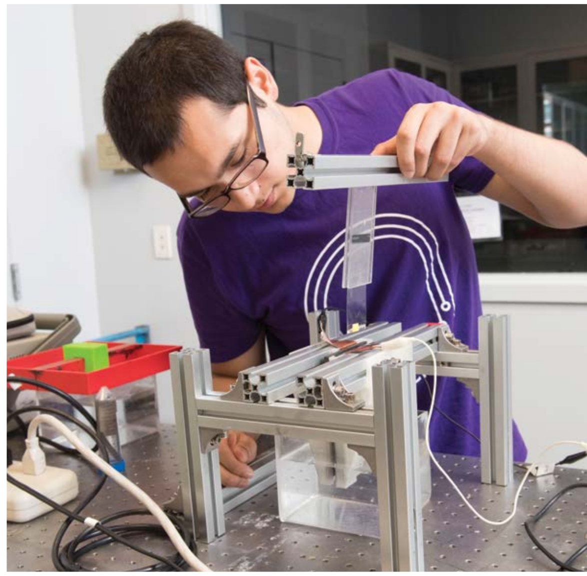
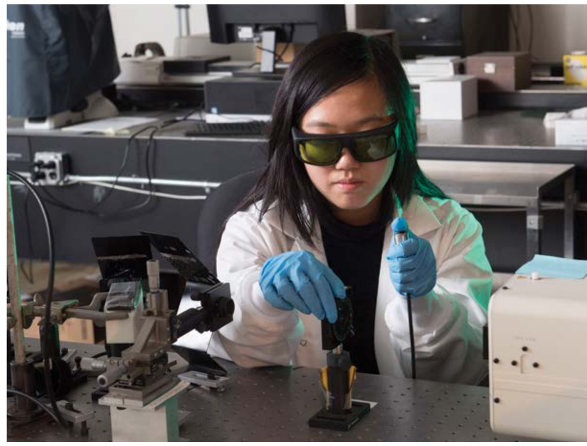
Develop and Implement an Emailing System for a Multi-Modular Tutoring Application

Many multi-modular applications have a need for an internal emailing system to communicate with users. In this project we look into the intricacies of design in modern applications and develop an emailing system that autonomously collects information from the users input and application database to send out emails in accordance to the application's module demand. The tools in use for this project are Django development Framework, Python for the backend structure, Javascript and HTML for front-end interface, and SQLite, AJAX, React, and Jquery. This emailing system will integrate with all email sending modules in a Tutoring application. Specifically for this project, we will concentrate on testing the emailing system implementing the User Sign-Up module in the application.

There are four main features in the system: collection of user data, creation of email, delivery of email, database storage of email parameters and content, and retrieval of sent email. We will utilize triggers within the application's module to activate and prompt the backend to send emails to users. Each time a "Next" or "Submit" trigger button is clicked within the Sign-Up form, the information provided by the user is stored in a session as a JSON and transported to the backend through AJAX. The challenges are the three page structure of this form, and secure transfer of the data through the entire transmission of the form. For efficiency purposes, we are simultaneously grabbing the user data and pushing it into the database. This system uses SMTP to send emails to users and an email table in the overall relational database for data storage.





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The Office of Undergraduate Academics has coordinated the Tandon Undergraduate Summer Research Program (UGSRP) since 2011. Sara-Lee Ramsawak joined took over these efforts in 2013. She is responsible for the expansion of the program from 61 student participants to well over 100 as well as faculty expansion that includes professors and research projects NYU Wireless, the GovLab, as well as the NYU Center for Urban Science and Progress. Jen Piro has recently joined in on the efforts this summer and has worked tirelessly to match the students with their best suited faculty mentors/ research staff in order to ensure fruitful participation. Both Sara and Jen have worked to provide academic, career, and personal development seminars, lectures, workshops, and events so that students come out of the program with enhanced knowledge of both their research area and various opportunities and paths as they move forward in their professional trajectories. Both Sara and Jen have dedicated themselves to this program and enhance it at every turn.

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