2018

TWELFTH ANNUAL

SUMMER RESEARCH PROGRAM UNDERGRADUATE ABSTRACTS

NYU TANDON SCHOOL OF ENGINEERING

2018 SUMMER RESEARCH

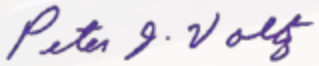
NYU Tandon School of Engineering's Undergraduate Summer Research Program provides a unique opportunity for NYU Tandon, NYU College of Arts and Science, NYU Abu Dhabi, NYU Shanghai, and other select students to engage in research over the course of the summer semester. This program offers students far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

Summer 2018 marked the twelfth year of the Undergraduate Summer Research Program. Since its inception, over 800 students have participated, and a large number of faculty members from a variety of departments have contributed to the program. 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.

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. Dr. Joseph G. Lombardino '58Chem, James J. Oussani, Jr. '77ME, and Dr. Harry C. Wechsler '48CM, for instance, have generously supported this program. Additionally, this year marked the seventh year of the Thompson Bartlett Fellowship. Ten of this summer's female researchers were graciously supported though this fellowship, made possible 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 and faculty mentors, and further strengthen this truly unique summer experience. Also this year, for the first time, 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 (IIIE) at NYU Tandon.

A special thanks also goes to Nicole Johnson, 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 TB Fellows. I would also like to acknowledge Sara-Lee Ramsawak, who coordinated this year's Undergraduate Summer Research Program and ensured that the program's daily operations ran seamlessly. She coordinates the program and continues to develop and enhance it at every turn.

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 2018 Undergraduate Summer Research Program. We all look forward to future summers of more intellectual and scholarly activities.



Peter Voltz
Associate Dean for Undergraduate and Graduate Academics

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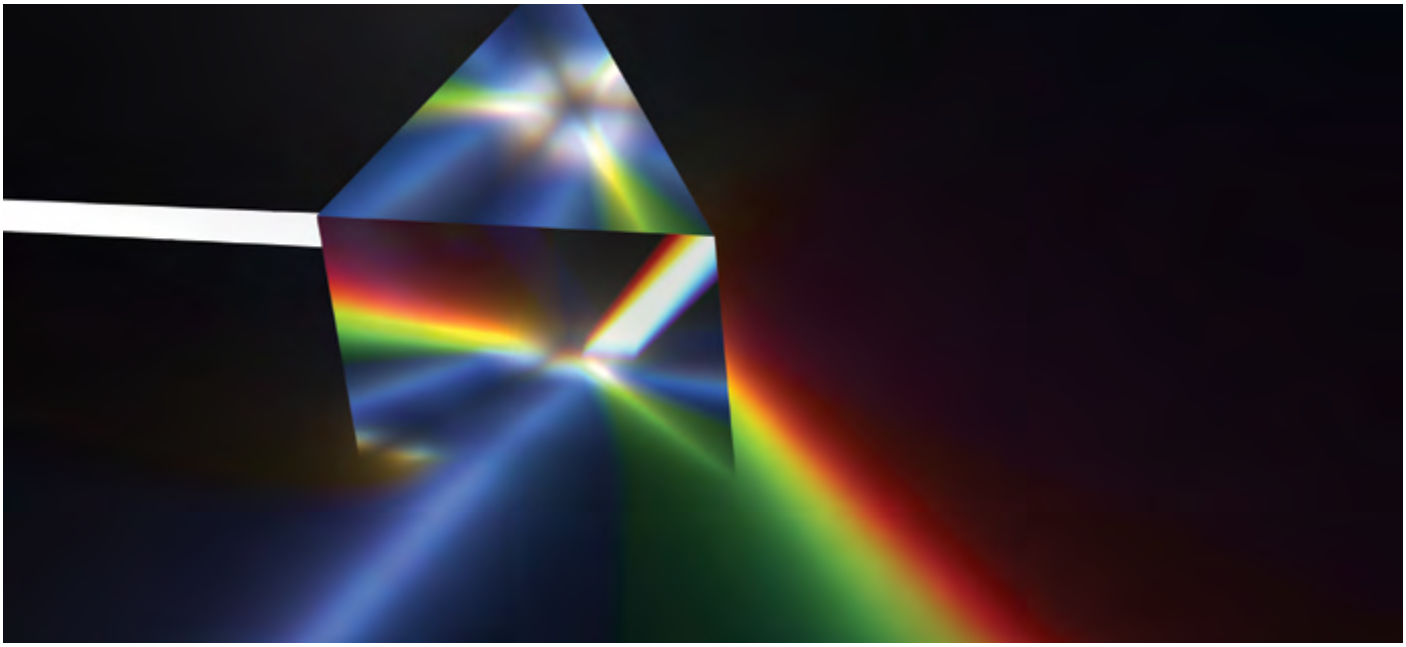
FABRY PEROT INTERFEROMETRY USING CMOS CAMERAS

The main objective of this research was to investigate the use of CMOS cameras in high resolution spectroscopy. Segmented and pixelated detectors have been used with grating spectrometers for some time, but they have not been widely adopted for high resolution spectroscopy with interferometers. Diffraction gratings can be used to observe large spectral ranges with low to moderate resolution. A Fabry Perot interferometer can measure wavelengths with extreme precision over a smaller spectral range by observing extremely high orders of interference which allows one to observe the miniscule differences between different wavelengths because those differences become more prominent as the fringe order increases. Traditionally, the spacing of a Fabry Perot interferometer is scanned to measure wavelengths. In this project we instead made use of a CMOS camera and the method of exact fractions to measure small wavelength difference. The extremely precise measurements produced with a Fabry Perot interferometer makes it possible for one to observe extremely small splitting, comparable to tens of picometers. Examples of observable small splitting effects are hyperfine splitting of energy levels due to electromagnetic interactions between electrons and the nucleus, isotope shifts of energy levels due to slight differences in mass, and Zeeman splitting due to the interaction between electrons and external magnetic fields. During this research, we used a Fabry Perot interferometer to observe the effect of isotopic shifts and hyperfine splitting of the 546 nm line in mercury, isotope shift of the 486 nm line in hydrogen, and the Zeeman splitting of the 546 nm line in mercury. We then compared those results to measurements made with a grating spectrometer.



▲ Peter Liu is measuring wavelengths with a Fabry Perot interferometer in conjunction with a CMOS camera using a method of exact fractions to calculate the most precise differences.

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GRAPHICAL USER INTERFACE DESIGN FOR VIEWING MASSIVE REMOTE SENSING DATA

Light Detection and Ranging (LiDAR) is a technique that collects geospatial information by illuminating the target with pulsed laser light and analyzing the reflected path with a sensor. LiDAR is prominently used for scientific discoveries, urban applications, and natural disaster forecasts due to its low cost and high resolution. While collecting LiDAR data over large areas can be achieved, the subsequent processing steps can have high computational demands as cutting-edge data sets now exceed 1 TB/km2 containing billions of points. Efficiently storing, processing, and visualizing LiDAR data are prerequisite steps for advanced LiDAR-based applications.

While applications and application programming interfaces (APIs) exist for point-cloud data storage, querying and visualization individually, few are designed for the distributed computing needed to support the coming data sets and the existing ones are not well-integrated together. To break this bottleneck, this project integrates such applications and APIs into a framework and supports it by designing a graphical user interface (GUI). The applications and APIs used include: Hbase (a non-relational, distributed database that provides efficient data storage and querying), Apache Zeppelin (a web-based notebook that supports data exploration and visualization), and Potree (a web-based point cloud renderer that provides fast visualizations of large 3D datasets).

This project envisions a framework that's modular, scalable, and portable. Currently the focus is on creating an easy to use but high functionality graphical user interface. Some functionalities include querying data based on bounding box, distance measuring tool, and density function calculations.

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AERIAL LASER SCANNING ANALYSIS

Airborne Light Detection and Ranging (LiDAR) technology can map terrain surfaces, be the basis for rapidly generating high-resolution 3D models, and enable automated object detection and extraction. Often, however, the LiDAR datasets are incomplete. Voids, occlusions and other absences may be caused by lines of sight issues, but this does not account for all missing data. While some data appears to be missing because of material reflectivity, this does not seem to be true consistently. Given the complexity of urban areas, to better understand why occlusion occurs, I am presently developing means to identify, investigate, and characterize these voids and occlusions, including where points have been mislabeled. A critical component to this is checking the real environment in a pair of publically available dense aerial LiDAR scans of a portion of Dublin Ireland's city center. By identifying where these occlusions appear and characterizing their geometric traits, a better understanding can be gained as to where they are likely to be encountered in future aerial scans. With such information, approaches can be developed to minimize their occurrence either through flight path planning or via secondary data sources.

The traditional approach to missing data in LiDAR point clouds is to use some form of infilling, often after an initial segmentation. Presently, many approaches, containing multiple algorithms and mathematical models, are available to improve the data quality and generate more robust models. In my work, I envision testing one of these approaches to see where it succeeds and where it fails, in an effort to develop new insights for generating more robust algorithms in the future.

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CONVOLUTIONAL NEURAL NETWORK MODELING OF REMOTE AERIAL SENSING DATA

LiDAR (Light Detection and Ranging) is a surveying technology used to measure distances through high-frequency laser rays. Advancements in the field have paved the way for increasingly accurate representations of ecological and urban environments. The LiDAR sensor notes the laser return time and, thus, accurately measures the distance of a point in the environment from the sensor. Each point in a LiDAR dataset is represented by x, y, and z coordinates, in addition to other descriptors such as intensity, and datasets of these measurements allow for the production of three-dimensional renderings through point clouds. Current research suggests possibilities for extracting crucial knowledge from these datasets through machine learning, notably Deep Convolutional Neural Networks (ConvNets).

Diverse approaches to implementing machine learning with LiDAR data include voxelization (distributing points in three-dimensional "pixels" called voxels), mesh analysis, and analyses on two-dimensional "screenshots" from the point cloud data. While previous implementations of ConvNets have been in a "black box" style, this project aims at a data-driven approach to using ConvNets directly on point cloud data to understand intuitively how "critical points" are used for the ConvNet to learn and to evaluate how machine learning training data can be optimized to be increasingly efficient in training data set selection. The two datasets employed in this summer's research are dense aerial LiDAR scans of Dublin in 2007 and 2015.

▲ Lingxuan Gao (pictured right) is developing a way to identify voids and occlusions in LiDAR datasets.

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SOUNDLESS CHEMICAL DEMOLITION AGENTS

Soundless Chemical Demolition Agents (SCDAs) are non-explosive, non-percussive alternatives to jackhammers and explosives. When mixed with water, SCDAs typically expand up to 3 times the original volume. The aqueous SCDA slurry is placed inside a borehole, and it creates an expansive pressure as the chemical reaction between the water and the calcium oxide based mix occurs. Once the expansive pressure exceeds the tensile strength of the concrete, cracks begin to propagate outward from the borehole. After the cracks in the specimen have a cumulative width of around one inch, the specimen can be removed with a shovel or a backhoe. Since SCDAs do not create flyrock, vibrations, and debris, they are safe, environmentally friendly, and can be used in cities and historic areas without damaging surrounding buildings.

Throughout this summer research, data from Laefer's previous experimental work of 33 unreinforced concrete blocks tested under varying conditions will be reanalyzed. New parameters in recently completed research will be used for the re-evaluation in order to help better predict cracking behavior. Important variables being studied include the following: hydration heat, ambient temperature, material strength, borehole confinement, and post cracking treatments.

Along with this will be a new experiment, in which SCDAs will be tested in lightly reinforced concrete. Since reinforced concrete significantly increases the tensile strength of the concrete, it is important to test this. This experiment will consist of 3 different specimens of concrete at different depths with a wire mesh placed inside. This will replicate various pavement scenarios where adjacent structures may be damaged if jack hammers are used. The Minimum Demolition Time (MDT), Time to First Crack (TFC), and the cumulative crack width will be recorded and analyzed for these specimens. The goal of this research is to find a predictive model that can be used in the field.

▲ Brianna Migliaccio is analyzing the behavior of soundless chemical demolition agents to make better predictions of cracking patterns.

CHEMICAL AND BIOMOLECULAR ENGINEERING

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ANALYSIS OF DIALYSIS METHODS USING FLUOROPHORE ASSISTED CARBOHYDRATE ELECTROPHORESIS

In dialysis, molecules in solution are separated based on size, through diffusion, using a semipermeable membrane––small molecules freely pass through membrane pores, while larger macromolecules cannot. It is performed prior to analysis of biological macromolecules, to change solvent composition or remove low molecular weight contaminants. Our research uses dialysis to purify the glycosaminoglycan, hyaluronan. Because hyaluronan is a linear carbohydrate polymer, ranging from a few to thousands of sugars long, and the chain's size can affect its function or usefulness as a biomarker in disease diagnosis, it is important to determine the smallest chain to be retained by a dialysis membrane. Different dialysis methods will be tested to determine the percent retention of hyaluronan samples, while comparing the material's cost efficiency, model, and membrane type.

Percent retention will be quantified using Fluorophore Assisted Carbohydrate Electrophoresis (FACE), a type of polyacrylamide gel electrophoresis, which separates low molecular weight glycosaminoglycans by size dependent migration through a gel in a uniform electric field. Longer samples are more retarded by the gel matrix, while shorter samples travel farther. However, when dealing with extremely small molecules of varying lengths, small oligosaccharides are lost during staining.

To prevent loss, hyaluronan oligosaccharide samples are pre-labeled with fluorescent dye, like 8-aminonaphthalene-,1,3,6-trisulfonic acid (ANTS), before running through a polyacrylamide gel, eliminating the need for further staining steps. Currently, different hyaluronan samples are being run through FACE gels to determine the best labeling conditions, and gel run times for the clearest separation.

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LIPOSOME MODELS FOR EXTRACELLULAR VESICLES

Extracellular communication via unilamellar vesicles is an important mechanism driving processes such as tissue remodeling and disease progression. Two such examples are exosomes, which are shed by exocytosis from larger bodies, and extracellular vesicles (EV's), which are derived directly from the plasma membranes of donor cells and fuse directly into the plasma membranes of recipient cells. The shedding of EV's is increased in cells which have a higher concentration of hyaluronic acid (HA) bound to their surfaces.

HA is a glycosaminoglycan and the main macromolecular component in synovial fluid. One aim of this project is to use size characterization with a nanoparticle tracking analyzer to prove whether increased shedding of EV's is a physical result of raised osmotic pressure due to increased production of HA at the cell's surface under inflammatory conditions.

Giant unilamellar vesicles (GUV's, 1 Qm+ diameter) and small unilamellar vesicles (liposomes, 50-200 nm diameter) are examples of vesicles that may be synthesized using controlled quantities of specific lipids. Procedures for the creation of these vesicles have been developed. In experiments with GUV's in sucrose solution, GUV's have been observed to shrink in a hypertonic environment and shed small vesicles. By controlling the lipids used for formulation and attaching HA to the surface of the resulting vesicles, procedures may be adapted for modeling cells under inflammatory stress and the resulting EV's. Once those models are developed, the objectives are to study how the sizes of these vesicles are affected by the increased HA at the surface and to examine, and hopefully affect, how these vesicles interact with cells.

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BLOCK COPOLYMER CHARACTERIZATION USING DEPOLARIZED LIGHT SCATTERING

Block copolymers (BCPs) mixed with lithium salts are an emerging class of lithium battery electrolytes. Their robust mechanical strength can impede detrimental dendritic growth, while their high ionic conductivity allows for low internal resistance. Although it has been recognized that BCP grain structure and local morphology determine their properties, such as shear strength and ionic conductivity, predictive expressions have not yet been derived for these relationships. To further understand these connections, our group has developed novel methods to measure parameters that characterize grain size and to study grain growth kinetics and thermodynamics, particularly in polystyrene-block-poly(ethylene oxide) (PSEO)/lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) mixtures.

Determination of grain size is imperative to the characterization of a BCP, as past experiments have shown that properties such as ionic conductivity are a strong function of grain size. In 2016, Wang et al. obtained a bimodal grain distribution model by using Depolarized Light Scattering (DPLS) and Small-Angle X-Ray Scattering (SAXS) methods on BCP samples. The analytical expression used to characterize the size of a grain is of a Gaussian form, but our group intends to explore whether a model using an exponential-decay fits the experimental data more appropriately than a Gaussian expression.

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EFFECT OF GOLD NANOPARTICLES ON LASER-INDUCED NUCLEATION

In previous research, Garetz et al. observed that supersaturated aqueous solutions, for example, glycine and urea, undergo non-photochemical laser induced nucleation (NPLIN) when exposed to high-intensity near-infrared laser pulses. In addition, the nucleation rate is hypothesized to further increase with the addition of gold nanorods specified for peak plasmon resonance absorption at 980 nm, near the laser wavelength of 1064 nm. The light passing through the sample would excite the surface electrons of the nanorods enhancing the local electric field and inducing nucleation. The objective of the experiments is to observe the effect of gold nanoparticles on the NPLIN rate of 1.5 supersaturated glycine solutions. Experiments were conducted on 1.5 supersaturated aqueous glycine solutions, with and without nanoparticles added. Solutions were exposed to 1064-nm near-infrared high-intensity laser pulses for one-minute. After conducting multiple trials, the result, however, does not support the hypothesis proposed; the addition of gold nanorods leads to the decrease in the likelihood of nucleation. This could be explained by the tendency of gold nanorods to absorb some of the laser light, heating the solution. The increased temperature of the solution would decrease of supersaturation and reduce the likelihood of nucleation.

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PERFORMANCE EVALUATION OF A CYCLODEXTRIN-SUPPORTED PALLADIUM COMPLEX IN CATALYZING SUZUKI-MIYAURA CROSS-COUPLING REACTIONS

Massive amount of methane is entrapped in Earth's natural resources. It is the largest component fraction of natural gas and has merit for its use in organic synthesis. However, the challenges arise in the controlled activation of carbon-hydrogen bonds of methane at moderate temperatures. These bonds are extremely stable and thus require a high amount of energy to break, making methane mostly unreactive. The activation of methane could lead to greener energy, as well as improvement and reduction of cost in the manufacture of commodities, chemicals, and pharmaceuticals.

The goal of this project is to explore the catalytic reaction of methane in Suzuki Miyaura carbon-carbon cross-coupling using a continuous-flow micro-reactor. For hundreds of years, chemists in labs have conducted synthesis in batch mode—stirring raw materials and regents in flasks and laboriously separating out the desired product. Instead, we use a continuous-flow system to expedite kinetic information, and streamline the discovery processes safely, cleanly, and cost-effectively.

Typically, Suzuki reaction combines together organohalides and boronic acids via a palladium (0) complex catalyst. This project hopes to replace organohalides with methane using a cyclodextrin-supported palladium complex (DACH-Pd-β-CD). This catalyst is reported to be effective in Suzuki reactions conducted in batch systems; our research evaluates its performance in continuous-flow systems. DACH-Pd-β-CD has high-reaching applications in green chemical synthesis since it uses an environmental friendly solvent (water), and has short reaction times, low catalyst loading, excellent yields and reusability through multiple cycles. Resulting scientific discoveries would open doors for energy-efficient and economical processes that lead to the advancement of natural gas utilization in a broad cross-section of society.

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MODULATION OF BETA-AMYLOID AGGREGATION

Alzheimer's disease (AD) is the most prevalent neurodegenerative disease and projected to afflict up to 14 million people by the year 2050. The aggregation of β-amyloid (Aβ) has been found to play a key role in the pathogenesis of AD. Aβ amyloid plaques are found in the brain of patients diagnosed with AD. Aβ aggregation is usually illustrated by a sigmoidal kinetic curve with three stages: lag phase, elongation phase and steady phase. During the lag phase, structurally disordered Aβ monomers spontaneously self-assemble to β-sheet rich oligomeric assemblies. During the elongation phase, amyloids further aggregate to form fibrils of highly ordered cross β-sheet structures. The fibrillation finally reaches the plateau in the steady phase.

The goal of this study is to determine the optimal concentration for studying Aβ aggregation and the Aβ to peptides ratios that may inhibit aggregation. We seek a concentration which produces an aggregation profile with a well-defined lag phase and will observe the effect of multiple peptides on Aβ aggregation.

The Aβ variant pair, KLVFWAK and ELVFWAE, were derived from the hydrophobic central domain (HCD) of Aβ via terminal point mutations to electrostatically drive hetero-assembly while minimizing homo-assembly at physiological pH. KLVFWAK displays limited homo-assembly at neutral pH, due to the charged terminal lysine residues. ELVFWAE was created using the same process. The aggregation of protein interactions will be characterized by Thioflavin T (ThT) fluorescence, and the optimal concentration of the Aβ and the ratio between Aβ and the peptides will be determined.

DASH CAM

The U.S. is a world leader in car crash deaths. Other countries have made progress in reducing fatal motor vehicle accidents than the U.S. A dash cam can help prevent accidents with camera-based collision avoidance software. A dash cam is a video camera mounted inside a windshield and pointed outward, as to monitor the actions of police officers or to record accidents to determine insurance liability. In the United States, dash cams are gaining popularity due to the need for an accurate source of road encounters concerning road rage, erratic lane changes, and accidents. A good dash cam has the following features high definition, long recording loop times, 1080p, and 32 gigabytes of memory. The legality of dash cam use varies from state to state within the United States. A driver can choose between a separate device with a price range of $100 to $500 or use their own mobile device which can access their phones operating device. This dash cam was created with XCode software a development kit for Apple apps. Our dash cam simultaneously displays two screens. It features long loop times, split screens, and facial recognition. We will be working on implementing augmented reality into the dash cam to help aid the driver with tracking objects while driving. Practicability and accessibility are paramount in a dash cam app and will not only help people with situations mentioned above but also help regulate driving habits. Dash cameras are becoming just as important as wearing a seatbelt while operating a motorized vehicle.

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▲ Yang Gao (pictured left) and Naqeeb Cahacci (pictured right) are developing a dash cam software that utilizes augmented reality to help drivers avoid collisions and regulate driving patterns.

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STAFF OF GANDALF

According to the World Health Organization, there are currently over 285 million people around the globe who are visually impaired, with 39 million people being legally blind.[1] Currently, the most widely used assistive devices include white canes and guide dogs. The guide dog is very expensive to train, requires care and attention, has a short service life and is prohibited in some buildings. Similarly, the white cane has several disadvantages such as putting strain on the users elbow, lacking detection above knee level, and often times missing curbs and edges. [2] The white cane was redesigned with inspiration from the Lord of the Rings into the Staff of Gandalf, an Electronic Transport Aid (ETA) that utilizes an array of ultrasonic sensors in order to detect objects in a full 180 degree system. The ultrasonic sensors provide haptic feedback to the user through vibration patterns up to a distance of 3 meters. An Arduino microcontroller obtains information such as the range, distance, and angle of an obstacle, and delivers feedback in the form of a haptic panel. Past prototypes that took the form of a cane, lantern, and staff were used to test different sensors such as ultrasonic and infrared, and various feedback mechanisms including vibrating motors and solenoid pins. The Staff of Gandalf serves as a device that provides users with a sense of the surrounding environment at all times and everywhere, allowing for a safe, convenient and inexpensive navigation tool for the visually impaired.

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SIMULATION OF ORIGINS OF LIFE

In the 1920s, the Oparin-Haldane Primordial Soup theory hypothesized the formation of life in the earth's oceans in a reducing atmosphere which contained almost no oxygen; 30 years later, the Miller-Urey Origins of Life experiment demonstrated the formation of essential biochemical molecules, namely amino acids, under the proposed conditions. In order to fully comprehend the formation of protein structures from amino acids at life's origin, the understanding of amino acid bonding at a molecular level is essential.

For many students, visualization of chemical bonding and processes can be extremely difficult, yet a very important skill to possess when analyzing and understanding not only chemical reactions but especially protein formation. Current tools for learning such as textbooks only give a 2-dimensional view of bonding, which prevents full comprehension of the molecular structure and are often quite costly.

With today's technology, the creation of an interactive computer application to recreate the formation of simple proteins from amino acid interaction in 3-dimensions is possible. To accurately portray the conditions of primitive earth, the conditions of peptide bond formation was studied as well as the types of amino acids present. The amino acids were modeled and bonding was simulated using PyMOL; PyMOL is a Python-based software program which allows molecules and molecular bonds to be simulated 3-dimensionally, giving users a clear visual from all angles. Adding the user-controlled Python GUI components allowed simulation of protein activity at different pH, temperature, and pressure, emphasizing the principle that proteins form and function in specific conditions.

Although the program is fairly simple conceptually, the possibilities in which it could be used extend far past the classroom. By understanding the perimeters and conditions in which amino acids and other organic compounds can react to create essential biomolecules such as proteins, the simulation of life formation on planets beyond our own is achievable.

▲ Rosanna Lam is utilizing an interactive computer application to study the bonding of amino acids at a molecular level.

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CONTROLLED ASSEMBLY OF PEPTIDES IN A MICROFLUIDIC DEVICE

β-Amyloid (Aβ) aggregation is a key feature in the pathogenesis of Alzheimer's Disease (AD). Aβ aggregates exist in the brain as a heterogeneous mixture of oligomeric and fibrillar aggregates of varying sizes and degrees of toxicity. A better understanding of the size-dependent neurotoxicity and structure of these aggregates will be essential towards Alzheimer's Disease research and the development of therapeutics strategies. Our lab has produced two peptides (KLVFWAE & ELVFWAE), that were derived from the hydrophobic region of -Amyloid (KLVFFAE), by introducing single point mutations at the terminal ends. These peptides do not self-aggregate but can hetero-assemble to form amyloidogenic structures that are morphologically analogous to -Amyloid aggregates. It is our goal to utilize this dual peptide system to precisely control the formation of these aggregates. We also intend to explore the use of this system to create functional biomaterials.

The controlled assembly of these peptides will be performed through microfluidic format. This study focuses on the development of a Polydimethylsiloxane (PDMS) microfluidic chip and the fabrication of size-specific aggregates within a controlled volume. Streptavidin coated magnetic beads and biotinylated peptides will be tested on multiple microfluidic chip designs, as we optimize the microfluidic platform and protocol for controlled peptide assembly.

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CHEMTRIS

General chemistry courses have generally been intuitive to learn due to observative results. As students progress through higher levels of chemistry, there are microscopic and symbolic concepts that require more molecular visualization, which is traditionally taught using two-dimensional textbook models and occasionally three-dimensional physical models. However, these methods lack representation of the chemical properties of the model being analyzed and do not fully explain or show specific interactions. Chemtris is a game, developed with Unity Engine, that contains a Tetris-like orientation which requires a spatial understanding of position and rotation to understand polarity and chirality. In the game, once certain elements have been stacked onto each other, a "reaction" occurs in which the blocks disappear. This serves as a visualization of organic molecules in an interactive environment that allows students to gain a better understanding of molecular concepts that could not be seen on the macroscopic scale. We are currently working on the IOS and Android version of the game, and we plan to develop a VR version after.

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THE PANIC BUTTON

As the trend of civilization and development continues, a large proportion of people spend most of their time alone. However, being alone should not compromise a person's ability to quickly get assistance in case of an accident or a sudden medical emergency. This is where the Panic Button, a personal emergency response application, comes into play. Traditional emergency systems are flawed: they have to be within a certain range to function normally, and they are often very expensive. Other existing mobile applications cannot be activated fast enough as they require users to unlock the phone and then use the application. The Panic Button application takes upon a different approach as it employs an extension, a physical, customizable button connected to the smartphone using Bluetooth technology. Whenever the user presses the button or activates through the app, a secure message is sent to contacts that were pre-selected and saved. The messages contain vital information such as the geo-location and medical prescriptions of the user. The button can also be customized for different modes, allowing the users to fully utilize its functions. Additionally, the production cost of the button is very low using the trending 3D printing technology, and the application itself is completely free. The application has been built in Google's Android platform in Android Studio, and it is currently being tested for a better user experience.

▲ Yiqun Zhang's Panic Button, a personal emergency response application for smartphones, enables users to send secure messages containing their vital medical information and geo-location.

DEAD MAN WALKING

The geriatric population, which consists of individuals over 65 years old, is the fastest growing part of the US population and citizens of this population are living a life which has increased in longevity as well activity which has come with a rise in the incidences of traumatic injuries . Much of the geriatric population actually lives alone and thus they are at a higher risk [1] of getting into accidents without receiving aid someone. The Dead Man Walking project strives to create a device to monitor vital signs without being invasive; these vital signs are recorded using facial recognition. To test this theory a photo was taken of an individual before and after 30 minutes of strenuous exercise. These photos were imported into photoshop then converted into grayscale and pixelated to locate the superficial temporal artery in order to detect pulse rate in a non invasive way. By knowing this information when an individual's body temperature increases, we can use an image analysis software is able to automatically recognize the change. Our current model consists of a webcam mounted on a stand with wheels equipped with infrared sensors to detect temperature changes. Python and OpenCV were used to code the model. Further additions will include facial 3D scanning to our device so that oxygen intake can be measured through chest movements, as well as other crucial vital signs such as respiration rate and blood pressure. With this device the geriatric community will continue to thrive without being confined to a twenty-four hour health care facility; when there are fluctuations in vital signs physicians will be alerted, reducing the time it takes to the elderly to receive aid.

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MULTIPLEXING POLYSTYRENE MICROSPHERES FOR BIOSENSOR APPLICATIONS

Microspheres are utilized as whispering gallery mode (WGM) biosensors; these have been shown to detect and even determine the size of particles as small as an ion in solution, without the use of any label. This is useful for bio-samples in particular because other techniques able to resolve similarly sized particles often require the use of a label to detect individual analytes.

Typically, each microsphere is used to run one assay, but due to their small size many such microspheres can be also used simultaneously to run multiple assays in parallel. The idea would be to analyze an entire solution, where each microsphere would return a unique signal from detection of individual biomolecules and a histogram can be constructed of the sample by collecting data points from many individual microspheres. This is contrasted by traditional ensemble techniques such as DLS which can only report mean values averaged over many particles.

For this project, we will utilize a silica slide to construct a bed of polystyrene microspherical resonators. By using total internal reflection microscopy (TIRM), an evanescent field extends into the solution beyond the slide which can be used to excite microspheres into a state of WGM resonance. By electrostatically suspending the microspheres above the silica slide (through control of salt concentration) and producing the evanescent field, only the microspheres that are excited into resonance feel a strong attractive pull toward the slide. We aim to construct an entire slide that contains only these microspheres that resonate and wash the rest out. Ultimately the goal is to have a high signal-to-noise ratio, multiplexed sensor that is entirely constructed in situ, allowing it to be used as soon as all the microspheres are pulled down to the bottom of the slide.

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EFFECTS OF PULSE DURATION ON DNA-MO SURFACE HYBRIDIZATION

DNA biosensor and DNA microarray development has grown immensely over the past few years and are important tools in various applications such as genotyping, drug discovery, and sequencing. DNA surface hybridization has been used in microarrays and biosensors to analyze concentration of genes through complementary pairing. In surface-hybridization experiments, solution-based "target" sequences bind to surface-immobilized "probe" sequences. The extent of hybridization is proportional to the concentration of target, yielding a higher output signal. Traditionally, DNA-DNA is used, but DNA has a negative charge, and therefore repels other DNA from binding, slowing reaction time of binding. Morpholino is an uncharged nucleic acid analogue that can be used for DNA-MO hybridization and allows for greater hybridization capacity. However, hybridization is still limited by local diffusion, so positive and negative potentials are applied to attract and repel DNA in solution. Pulsed field surface hybridization reduces the time needed to achieve equilibrium and minimizes cross-hybridization. From previous studies, hybridization and de-hybridization were greater at longer time lengths (6 min, 18 min, and 54 min). The purpose of this project is to study how the duration of pulses affects hybridization. Hybridization of morpholino to mismatch DNA target was measured using electrochemical techniques to determine noncompetitive specificity and time dependence. Using data obtained from these studies, pulsed field control can be optimized.

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DIFFERENTIAL PULSE AMPEROMETRY ON THE ELECTROHYDRODIMERIZATION OF ACRYLONITRILE TO ADIPONITRILE

Electrochemistry, a field first studied back in the eighteenth century, has undergone significant change and regained its popularity since the 1950s. The continuously increasing global CO2 emissions and energy demand drive a transition towards green industrial chemical processes. Recent studies on electrochemical processes aim to improve the electron transfer processes at the electrode surface to enhance performance metrics and allow for scalability of electrochemical processes that can be easily integrated with renewable energy sources. Electrochemical pulsed techniques are a relatively new and promising field that address this challenge. In this project, differential pulse amperometry (DPA), a technique that enables interchanging voltage between rest and pulse state, is studied upon the specific case of the electrohydrodimerization of acrylonitrile (AN) to adiponitrile (ADN), a key intermediate reaction in the industrial production of Nylon 6,6.

The backbone assumption of the project is that a short, optimal rest in current, combined with intervals of applied cathodic voltage will help mitigate mass transport limitations of organic reactants to the electrode surface, especially at high voltage and current density, and maximize ADN production rates. In this project, the performance of DPA will be studied within the context of diverse combinations of pulse period, and the evaluation will be based on the selectivity towards the desired product (ADN), its production rate, and the overall power consumption of the system.

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NANOSTRUCTURED ELECTROCATALYSTS FOR RENEWABLE ENERGY CONVERSION

Nafion is a stable ionomer that is frequently used as a proton conductor in proton exchange membrane fuel cells for its ion transport properties. However, the proton-conductivity of Nafion becomes dependent on thickness when it is confined to thin films (10-100 nm), making it unsuitable for use as a fuel-cell catalyst layer in many electrochemical systems. Also, perfluorinated sulfonic acid ionomers, like Nafion, generally exhibit slow gas permeation, which is a determining factor of the current density achievable by the electrochemical catalyst layers. The conductivity of Nafion is dependent on how hydrated the material is, and, therefore, the material will only work in certain humidities and other environmental conditions.

This research focuses on the development of hydrogels composed of poly acrylic acid/poly vinyl alcohol to be used as ionomer binders in proton exchange membrane catalyst layers in place of Nafion. Less than 100nm of the gels are applied as thin films to electrodes, crosslinked, and swollen with an inorganic acidic electrolyte. Because hydrogels swell homogeneously, the conductivity of these materials is not dependent on film-thickness. They also exhibit improved gas permeability because the films are loosely crosslinked, providing channels for gas to flow through and thus making the material more conductive. The gels can be made with varying concentrations of poly acrylic acid and poly vinyl alcohol and swollen in varying concentrations of acidic electrolyte, so they are tunable. These hydrogels can be used as an alternative to Nafion and offer improved performance regarding water splitting electrolysis and hydrogen fuel cells.

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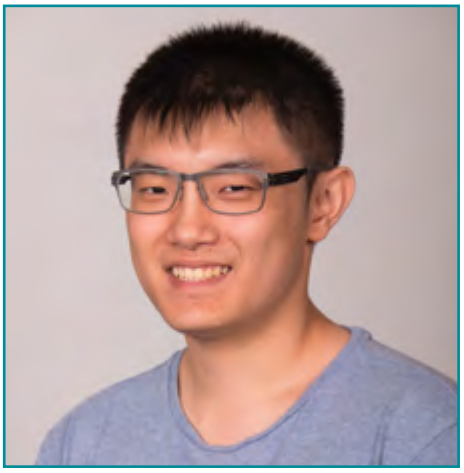
HYDROGEL-BASED PHOTOCATALYTIC REACTORS FOR LIGHT-DRIVEN WATER TREATMENT

Meeting the global demand for potable water is a paramount challenge of this century, and it is not yet met in many regions of the world. Wastewater treatment is one of the most crucial forefronts for meeting this demand. During secondary treatment, wastewater treatment plants often use activated carbon, advanced oxidation processes or biological treatment to remove dissolved organic compounds. Each of these processes have associated issues: activated carbon can only be used once, advanced oxidation processes often require handling peroxide or high energy input, and biological treatment is slow and requires precise control of pH. As an alternative method of removing dissolved organic compounds, we propose to fabricate hydrogel photocatalyst composite devices, which absorb organic compounds and oxidize them at the surface of UV activated TiO2 nanoparticles embedded in the hydrogel. Hydrogel fluidic devices were fabricated by soft lithography utilizing free-radical polymerization of pHEMA in a slurry containing TiO2 nanoparticles. Neutral red was used as a model contaminant to investigate diffusion and degradation of trace organic compounds in the devices. Different length channels (1-3 cm), concentrations of dye (1-12 mg/L) and flow rates (2.5-10 mL/hr) were also explored. The results of this study show that these devices were able to uptake a significant quantity of the organic molecules passed the channel. The effect of incident UV radiation on photocatalysts degrading the dye in the hydrogel and increasing uptake is currently under investigation.



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ADVANCED ELECTROLYSIS DEVICES

Renewable energy technologies, such as photovoltaic technology, have advanced greatly over the past years as there have been greater government and public interest in replacing fossil fuels with cleaner energy resources. Some of the advantages that renewable energies, such as solar and wind, have over fossil fuel is that they are more environment friendly and more abundant. While photovoltaic cells are getting cheaper and are becoming a viable replacement to our dependence on fossil fuel, one of the obstacles that stills needs to be overcome before they become an ideal primary energy resource is finding a means of storing the excess energy to be used later. Whereas fossil fuel can be used at any time of the day to be converted to usable energy, renewable energies such as solar energy, can only have energy conversion at certain time intervals of any given day, and under certain surrounding conditions such as weather. Therefore, energy storage is needed to be developed that can store large amounts of energy, while being affordable and be scalable.

There has been ongoing research on the development of redox flow batteries as an energy storage technology for these renewable energies. A redox flow battery contains two soluble redox reactant species that flow through an electrochemical cell, with the anode and cathode separated by a membrane. While the redox species flow through the cell, they are oxidized or reduced when being charged or discharged, respectively. Redox flow batteries are seen to be more flexible, scalable, have higher energy capacity and total power output, and have little impact on the environment, compared to lithium-ion batteries and to other energy storage alternatives. For our project, we will be focusing on understanding and designing a redox flow battery that uses Cerium ions as the redox pair (Ce3+/Ce4+). The main focus of this project would be to increase the efficiency of the cell by varying different parameters of the flow battery (e.g. flow rate, temperature), and from there to keep working on finding ways to further increase the efficiency of redox reaction of cerium ions.

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PROTEIN-ENGINEERED INJECTABLE HYDROGELS FOR TREATING OSTEOARTHRITIS

Hydrogels have been extensively studied as delivery carriers for various drugs and therapeutics. Unlike synthetic polymer-based hydrogels, protein-derived hydrogels offer several advantages including biocompatibility and biodegradability. Here, we are developing a protein block copolymer injectable hydrogel, EC, which combines syringeability of sol and in situ gelling properties of a gel. This EC system consists of E, elastin-like polypeptide, and C, cartilage oligomeric matrix protein coiled-coil (COMPcc). EC demonstrates a thermoresponsive ability, existing as a solution at lower temperature (4°C) and arranging itself into tightly-packed micelles at physiological temperature (37°C). These micelles, characterized by dynamic light scattering (DLS) and transmission electron microscopy (TEM), allow for gel formation. We confirmed the gelation of EC in mice models and will further explore its potential in storing and delivering progranulin (PGRN), a chondroprotective protein therapeutic, providing a sustained effect of the drug in post-traumatic osteoarthritis (PTOA) patients.

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FABRICATION OF TRANSITION METAL CHALCOGENIDE CU_2SE SEMICONDUCTING THIN FILMS AND THERMOELECTRIC PROPERTY CHARACTERIZATION

The global energy crisis and environmental problems caused by large-scale industrial development have drawn attention to alternative energy sources. Thermoelectric (TE) materials, which convert electricity to heat and vice versa, may offer solutions to these issues via waste heat recovery, power generation, and solid-state cooling. However, most TE materials are fabricated from toxic materials such as tellurium and lead. Hence, we plan on using solution processed flexible thin films of sustainable thermoelectric materials. Copper selenide (Cu_2Se), a transition metal chalcogenide and p-type semiconductor, exhibits good thermoelectric performance in a wide temperature range and is more environmentally friendly compared to current toxic TE materials.

The goal of this work is to determine reliable, low-energy and low-cost routes of fabricating Cu_2Se thin films with high figure of merit, ZT, which quantifies the thermoelectric performance of a material. To obtain a high ZT value, both Seebeck coefficient and electrical conductivity must be large and thermal conductivity should be minimized. This is fundamentally difficult to achieve because reduction in thermal conductivity is typically accompanied by a large penalty to electrical conductivity. Nanostructured materials and thin films can potentially break this relationship between the electronic and thermal properties of a material. We adopt two methods of making Cu_2Se thin films: 1) Directly fabricate nanostructured Cu_2Se thin films using a solvent deposition process and dope the films; 2) Using a cation exchange process using cadmium selenide nanocrystals. We perform structural characterization of our thin films via x-ray diffraction and scanning electron microscopy. Through electrical conductivity and Seebeck coefficient measurements, we compare their thermoelectric properties and optimize ZT values by varying their chemical composition and film morphology.

▲ Nan (Louise) Chen is determining optimal fabrication methods for thin films consisting of sustainable thermoelectric materials.

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COLLOIDAL QUANTUM DOTS FOR X-RAY PHOTON DETECTOR FOR EARLY DETECTION OF CANCER

According to U.S. Breast Cancer Statistics, breast cancer is stated as second deadliest cancer in the world which will increase by 266,120 in 2018 in the U.S. The demand on finding the cancer at early stages grows tremendously since most cancers are detected at relatively late stages. Moreover, heavier dosage of X-ray is required for the detection of cancer, which in itself may potentially harm patients.

Recently, colloidal quantum dots are studied to tackle various technological problems, one of which is to improve X-ray image resolution. Quantum dots are nanoscale particles that exhibit quantum confinement, in which energy levels are made discrete upon decreasing particle size. In our project, our aim is to use quantum dots which captures the visible light from the scintillators and converts it into electrical signals which reaches the amorphous selenium for further X-ray image readout.

Conventional detectors use Cesium Iodide Thallium (CsI:Tl) and amorphous Selenium in which CsI:Tl acts as a scintillator which converts X-rays into visible light at a wavelength of 550 nm, but amorphous selenium (a-Se) is not an efficient absorber of visible light at 550 nm. In this project, our aim is to use an artificial material, Cadmium selenide quantum dots to efficiently absorb visible light of 550 nm which is emitted from scintillators. This absorbed photons are converted to charge carriers which is absorbed by a-Se to form image. Over the summer, we would be focusing on the synthesizing methods to control the size of CdSe, spin-coat thin film, optimize absorbance wavelength, and characterize the CdSe film which captures visible light with high efficiency than a-Se, which in result reduces the heavy dosage to be used for cancer detection.

▲ Lixuan Yang is studying the use of quantum dots as a method for early cancer detection.

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THIN FILM LIGAND EXCHANGE OF AG_2SE QUANTUM DOTS

Quantum dots (QDs) are semiconductor nanoparticles with size and shape dependent properties that differ from their bulk counterparts. Thermoelectric materials can convert heat directly into electricity and vice versa. I am interested in Ag_2Se QDs for thermoelectrics because bulk Ag_2Se has good thermoelectric performance at room temperature. The efficiency of a thermoelectric material is determined by the dimensionless figure-of-merit ZT, which is directly proportional to Seebeck coefficient and electrical conductivity and inversely proportional to thermal conductivity. Nanostructuring can break the inverse relationship between Seebeck and electrical conductivity and reduce thermal conductivity, all of which will improve the ZT for Ag_2Se QDs. Additionally, it has been shown that Ag_2Se QDs exhibit mid-infrared absorption at room temperature, which has an important application in thermal photodetection. Currently, the state-of-the-art photodetectors are fabricated with HgTe, which is highly toxic. The challenge with Ag_2Se QDs is that they are colloidally synthesized with long carbon chain, electrically insulating ligands. For both thermoelectric and photodetector devices, these ligands need to be exchanged with shorter, more polar ligands to facilitate charge transport between the QDs. In my work, I have demonstrated a robust and straightforward procedure to effectively fabricate thin films of Ag_2Se QDs exchanged with short thiol ligands. Also, I have studied the effect of mild thermal annealing and quenching on the thermoelectric performance of the ligand exchanged thin films. SEM and XRD were used for structural characterization. UV-Vis-NIR and FT-IR spectroscopy were used for optical characterization. Electrical conductivity and Seebeck coefficient were measured for thermoelectric characterization.

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ENGINEERING OF SUPERCHARGED COILED-COIL PROTEIN FOR GENE DELIVERY

Gene therapy is the therapeutic delivery of nucleic acid into cells to treat disease, and while this practice holds great potential, a safe and effective delivery vehicle for in vivo use has yet to be created. Nucleic acids are highly susceptible to nucleases, and it has proven difficult to reach a high transfection rate while maintaining a low toxicity. Protein engineering techniques have emerged due to their unique advantages of specificity in terms of structure and assembly, biodegradability, non-toxic contaminants, and environmentally friendly production. Our group has created a lipoproteoplex (LPP) to act as a novel delivery vehicle, and it is comprised of a supercharged alpha-helical protein, CSP, that can self-assemble into a pentamer and bind nucleic acids such as short interfering RNA (siRNA) or plasmid DNA. CSP is an engineered mutant of the cartilage oligomeric matrix protein coiled-coil (COMPcc) with 8 solvent exposed residues mutated to arginine to allow for binding to nucleic acids. Another mutant called N8 has also been created, which contains four extra histidine residues compared to CSP. These nucleic acid bound proteins, called proteoplexes, are encapsulated in a cationic liposome forming the LPP, which can then be delivered into cells. The LPPs for both proteins have shown to have a smaller size and a higher charge than their corresponding proteoplexes, determined by dynamic light scattering and zeta potential measurements respectively. These properties can aid in internalization and transfection, more effectively enhancing and/or inhibiting specific gene expression in cells.

FARM BYTES—WE ARE THE NEW FARMERS

The FarmBytes: We are the New Farmers vertical aquaponic farm is a manmade and therefore controllable ecosystem. Tilapia fish produce waste which is converted to nitrate by bacteria, the water feeds the cyanobacteria and plants growing in a soilless stacking system. Vertical aquaponics conserves energy, water, and space while allowing for continuous harvest of algae, fish, and produce.

The nitrifying bacteria are responsible for a two step process where ammonia is converted to nitrate. The ammonia oxidizing bacteria and nitrite oxidizing bacteria provide nitrate to the plants and reduce the ammonia concentration to a non toxic level. Spirulina is a cyanobacteria that is popular for its nutritional benefits and is grown in the farm to increase profits, nutrients of other organisms and biodiversity. With only a few studies of nitrifying bacteria and cyanobacteria in aquaponics, we present an analysis of the nitrifying bacteria present, specifically Nitrosomonas, Nitrobacter, and Nitrospina genera, as well as the growth and metabolism of cyanobacteria. The nitrifying bacterial cell structure, morphology, metabolism, optimal ammonia concentrations, optimal pH, genetic profile, and bioinformatic analysis were studied. It was found that bacteria inoculated from primary and secondary cultures grew in pH 6 conditions and bacteria inoculated directly from the farm grew in pH 6 and 7 conditions. Through simple staining, negative staining, and gram staining we observed that the nitrifying bacteria is gram negative and streptobacillus. The three nitrifying bacteria genera are rapid lactose fermenters found via differential and selective media. To isolate which species and strain of nitrifying bacteria is present, bioinformatic analysis using BLASTN showed regions where various species and strains were dissimilar and primers for PCR were created for those dissimilar regions. Cyanobacteria was tested for optimal growth using varying pH, temperature, and nutrient solutions. It was found that cyanobacteria can withstand a wide range of pH due to its ability to self induce a pH of 10. By holistically understanding the microorganisms in the aquaponic system, farms can be optimized for increased growth, nutrient value, and biodiversity.

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COLLOIDAL SYNTHESIS AND CHARACTERIZATION OF METAL PHOSPHIDE NANOPARTICLES

In the search for sustainable materials for optoelectronic devices, II-V and IV-V metal phosphides have garnered attention as earth-abundant and environmentally friendly alternatives to III-V semiconductors that consist of rare and expensive elements. Existing synthetic routes to metal phosphides, however, have been largely based on phosphorus precursors that are expensive, toxic, and difficult to handle. The goal of this research is to therefore determine reliable, low-energy synthetic routes to metal phosphide nanocrystals that use safe and cost-efficient precursors. Recently, aminophosphines were identified as examples of such precursors for the III-V semiconductor indium phosphide. In this work, we report the successful use of an aminophosphine, tris(diethylamino)phosphine, in the colloidal syntheses of zinc phosphide and tin phosphide. X-ray diffraction and high-resolution transmission electron microscopy show that the nanoparticles are crystalline. Optical spectra are also reported. These results show that aminophosphines provide safe and cost-efficient alternatives to conventional phosphorus precursors for colloidal metal phosphide nanocrystal syntheses.

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FARMBYTES: MACHINE LEARNING FOR VERTICAL FARMS

As population and food demand increase, the exploration of vertical farming, an urban farming technique, is becoming increasingly important. The autonomous vertical farm, FarmBytes, is optimized through the use of technology that automatically identifies plant diseases through the analysis of digital images of leaves. Historically, researchers of this topic have relied on classical computer vision techniques including Otsu's Method for image segmentation, spatial dependency matrices for textural analysis, and traditional pattern recognition and machine learning. Taking advantage of modern computational power, recent articles have begun focusing on evaluating the applicability of convolutional neural networks (CNNs) to this task. This project presents a comparison of these two methodologies. We believe this work to be unique insofar as it relies on complete autonomy of image capturing: previous work has focused on processing datasets of carefully-taken images of individual leaves that have been removed from their plants, but the autonomy of our farm required us to develop a system to automatically gather a dataset of images which each contain several leaves that remain unpicked. To evaluate the traditional computer vision techniques, we used a weighted ridge regression model that relied on features described by spatial dependency matrix representations of our images. The accuracy of that model is compared against the accuracy of a CNN developed by using transfer learning on the Inception-v3 network with the ImageNet dataset. Our results demonstrate the efficacy of utilizing machine learning to allow farmers to keep their vertical farms happy and healthy.

▲ To improve vertical farming techniques, David Heaney *(pictured right)* is conducting a comparison of classic computer vision technology and convolutional neural networks.

3D PRINTING OF NEURONS AND BONE

Education and understanding are greatly enhanced when 2D illustrations are supplemented with realistic 3D models. It can be difficult for students to comprehend the spatial dimensions of anatomical structures solely from textbook images and microscope slides; however, 3D printing can revolutionize education by providing an interactive method of learning. Existing models were found to lack the level of detail and accuracy that biologically active neurons and bones possess. Identification of the eliminated details shifted the focus towards creating models with a high degree of structural accuracy.

Neurons are specialized cells that transmit nerve impulses throughout the body. They have complex, highly branched structures with an extensive 3D network. Different types of neurons were modeled based on their morphological data. These models were enlarged and thickened and then printed using a flexible polymer. These models can be handled by students to improve their understanding of neural structures and to actively demonstrate the function of these cells in the body.

Existing 3D models of bones accurately portray the external structure of bone. However, they lack in their ability to depict inner anatomical structures. To properly display these structures, an interactive model of the first proximal phalanx was created using 3D printers and laser cutters. The bone model was downloaded, then modified in Meshmixer. Laser cutters were then used to engrave a detailed cross-section of the bone's microscopic substructures, including osteons, Haversian canals, and the medullary cavity. This novel approach provides students with an interactive tool to visualize how these structures work together to maintain a healthy bone.

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CIVIL AND URBAN ENGINEERING

LARGE SCALE MULTIAGENT SIMULATION OF NYC MOBILITY

Due to the introduction of new transportation technologies such as ride-sharing, bike-sharing, and electric vehicles, many traditional transportation analytical means have failed to capture the complexity of New York City's transportation system. A baseline model that captures realistic transportation patterns of New York City is a critical tool for transportation engineers and policy makers to evaluate the effect of a new transportation policy. Given the existing NYC transportation network, we create a synthetic population and use MATSim to simulate all transportation activities in the city in any given days. MATsim is an open-sourced activity-based multi-agent simulation software created based on the co-evolutionary principle. An agent, an individual in the synthetic population, iterates its daily activities while competing for space-time slots with the other agents in the transportation infrastructure to reduce its both travel time and monetary cost. Like the route assignment iterative cycle, but goes beyond route assignment by incorporating other choice dimensions like time, mode, destination into the iterative loop (Horni, Nagel, Axhausen 2018). A synthetic population is created by extracting trips' origins and destinations, demography data from the 2010/2011 Regional Household Travel Survey to accurately reflect the true population of NYC. The simulation model is complemented with binary and multinomial logit models to depict mode choices and location choices each agent makes. By simulating current transportation system, we can analyze different changes that can be made to our system in the future, like the closure of the L train line or redesign of the bus network in the city.

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PRIVACY CONTROL MECHANISM AGAINST INVERSE OPTIMIZATION TECHNIQUES

The amount of information available to urban planners has increased exponentially in recent years, with the potential to transform how we implement policies and design cities. However, there are privacy concerns with sharing so much data. Many private transit companies, like Uber, are unwilling to share route data for fear of machine learning techniques that can reverse engineer the algorithm parameters, such as distance, ride times, and wait times that are used to plan their routes.

The goal is to create and demonstrate an effective privacy filter that can be used on a variety of sensitive information. Privacy control mechanisms can generate synthetic data that hides while still preserving utility for researchers and city planners, with accurate statistics such as average ride times or common destinations. K-anonymous diffusion hides real tour data among synthetically generated tours. Using the principle of maximum entropy, valid synthetic tours are generated by solving inverse optimization problems until maximum entropy of the set is reached, ensuring that the distribution of synthetic tours does not reveal any information about the true tour.

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SUNLIGHT INDEPENDENT DECAY OF ANTIBIOTIC RESISTANCE GENES IN THE NATURAL WATER ENVIRONMENT

Wastewater treatment plants (WWTP) receive millions of gallons of polluted water daily. Wastewater influent, the water which flows into the plants, contains a plethora of microorganisms, pharmaceuticals, and organics, that all need to be filtered out and treated. Once the water undergoes a succession of treatment processes, it is released from the WWTP as wastewater effluent. Bacteria is a common organism found in the influent. Chlorination is one of the methods used to kill the bacteria and after they die, their DNA is released into the water. Among the bacteria thriving in the water are various antibiotic resistant bacteria (ARB), which have antibiotic resistance genes (ARG). ARGs are genes that code for antibiotic resistance, and are more challenging to remove by typical treatment processes used by WWTPs. As a result, ARGs are released into the environment where horizontal gene transfer processes, such as transformation, confer resistance to surrounding bacteria. Therefore, it is important to understand the genes that code for resistance and how they are inactivated in various environmental conditions. This study focuses on the degradation of ARG through sunlight independent processes such as through enzymes, variations of temperatures, and nucleases. Natural environmental conditions will be mimicked in laboratory experiments to evaluate the contribution of dark processes to the inactivation of ARG. This will ultimately supplement a model for sunlight inactivation of ARG currently in development. The objective of this research is to holistically understand the inactivation of ARG in order to develop wastewater treatment methods to more effectively filter wastewater influent.

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SOLAR-DRIVEN DEGRADATION OF INTRACELLULAR ANTIBIOTIC RESISTANCE GENES IN SHALLOW WATERS

Current water treatment methods target the elimination of bacteria but not the antibiotic resistance genes (ARGs) expelled by these microbes 1. As such, these ARGs are commonly released back into the environment where they can be absorbed by competent indigenous bacteria in surface waters 2. Solar disinfection may play a role in limiting the propagation of antibiotic resistance in surface waters as it has been shown to damage bacterial DNA[3]. However, the relative contributions of DNA damage from direct light absorption and indirect photochemical reactions is unclear 4. Additionally, bacteria have evolved DNA repair mechanisms that may protect against degradation of adaptive sequences such as ARGs[5].

To assess the impact of intracellular processes on the rate of ARG and bacterial inactivation due to sunlight, phosphate buffer solutions containing vancomycin-resistant *E. faecium* or *E. faecalis* were exposed to full spectrum sunlight. Bacterial DNA was extracted every 6 to 12 hours and the *vanA* gene responsible for vancomycin resistance in *E. faecium* was quantified using qPCR to assess the rate of ARG degradation. Additionally, bacterial abundance of both species was monitored by plating samples of the experimental solutions at regular time intervals.

Bacterial inactivation was three times faster for *E. faecalis* compared to *E. faecium*, suggesting differential susceptibility to solar disinfection. The rates of ARG degradation for *E. faecium* calculated from this experiment will be compared to those generated from extracellular experiments in order to elucidate the internal protection mechanisms that enable *E. faecium* to persist despite exposure to sunlight. Future work will replicate this experiment in different aqueous systems to better understand the relationship between bacterial inactivation, cellular processes and the integrity of intracellular ARGs. Such data will be useful in designing holistic disinfection protocols that account for both ARBs and ARGs.

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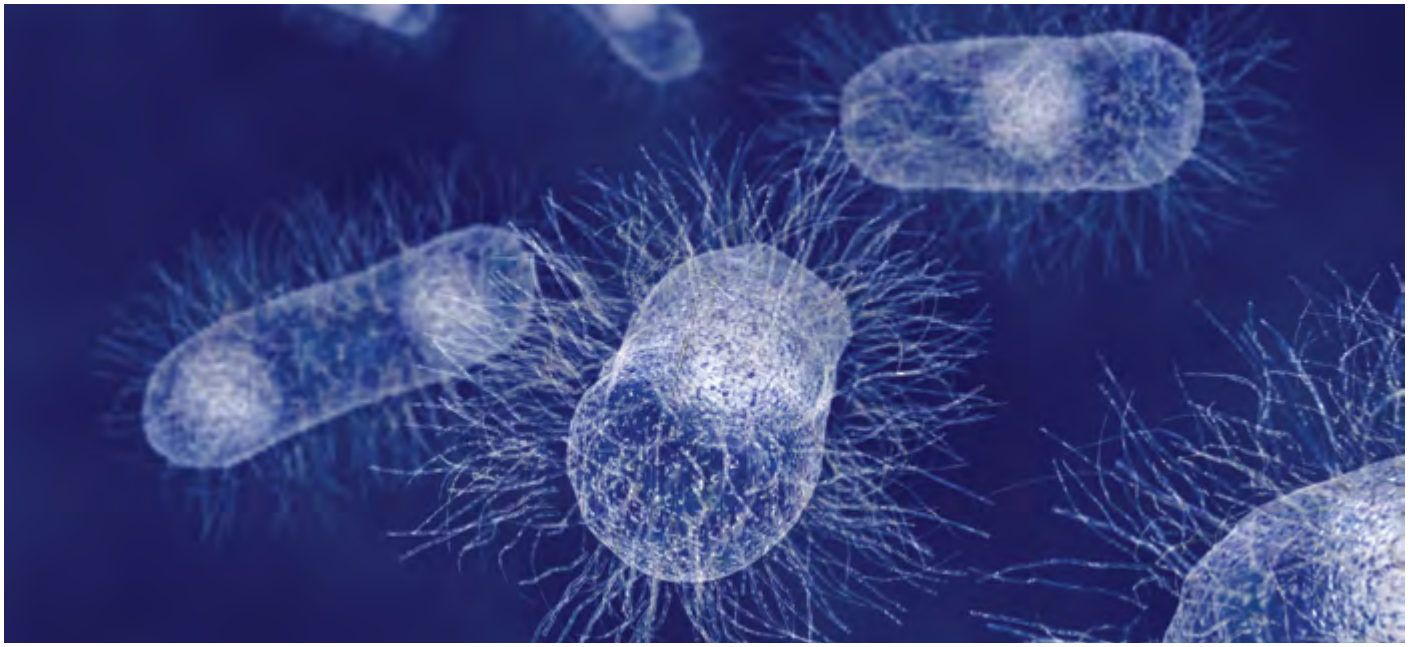
EFFECT OF STARVATION ON CHLORINE INACTIVATION KINETICS OF BACTERIA *(ESCHERICHIA COLI)*

Standard disinfection procedures for water and wastewater treatments are established from experiments conducted with laboratory-cultured bacteria. This is concerning, as previous studies have found that "indigenous" bacteria manifest higher disinfection resistance than that of laboratory-cultured bacteria. Gundlacht and Winter (2014; *Microbiol*. 160: 1690-1704) stated that stress-induced bacteria may undergo adaptation facilitated by phenotypic variation without mutations. This project addresses the question whether stress-induced bacteria, *Escerichia coli* in particular, become more resistant to chlorine inactivation. The growth conditions of laboratory-cultured bacteria are examined through experimentation on the availability of nutrients: laboratory-sourced *Escherichia coli* are cultured in nutrient-limited broth with a 1:10 dilution to simulate various starvation conditions. The bacteria are then be subjected to chlorine inactivation experiments: sodium hypochlorite (NaClO) will be used to prepare a free chlorine stock solution, which will be added to experimental reactors of different starting concentrations (0.1ppm, 0.2ppm, and 0.3 ppm). The Chick-Watson model was used to calculate two kinetic parameters, specifically, the intrinsic decay rate of the bacteria and the chlorine dose for 1-log inactivation (the product of the disinfectant concentration and time (Ct)). The kinetic parameters of the nutrient-limited laboratory-cultured *Escherichia coli* are compared to those of nutrient-rich laboratory-cultured bacteria and "indigenous" wastewater-sourced bacteria. Further experiments need to be conducted to arrive at conclusive results.



▲ Maria Dominique (Nikki) Ong is evaluating whether starvation results in greater resistance to chlorine inactivation in stress-induced Escerichia coli.

MONITORING MATERIAL FLOW IN THE OPERATING ROOM: TECHNOLOGICAL SOLUTION FOR DATA ACQUISITION

Healthcare facilities are estimated to be responsible for 1,814,369,480 kg of waste produced annually in the US [1], nearly a third of which comes from the operating room (OR) [2]. While the quality and safety of patient healthcare remains a priority, many healthcare professionals recognize that efforts need to be made to make the OR more sustainable. Due to the lack of readily available data and the complex nature of medical waste, rigorous waste auditing is required to track the progress of any such efforts. However, the waste auditing method currently in use is inaccurate, time consuming and resource inefficient due to its dependence on manual labor. Hence, an improved process is required.

This project aims to design an automated solution to monitor material flow through the OR using concepts of machine learning. The proposed device will take in surgical output, analyze its properties, recognize if it is waste and dispose of the waste in the appropriate waste stream after recording the relevant data. The project aims to cut back on the time and effort required for auditing while giving an increasingly accurate and detailed account of material properties such as weight, dimensions and material type. This will provide hospitals with an efficient and non-intrusive way to track material use in the OR.

The data collected from this solution will be of particular use to environmental researchers. Once in action the solution can be used to compare waste generation form various procedures within a particular department or even across medical fields, thus encouraging surgeons and hospital personnel to track and minimize their waste contribution. Further developments to the system may include configuration with a larger medical database and recommendations to minimize and properly dispose waste.

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FOOTPRINTING OF AN INPATIENT STAY

With the healthcare sector of the United States (US) spending about $2.8 trillion and making up approximately 17% of the US gross domestic product in 2012 alone, there is no doubt that the healthcare sector plays a major role in the economic growth of the US. However, the healthcare sector also contributes to a large set of emissions that adversely affects the lives of the public [1]. In fact, approximately 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, come from the healthcare sector [2]. Although there are significant opportunities for environmental efficiency improvements, which would lead to a reduction in costs, resources, and waste without compromising the quality of patient care, this area of medicine is overlooked globally.

The focus of this study is to calculate the environmental footprint of an average patient in the intensive care unit and the inpatient wards. Literature review, site observations, utility records, direct measurements, waste audits, and interviews with hospital staff were utilized to quantify the life cycle emissions of medical care. Based on preliminary research and data, it seems that the energy utilized for lighting, heating, ventilation, air conditioning, sterilizing equipment, and monitoring patient health along with the production of disposable materials and single-use equipment are significant contributors of environmental emissions [1]. Further research and results will indicate where and how hospitals can make changes to reduce their overall environmental footprint.

The US helps to set the standards for healthcare worldwide. Thus, improvements in its system will lead to more sustainable healthcare sectors internationally. Even though only a limited amount of research that provides quantitative, sustainable solutions exists, results can be compared to a similar study that has been conducted in the United Kingdom to arrive at more environmental friendly practices [3].

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COMPUTER SCIENCE AND COMPUTER ENGINEERING

CREATING VISUAL INSTANCE LEVEL AND GLOBAL EXPLANATIONS FOR MACHINE LEARNING MODELS

Recent advancements in machine learning have allowed for the creation of models with great predictive accuracy in a variety of applications. However, the complexity of such models make understanding and interpreting them difficult, and it is often the case that neither the trained model nor its individual predictions are readily explainable. This poses a considerable problem for work concerning high-risk datasets and sensitive decisions where reliance on only the model's output is not feasible. Fields such as medicine require understanding the underlying logic behind each prediction as every decision can have serious and longstanding implications.

Similarly, even with their great potential, complex machine learning solutions are struggling in finding widespread acceptance in the financial industry where the lack of explainability makes it hard to fulfill regulatory requirements. To incentivize research in this area, FICO has launched a challenge with a real home equity credit data set where the objective is to create models that are both accurate and interpretable, in which we will be participating with this project.

While white-box analysis techniques that allow for straightforward human interpretation are available, they are usually limited to simple models that cannot achieve the accuracy of more complex ones such as Support Vector Machines (SVMs) or Deep Neural Networks (DNNs).

Our project takes a wider approach which considers the model as a black-box. By combining local instance level explanations and a global model interpretation we are creating an interactive web application to visualize the logic behind each decision. The solution identifies the most important features contributing to a decision and suggests the minimal set of changes needed to alter the model's output. This is done by systematically perturbing a sample instance and measuring the resistance to change against a predetermined threshold, and by altering the feature values through a greedy procedure.

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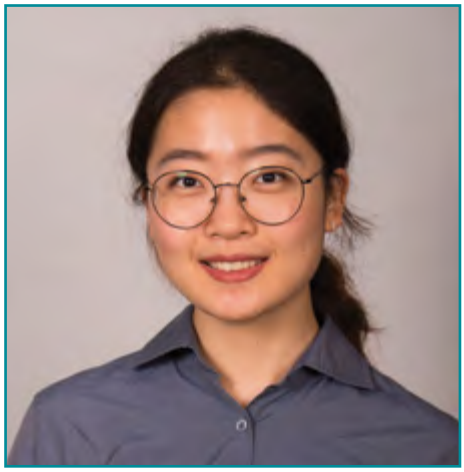

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VISUALIZING RESEARCH TRENDS VIA TEXTUAL ANALYSIS

Textual analysis is an area of data analytics that focuses on extracting information from sets of textual data to help people understand the true context or key ideas carried by these texts. With the vast amount of information that is being circulated around the globe, it has become nearly impossible for human beings to assess and categorize everything manually. Thus, many data analysts and researchers take advantage of textual analysis techniques involving machine learning algorithms to pre-process data for different types of analyses and projections.

In this project, we use textual analysis to design a method of visualizing research trends throughout time. We chose a set of Neural Information Processing Systems (NIPS) conference papers that range from years 1987 to 2017 to perform our research. In order to outline the most effective process of identifying main topics, we used the Rapid Automatic Keyword Extraction (RAKE) algorithm to obtain keywords and phrases from the documents and filtered these keywords using significant unigrams (obtained from 'significant terms aggregation' method provided by Elasticsearch). We created simple visualizations of our text data (number of documents containing a keyword, a relative "score" of the keyword, etc.) using Tableau to have an idea of what we may observe as the research progresses. We also transformed these keywords into vectors to determine the numerical relationships among these words and projected the vector clustering for further analysis.

We are currently creating a comprehensive visualization that captures not only the main NIPS topics determined by textual analysis but also the temporal trend of these topics using D3.js, a data visualization library in JavaScript. Through this research, we hope to design new visualization techniques for projecting changes in text over time given any set of textual data.

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DEVELOPMENT OF NOVEL FORENSIC ANALYTICAL TOOL TO MITIGATE CYBERCRIME

Cybercrime has become a growing threat in our increasingly technological world. To extract sensitive information, some cybercriminals exploit vulnerabilities in computer systems; others, exploit human trust.

Email-based scamming has been around for years and continues to succeed against unsuspecting targets. It may take years of emailing for a scammer to establish an online relationship, before repeatedly "borrowing" money from a love-struck target; it can take a single email posing as an organization's CEO to get an employee to frantically send corporate account information. The ease, speed, and relative anonymity of emails makes it a powerful online tool for scammers. Fortunately, for forensic investigators, these web-based conversations leave a digital trail.

The purpose of this study is to develop an interactive visual analytics tool demonstrating the temporal sequence of scam email threads and their keyword content. In collaboration with a federal agency and forensic investigation team, we obtained thousands of diverse email conversations between scammers and their targets. The analytics tool was designed and developed to assist forensic investigators in identifying behavioral patterns among scammers, in order to devise better countermeasures against their attacks. Further exploration of this data results in actionable outcomes: investigators can gain more insights to identify new categories of email scam types, deconstruct large criminal networks, and stop ongoing fraud attempts.

INDRA'S NET, AN AGENT-BASED MODELLING SYSTEM

Agent-based modeling is a form of modeling that simulates the interactions between agents that follow certain rules in an environment. For example, agent-based models can simulate economic patterns, social activities, natural phenomena and so on.

Indra's Net is an agent-based modeling system that simplifies the creation and execution of agent-based models, making the effort as little as a few lines of code for coders, or a few configurable parameters on a screen for non-coders. Indra's Net also offers a decent graphics output solution, which can be directed to a window or a webpage. In addition, Indra's Net also provides an easy-to-use parameter-loading solution, which supports parameter sources including terminal input, prebuilt property files, and environment variables.

Indra's Net has a default hierarchy of models, so coders can easily create their models in the agent-based modeling system by inheriting the right classes and overriding a few methods. After the creation of models, coders can also make the models easy-to-use using the interface provided by Indra's Net.

Indra's Net also provides a series of built-in models, which can be easily customized with configurable parameters, so even non-coders can make their own models based on the default models.

In addition, a website using Indra's Net in the background is an easy-to-use interface to experience the powerful functionality of this agent-based modeling system can be found here: indrasnet.pythonanywhere.com

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ANIMATED ALGORITHMS

"Algocynfas" is a project that aims to create self-graphing algorithms. By applying HTML5 's 'Canvas' element and making use of JavaScript library "Fabric" and "Sigma", the project can visually demonstrate various sorting algorithms, graphing algorithms and data structures. In this project, the newest software-developing concept from DevOps is being implemented to get continuously development; version control is used to release new functionalities to the user's interface.

For pedagogical purposes, the user library is closely built upon *Introduction to Algorithms* also known as the CLRS algorithm book. Students will be able to compare the pseudo codes in the CLRS with the actual java script codes while they are watching an animation of certain algorithm. Also, in order to let students experiment, not only are sample input values offered, but customization input value in an acceptable range is also allowed. This will facilitate students to study from various cases, and therefore understand the working principle of algorithms better.

For further applications, Algocynfas is an open source project on the Internet. Its HTML pages are implemented by a include facility, which makes it easy to be pulled into other people's webpage for further use. Moreover, Algocynfa's bottom-up design allows other users to reuse codes and libraries to facilitate the animation of their own data structures and algorithms. Also, the project has potential to become a useful library for the presentations of various algorithm designs.

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ASSEMBLY LANGUAGE EMULATOR

Emu is a multi-language assembly language emulator used as a learning tool to introduce students to assembly language. The project focuses on designing an easy-to-use web-based assembler for students so that they do not need to learn command line assembler and debugger tools. Emu was originally designed to interpret the Intel x86 assembly language, but after making improvements, it can interpret Intel x86, AT&T x86, and MIPS assembly languages. Emu adapts to the assembly language the user selects on the home page through the virtual machine that is thrown back and forth between the server and the client. Because MIPS runs on a different chip from Intel and AT&T, MIPS uses a different virtual machine. Upon running code, the code is analyzed for keywords that pertain to the specific language selected. Sample programs and instruction guides are created for the students to experiment on their own. Students can view the changes made by the programs by looking at the values stored in the register and memory displays. Python's unit testing framework is used to test programs that are written in various assembly languages, matched with their corresponding virtual machines. In addition, error tests are written to ensure that the emulator can report back the error to the user. Highlighting instructions while stepping is implemented and generating alert messages upon encountering an error are implemented using Javascript to guide users. Emu will continuously improve to allow for other assembly languages, such as RISC-V.

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RELATIONSHIP BETWEEN DEMOGRAPHIC CHARACTERISTICS, HATE CRIMES, AND DISCRIMINATION DETERMINED USING SS-SOM

There is a growing understanding in social sciences for a need to characterize social processes like racism and homophobia using contextual boundaries so as to assess their effect on the hate crime rate and determine the demographic factors affecting it. Traditionally, measuring the prevalence of racism and homophobia has been difficult, hence, researchers have created different machine learning models to determine racism and homophobia attitudes from social media such as Facebook, Twitter, Instagram, and create homogeneous regions that capture the prevalence robustly.

Socio-spatial-Self organizing map, "SS-SOM", is one such model which uses artificial neural networks for classifying text and generate a controlled number of non-overlapping, topologically-constrained and topically-similar clusters. SS-SOM first classifies Tweets into racist versus non-racist and homophobic versus non-homophobic Tweets. Then, the target city is divided into grid cells, the geo-location of each Tweet is used to map Tweets to the cells, and the prevalence of racism/homophobia in each grid cell is normalized. Finally, an augmented version of SOM algorithm is used to cluster topically and topologically similar grid-cells.

We build upon this work to find relationships between demographic characteristics, hate crimes, and discrimination determined using SS-SOM using linear regression. We map the demographic data (from Zip codes), hate crime data (from precincts) and discrimination data (from SS-SOM clusters) to grid cell level to facilitate linear regression of different parameters at same spatial resolution. We expand this study across multiple cities to determine whether hate crime rates and the prevalence of racism/homophobia, confounded by certain demographic characteristics, are correlated or not.

▲ Zhengyi Li is analyzing the demographics of discrimination on social media and determining whether a correlation to hate crimes in those areas exists.

NEW TYPES OF COMPUTING

Neural networks, a common model for machine learning, consist of interconnected nodes modeled after the neurons in the human brain. The network is designed to learn by adjusting the mathematical relationship between the nodes until it can predict the correct outcome for any given input. Traditionally, neural networks are implemented in software, running on microprocessor chips or on graphical processing unit chips (GPU chips). However, neural networks can also be implemented in hardware, running on custom or reconfigurable chips with faster speed. As custom chips are expensive and not flexible, our research project will focus on using reconfigurable chips (field programmable gate array chips, FPGA chips) to implement a neural network.

In this project, our neural network identifies handwritten characters. Both the network and the training algorithm are implemented on an FPGA board. Data points used in training are sent to the FPGA board via serial communication. Users can test the network by writing characters on a touchscreen. The FPGA board collects the pixel data and processes it through the network to determine the written character. The output of the network is displayed as an ASCII character on the display. The goal of our research is to explore the potential for accelerating training of a neural network using reconfigurable hardware, as opposed to the traditional software implementations. In the future, we wish to extend our implementation to other common applications such as facial recognition.

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AN ANALYSIS OF FACEBOOK'S POLITICAL AD ARCHIVE

Facebook launched their searchable archive of U.S. advertisements with political content on May 24, 2018. According to Facebook: "The archive includes Facebook and Instagram ads that have been classified as containing political content, or content about national issues of public importance." This archive provides an increased level of transparency of political ads on Facebook and Instagram. We perform an initial analysis of Facebook's archive of ads with political content that primarily span eight weeks from May 2018 - July 2018. We have collected these ads from Facebook's archive which likely represent a subset of all ads contained in the archive by performing daily scrapes. Through our analysis of over 100,000 ads with political content, we show how candidates, elected officials, PACs, non-profits, for-profit companies, and individual citizens are disseminating U.S. political content using Facebook's advertising platform. We registered an account on Facebook and started reverse-engineering the AJAX calls that Facebook uses to search their political ad archive and request detailed information for a set of ad identifiers. We have created and made public a separate Python script that extracts key information from the JSON like replies and inserts it into our database. Our database is also publicly available and is a mixture of directly scraped political ad data from Facebook.

▲ Shikhar Sakhuja analyzes Facebook's searchable archive of advertisements to determine how officials, citizens, and companies are spreading political content on Facebook's advertising platform.

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DEEP DEFENSE

In the last 10 years, machine learning has become mainstream. There are various reasons for this, among them are the increases in computing resources, data availability and the popularity of neural networks. Though Neural Networks can perform amazing tasks; such as recognizing tumors in medicine, creating convincing conversation and even driving our cars there has been relatively little thought towards how to protect these systems from malicious changes in a real-world environment. Our research takes two existing published works: DeepXplore, which checks which neurons of a neural network are used in accomplishing a specific task and FinePruning, which removes unused parts of the network to reduce the surface area for attack, and turns them into a scalable service. This service could be used by anyone to evaluate Deep Learning model vulnerabilities. Our service will also make recommendations on which areas of the model need to be removed in order to make it more secure.

▲ Ian Butler is protecting machine learning by researching ways to defend networks against malicious attacks.

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USING THE GO PROGRAMMING LANGUAGE TO TEACH DISTRIBUTED SYSTEMS

As online computing has become ubiquitous, web developers have new challenges in building web applications that scale to meet increasing user demand. The most common way to meet this user demand in industry has been the use of distributed systems. Distributed Systems allow user load to be shared across a cluster of many servers, as well as increase redundancy to protect against server crashes. However, running a single application across many servers introduces substantial complexity. One of the most complex problems that needs to be solved in distributed applications is of achieving consensus among all nodes. Consensus algorithms are designed to keep the data amongst all the servers in the cluster consistent, while also being resilient to server crashes.

The original and most prevalent consensus protocol, Paxos, is notoriously complex and its architecture is not particularly well suited for the web application use case. Modern protocols, such as Raft and Viewstamped Replication, are simpler and more explicitly described allowing for a more faithful implementation in practice. In either case, learning these algorithms in a classroom setting can be difficult since they cannot be implemented independently of an application which adds additional overhead to the implementation process.

Our project aims to simplify the learning process of consensus algorithms for distributed applications by providing a framework for students to learn each of these consensus protocols. Students can use this framework to focus on the specifics of the various consensus protocols, independently of the the application infrastructure, which will aid in the education of distributed systems.

TAREK HASSOUN

BS Computer Science 2020

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Other Mentor
Ryan Rozbiani

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U•START—CREATE TOGETHER

U•START is a creation platform, helping connect students showcasing projects, ideas, businesses, and various other professional interests in and out of STEM related fields. Similar to other career-oriented platforms, U•START offers a way for students and graduates to present their portfolio, talents, and various experiences on their own personalized profile page for our students to see. They can then connect and work on various projects, chat, and attend/host professional events. Over the course of this Undergraduate Summer Research Program here at Tandon, we are working with the U•START team to finish the website platform.

Our work involves working on the website platform as well as the application platform for U•START. Through the on-hands work opportunity, we are able to grasp the fundamentals of working in a professional software environment as well as the basics of web and app development. Our work ranges from adding new features, initializing server side connections, creating web page designs, reinforcing security, and many other software development product based tasks.

The U•START application and website platform were developed using Golang, an open source programming language created by Google whose language design is very similar to the of C. Although it is still a new language, its rich library and documentation allow for a user-friendly experience that allows for a lot of flexibility. In addition, U•START runs with Elasticsearch which is a NoSQL document based database. Since it is able to handle real-time server/user requests very efficiently, it's our preferred tool for a creation platform as intensive as U•START. By the end of the summer, we are hoping to finalize the U•START product on all fronts and to have it actively running on the world wide web.

VICTOR ZHENG

BS Computer Science 2019

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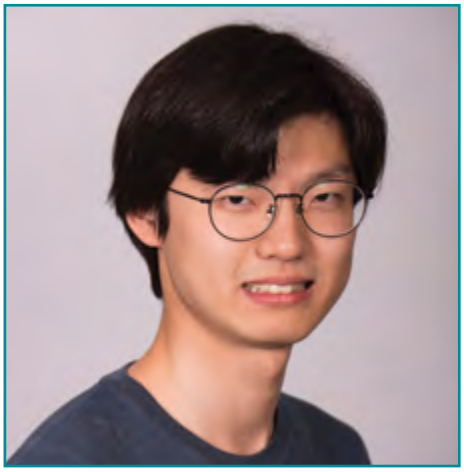
INDEX TIERING TECHNIQUES FOR SEARCH ENGINES

When a search engine such as Google receives a query, it needs to search through a collection of trillions of websites and documents before returning a list of relevant results. On top of that, search engines must deal with processing billions of queries per day. That being said, the systems are heavily loaded, and can cost many millions of dollars per year to run. Thus, for this reason, research is being conducted to make search engines more effective. This is done by making it more efficient to return results (throughput) and by satisfying customer needs (relevancy and latency).

One approach to this problem is to break up the collection into tiers. In a two-tier situation, the first tier is smaller and will contain documents with higher scores than those in the second tier. Document scores could be based on the number of previous queries the document is relevant to. Say for example, tier 1 has 100 documents and tier 2 has 900 documents. Since tier 1 contains documents that are relevant to most queries, there could be times when it can cover enough results for a query without the need of going to tier 2. This means that in some cases, the engine could avoid searching through 90% of the collection.

There are two main problems in tiering. The first is being able to effectively assign documents to each tier. The other is being able to route the queries to obtain satisfactory results. The focus of this project will be on the second problem. After searching through tier 1, the results may not be relevant enough for the user, hence tier 2 needs to be searched. But, how does one draw the line for this? To answer that, research will go into building an efficient machine learning model that will take in a combination of features to devise an effective policy for deciding the need to search in tier 2 for a given query.



MINGYANG WANG

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LOAD BALANCING AND QUERY ROUTING PROBLEMS IN PARALLEL SEARCH ENGINES

Large search engines like Google handle tens of thousands queries per second and that translates into billions of searches per day. Facing such extensive workload, search engines execute these queries by parallelizing them across hundreds or thousands of machines. In order to achieve this parallelization, the terabyte-sized document data of all the indexed webpages are partitioned into shards, and replicas of these shards are assigned to machines. When queries arrive, they are routed to shard replicas under various polices to satisfy service level agreements (SLAs) that place limits on the quality and latency of the results delivered. Given that machines have varying processing powers and that each query might consult different numbers of shards resulting in different workloads, load balancing heuristics leverage these conditions and make decisions on which shard or machine a query should be routed to, which query should a machine or a shard execute first and more.

In this project, our goal is to propose, analyze, and experimentally evaluate new load balancing policies that achieve high throughput while satisfying a given SLA in a selective search architecture (a setting where documents are split into shards by topics, and queries are only routed to a few shards that are the most relevant) with discrete event simulation. We first implement a number of different queues for searching and merging on a machine level, and then run simulations against large query logs to investigate how these different implementations impact tail latencies and throughput. We then explore the performance of machine-load-aware query routing policies enhanced by query running time estimations. Finally, we evaluate ways of enforcing SLAs using these mechanisms.

YUHONG ZHANG

BS Computer Science 2019

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Michal Siedlaczek

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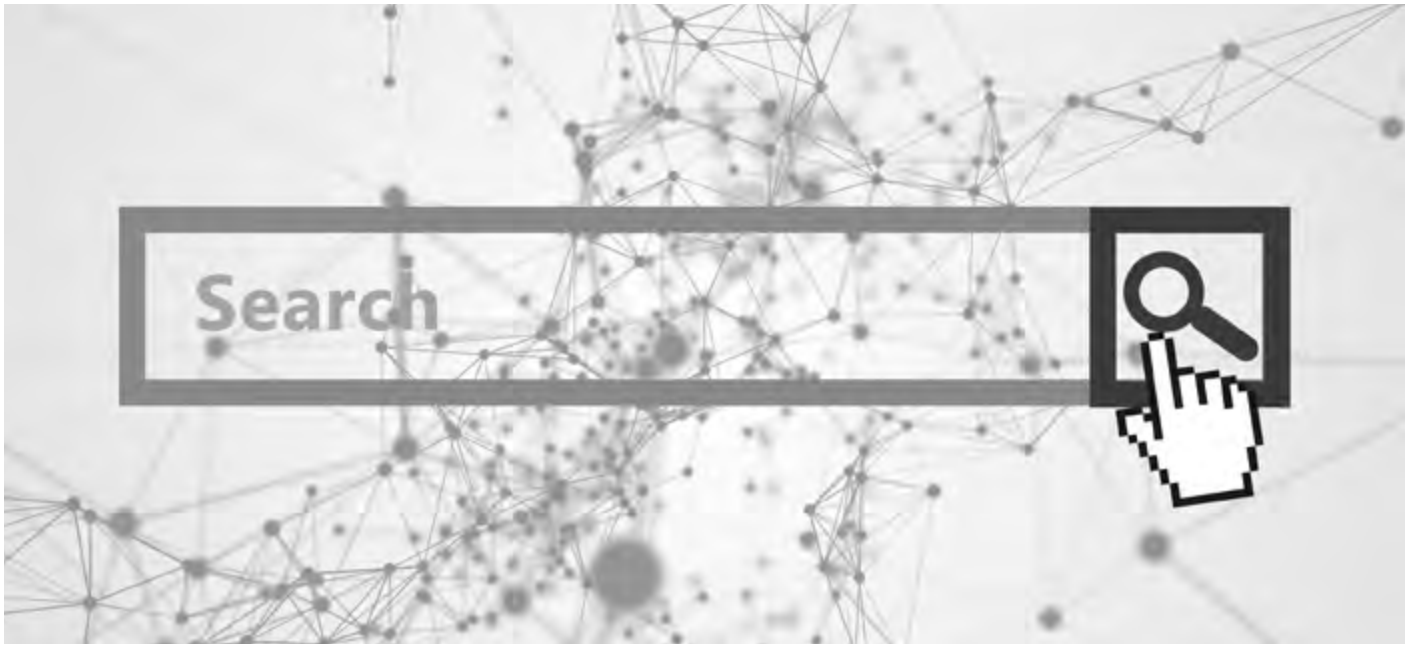
SIMD-ALGORITHMS FOR TOP-K SEARCH QUERY PROCESSING WITH LARGE K

Modern web search engines apply hundreds of complex features to determine which results to return to a user. However, applying such complex ranking functions to all potentially relevant documents would be very costly. For this reason, in a very first step a relatively simple and fast ranking function is applied to obtain a few hundred or thousand candidate results for reranking with the complex ranker. This first step is modeled as a top-k query processing problem, where the highest ranking k results need to be retrieved. A common-sense approach is to exhaustively scan every posting list which contains at least one term of the query, accumulate the scores, and select the top-k results. However, to make this more efficient, a lot of research has been focusing on designing Early Termination (ET) Algorithms that retrieve the k highest scoring results without an exhaustive scan, by skipping or ignoring some parts of the index.

Several safe ET algorithms have been designed to improve the performance of top-k search query processing, and proved to be especially effective on small k such as 10 or 50. But studies showed that when k goes up to 100, 1000, or even higher, the performance of these ET algorithms declines significantly, such that eventually the brute-force approach becomes the better choice. The goal of our research is to challenge this claim, and to design an ET algorithm that works well even for large values of k.

In this research, we start from the idea of an existing Block-Max algorithm to use a co-called live-area approach. We test the performance of the algorithm on different k values to explore its performance decline as k increases, and combine it with the original exhaustive Term-at-a-Time algorithm to seek a solution for large k query processing. The SIMD commands available in the current generation of Intel processors might be further adopted to achieve additional improvement.



▲ To improve the capabilities of web search engines, Yuhong Zhang is designing an early termination algorithm that is effective for large values of k.

ELECTRICAL ENGINEERING AND COMPUTER ENGINEERING

YANG YANZHI

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DESIGN AND IMPLEMENTATION OF AUTONOMOUS CAR USING RASPBERRY PI

Autonomous cars are going to revolutionize people's daily life in the near future. Google, Tesla, Uber and prominent startups have made extensive effort to develop robust and smart autonomous cars using advanced technology, such as machine learning and Internet of Things (IoT). In short, the most crucial components for an autonomous car to guarantee safety consist of perception, decision and control. The perception module gives the car the critical information from the road, such as detected lane, other cars and pedestrian. The decision module then instruct the car what to do. Finally, the control module completes the instruction by proper maneuver. In this project, we implement all three steps using a Raspberry Pi car as the platform. For the perception module, a Pi Camera is programed to function as the eye of the car, which can provide necessary data from the real world to the car. Then, lane detection can be achieved by computer vision techniques, e.g., Polynomial Fitting and Hough line transformation. The perception module can output a variety of lane information, such as car relative position to the lane and its orientation with respect to the road. Given the proper lane information, the autonomous car will decide the next action, such as lane keeping. In order to accomplish this task, the car needs to be controlled to follow the lane centerline. For our control module, a data-driven learning process is designed and implemented for the car. After a trial and error process, the car is capable of efficiently and robustly keeping itself in the middle of the lane by adjusting its orientation and speed.

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BS Electrical Engineering 2019

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DEEP NEURAL NETWORK SYNTHESIS FOR CONTROL OF AN UNMANNED GROUND VEHICLE IN UNCERTAIN ENVIRONMENTS

It is desirable for an autonomous robotic vehicle to determine its trajectory given the current information about its surroundings. This navigation task is achieved through processing the sensory data to estimate the positioning and provide commands that alter the position. While it is possible to construct a controller using specifically crafted features to determine velocity and heading commands, the resulting controller may not fare sufficiently well with given features in uncertain, unfamiliar environments. With the advent of faster computing and improved algorithms, it is possible to take a learning-based approach with miniature, on board computers: utilizing deep neural networks on portable low-power graphical processing units (GPUs), the controller can be made to select the features it requires given the environment, generalize the navigation task in foreign settings, and adapt itself to the changes as needed. The goal of this project is to achieve autonomous navigation in uncertain environments for a differential-drive unmanned ground vehicle (UGV). Specifically, the project delves into the indoor navigation in a corridor setting. The velocity command is generated based on the LiDAR sensor's range image output, while the heading is determined through a deep neural network that fuses camera and LiDAR imaging data.

ROHAN CHAKRABORTY

BS Computer Engineering, MS Electrical Engineering 2019

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Prashanth Krishnamurthy

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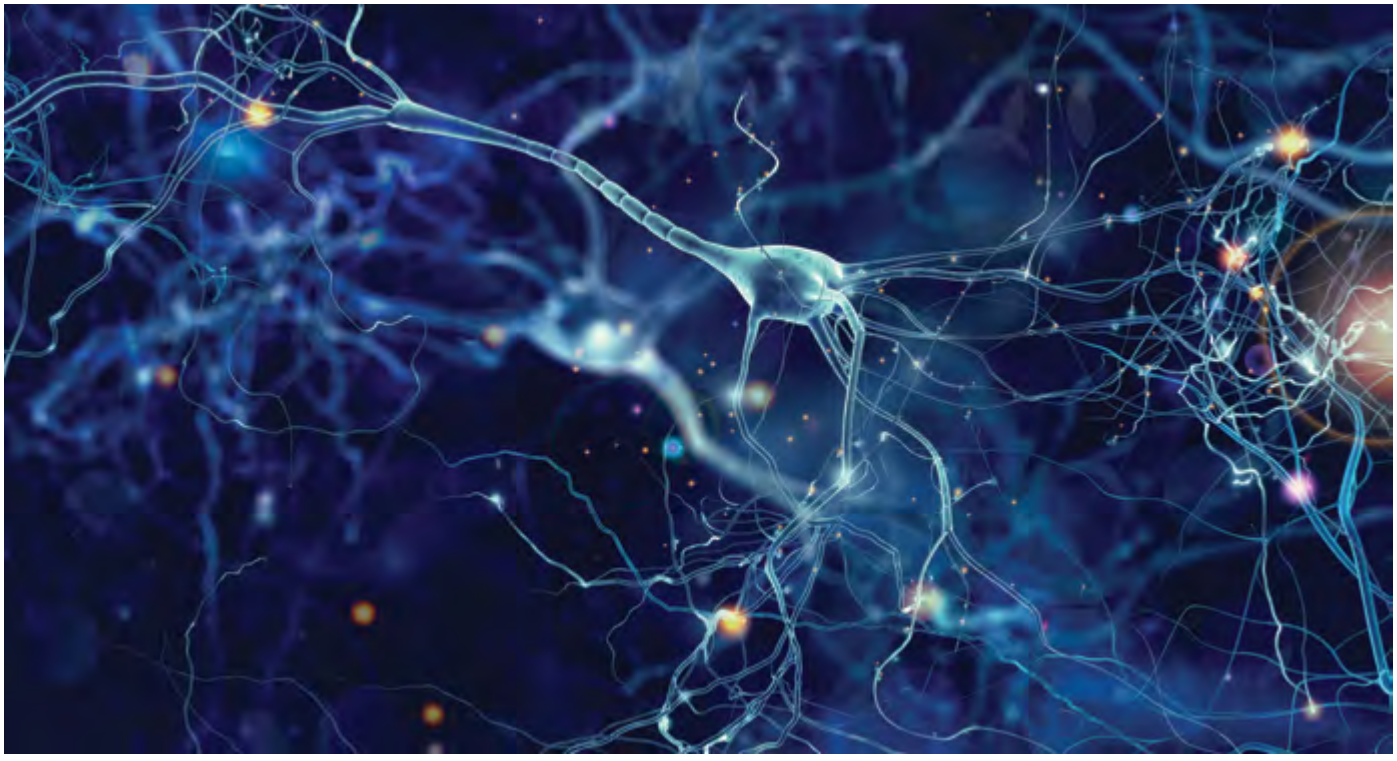
MIMICKING A MOTION PROCESSING LIBRARY WITH DEEP NEURAL NETWORKS

Modern inertial measurement sensors based on MEMS technology require on board processors and dedicated processing libraries implementing large and sophisticated sensor fusion techniques to yield rigid-body rotations and states. An artificial deep neural network (DNN) can potentially learn such a sensor fusion algorithm given the inputs and outputs of the processing library. This project aims to mimic a proprietary black-box motion processing algorithm by leveraging the self-learning capabilities of DNNs. The MPU-9150 is an inertial measurement unit (IMU) that is used along with the Invensense Motion Processing Library (MPL) to generate 3 axis angle and angular velocity measurements. DNN architectures are trained on the raw IMU data extracted from another IMU sensor (the LSM9DS0) and mapped to the MPU yaw, pitch and roll outputs. For this purpose, an auto-encoder like DNN architecture is utilized to map a time sequence of raw IMU values to the yaw, pitch, and roll angles that are most likely to occur at the end of the time window. This allows the DNN to learn the unknown internal sensor fusion algorithm that has been implemented on the MPU's motion processing library and produce outputs with the LSM's raw data that have an accuracy similar to that of the MPL.



▲ Rohan Chakraborty analyzes deep neural networks to determine if they can mimic, and potentially replace, motion processing libraries.

YUXI LUO

BS Computer Science 2020

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Yao Wang

Other Mentors
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Mei Fu

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A KINECT-BASED, IN-HOME EXERCISE SYSTEM FOR LYMPHATIC HEALTH AND LYMPHEDEMA INTERVENTION

Using Kinect sensors developed by Microsoft to provide feedback and monitor patients' performance for rehabilitation exercises is becoming popular in health-care area. However, in some cases the standard of evaluation of their movement is hard to develop, due to variation of movements and the difficulty to track certain exercises. This project develops a prototype system for guiding patients to reduce the risk of lymphedema after cancer surgery, or manage the development of lymphedema, or help relieve pain or discomfort related to breast cancer treatment and lymphedema. The prototype system teaches a set of lymphatic exercises to improve lymphatic health and to reduce the risk of lymphedema, and provides relevant feedback when patients perform an exercise in real time. In order to better guide patients to learn and perform exercises, the system includes 4 modes: Instruction with Text Mode to check important notes before performing exercises, Training Mode to warm up and get used to the prototype system, Evaluation Mode to perform exercises and receive real-time feedback, and History Log Mode to review patient's own historical performances with respect to ideal data. In particular, this project will significantly improve the user interface of the prototype system and incorporate several new features.

ZHANGHAO CHEN

BS Computer Science 2019

Suzhou High School
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Faculty
Quanyan Zhu

NYU Shanghai

AUTOMATIC GENERATION OF CONTEXT-SPECIFIC FAKE REVIEWS

Fake reviews are a major threat to online review systems by spreading misinformation. Malicious crowdsourcing forums are currently the major sources of fake reviews, but are limited by the cost of hiring and managing human labors. Recently, with the development of natural language generation (NLG) techniques, large-scale and low-cost fake review generation is made possible. However, existing methods lack the ability to generate context-specific reviews, and is therefore easy to be detected.

This project aims at developing a mechanism to automatically generate context-specific fake reviews. We propose to use a recurrent neural network (RNN) facilitated with the generative adversarial network (GAN) architecture to generate coherent and diversified fake reviews. To address the problem of context-relevance, we introduce an attention-based context encoder network to make the generated reviews relevant to the given contexts. Generated reviews are compared with that generated by RNN-GAN generators without context decoder and traditional RNN generator. This establishes a better understanding of the possible future attacks towards online review systems and helps us be better prepared for defending against such attacks.

If time permits, we will go on to develop a detection mechanism against this type of attack. The discriminator itself in the trained GAN is itself already a good detector of the attacks. Even if we do not have access to the attacking model, we can train a generator to fit the pattern of the observed fake reviews, and adversarially train a detector. Moreover, we can utilize multi-channel information like the reviewer's behavioral pattern to facilitate the detection of such attacks.

RUNDONG CHEN

BS Electrical and Computer Engineering 2019

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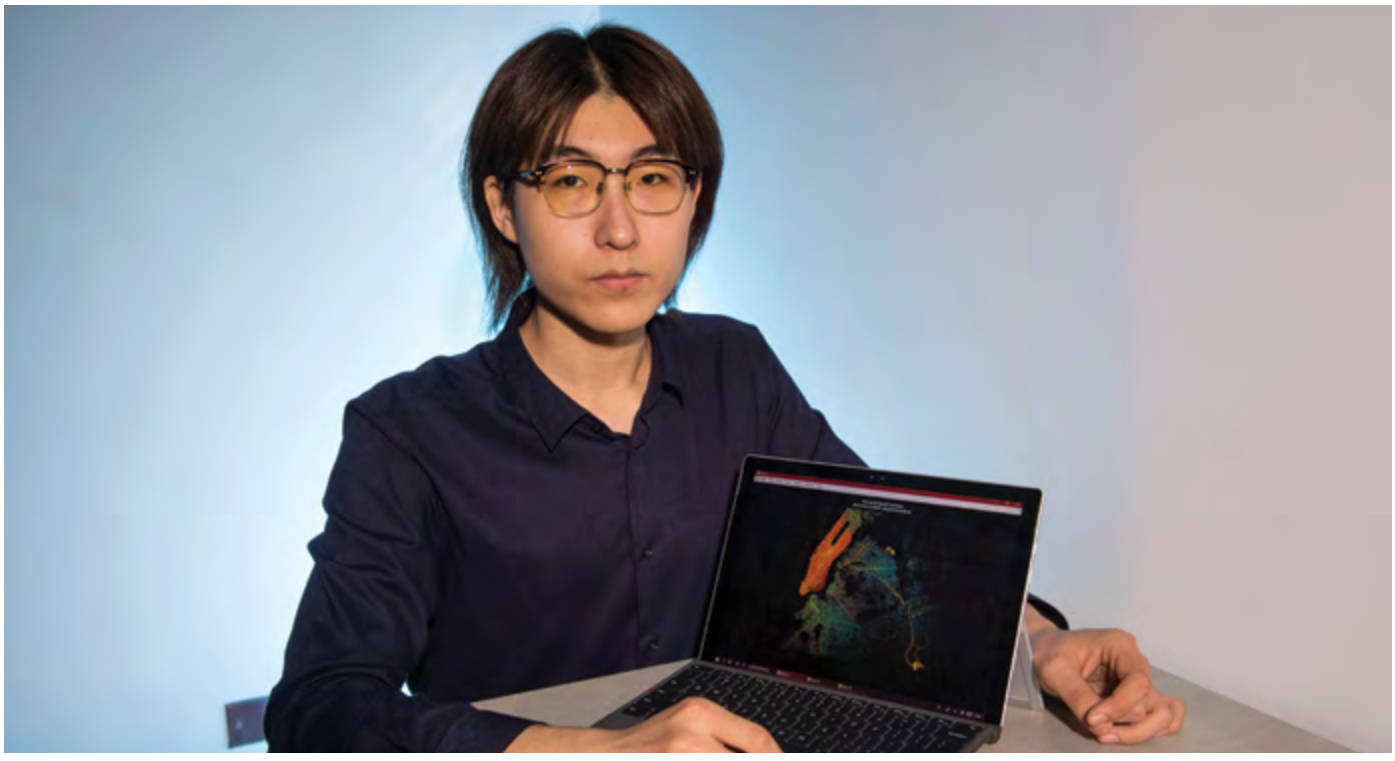
Faculty
Quanyan Zhu

Other Mentor
Junaid Farooq

NYU Tandon School of Engineering

AUTOMATED PICKUP DECISIONS IN AUTONOMOUS TAXIS: A REVENUE-MAXIMIZING MECHANISM DESIGN APPROACH

Self-driving cars have become increasingly popular in recent years due to the great advantages they bring us, such as reducing the number of traffic accidents and improving fuel efficiency. Advancing technology has made it possible for autonomous cars to emerge in real life applications. Companies like Uber and Lyft are investing heavily in autonomous taxi services to eliminate driver fees/premiums to increase profits. Centralized taxi allocation in response to massive customer requests may be difficult to accomplish in real time, so automated pickup decisions are preferable in such autonomous taxi setups. For online pickup decisions, we need an optimal decision-making mechanism to select passengers to pick up in a revenue-maximizing manner. To accomplish this, we develop a sequential search-based decision framework using statistics of pickup locations and times in NYC. Past taxi transaction data from New York City Taxi and Limousine Commission (NYC TLC) is analyzed to generate statistics of fare, trip distance, trip duration, pickup distance, and some additional quantities, such as surcharge, toll, passenger count, etc. From these historical statistics, a dynamic threshold (or reservation price) can be generated by the framework given the current time and taxi location whenever a pickup decision is required. Based on the threshold value, a taxi can decide whether to choose from currently available requests or to wait for a more desirable one to appear. The effect of the current trip destination on future trips will also be considered to further improve the performance and reliability of this mechanism.



▲ Rundong Chen is analyzing data from New York City's taxi network to develop a framework for autonomous taxi pickups.

JIN SHANG

BS Math/Computer Science 2019

Harbin No.3 High School
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Junaid Farooq

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ONLINE TRANSMISSION MECHANISM DESIGN FOR WIRELESS IOT SENSORS UNDER POWER SAVING MODE

The Internet of things (IoT) comprises of wireless sensors and actuators connected via access points to the Internet. Often, the sensing devices are remotely deployed with limited battery power and equipped with energy harvesting equipment such as solar panels. These devices transmit real-time data to the base stations which is used in detection of other applications. Under sufficient power availability, wireless transmissions from sensors can be scheduled at regular time intervals to maintain real-time detection and information retrieval by the base station. However, once the battery is significantly depleted, the devices enters into power saving mode and is required to be more selective in transmitting information to the base station (BS). Transmitting a particular piece of sensed data will result in power consumption while discarding it might result in loss of utility at the BS. The goal is to design an optimal dynamic policy which enables the device to decide whether to transmit or to discard a piece of sensing data particularly under the power saving mode. This will enable the sensor to prolong its operation while causing minimum loss of utility of the application. We develop a mathematical model to capture the utility of the IoT sensor transmissions and use tools from dynamic programming to derive an optimal real-time transmission policy that is based on the statistics of information arrival, the likelihood of harvested energy, and the availability of the wireless channel.

▲ Jin Shang is developing an optimal dynamic policy that enables a device to determine whether to transmit or discard individual pieces of data while in power-saving mode.

FUTURE LABS

RAIZY COHEN

BS Computer Engineering, MS Electrical Engineering 2019

Yeshivah of Flatbush
Brooklyn, New York

Faculty
Kurt Becker

Other Mentor
Terry Kim
Glenn McClanan

NYU Tandon School of Engineering

HELEOT

Heleot is a startup based in the NYU Veteran Future Labs in Industry City, which aims to improve upon the internet product review system. The goal of Heleot is to make relevant information about products accessible. When looking to buy a new product, a vast majority of consumers turn to online research, specifically product reviews. Traditionally, these have been in the form of written reviews on popular e-commerce websites. Despite the fact that video consumption has increased exponentially in recent years, the online reviewing system has not advanced at that same pace. Video reviews posted online are often long and unengaging. Internet reviews are often unreliable or biased. It is hard to find trustworthy reviews, as customer experiences are often sullied by bad customer service or late delivery. There is also a five-star system which emphasizes the customer experience, which is varying, over the user experience, which is typically uniform. Heleot is a web platform where users can upload 30 second video reviews. The videos are limited to half a minute so that users who are looking for input on a product can get concise information about user experience and other facts relevant to their purchasing decisions. People who watch reviews can also post questions for the reviewer to answer or follow them to get updates on how the product functions as time passes. It is community-based, so that people can watch reviews left by their family, their friends, or influencers whom they trust.

▲ Raizy Cohen is working with Heleot, a web platform that enables consumers to make more educated decisions when purchasing products.

SASHA CHOWDHURY

BS Integrated Digital Media 2020

Stone Bridge High School
Ashburn, Virginia

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Kurt Becker

Other Mentors
Hannah Donovan
Anton Marini
Genevieve Patterson

NYU Tandon School of Engineering

IIIE Fellowship 1: Trash TV Residency

VIDEO ONTOLOGY RESEARCH

TRASH's software research will operate in the intersection of human-computer interaction, computer vision, and computational videography, to develop algorithms, representations, and data sets that allow consumer-grade devices such as smartphones, tablets, and commodity PCs to understand video and generate narrative video sequences. More specifically, this research emphasizes rich semantic embedding spaces, end-to-end trained multi-task neural networks, and large-scale data and their application to video manipulation, enhancement, and the ultimate goal of automated film editing.

The last five years have witnessed enormous advances in the state of the art in computer vision. The intertwined achievements of massive training datasets and deep neural networks have produced famous category-based classifiers. Such pretrained networks that recognize categories of objects like cat, dog, hair dryer, and categories of scenes like restaurant, bedroom, hiking trail from the kernel of TRASH's automated editing system. The goal is to further develop a taxonomical representation of consumer B–6 video that goes beyond the everyday categories available in off the shelf neural network solutions. The development of a host of classifiers, internally named "CinemaNet" defines dozens of film-specific concepts that are relevant to understanding video for editing purposes. The planned experiments will significantly grow that dataset to include more fine-grained cinematic concepts, visual concepts that are particularly relevant to video on social media, and a wider variety of semantic concepts relevant to understanding human emotion and reaction to film.

ZOE DU

BS Electrical/Computer Engineering 2020

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Carina Lee

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IIIE FELLOWSHIP 2: FUTURE LABS AT TANDON

The internship at Skopos Lab help me obtain some hands-on experience about jobs in the field of financial technology. The research project involves investigating companies and their perceived risk factors by reading about the company and then determining the level of relevance of a regulation on that business. I assisted the company to build datasets and algorithm to predict the pass and failure of current bills in order to provide the best available predictive analytics for policy-making and news events and their impacts on companies and financial markets. Besides, research on the topic like marijuana legalization is a good way to gain a broad view about policy-making and business. Users of products include top law firms (e.g. Sidley Austin), universities (e.g. NYU Law and Harvard Law School), government institutions (e.g. Hawaii Supreme Court), global investment banks and hedge funds.

MATHEMATICS

ZHENG FENG

BS Math and Physics 2020

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Other Mentor
Michel Lobenberg

NYU Tandon School of Engineering

EVALUATING THE EFFECT OF CLIMATE CHANGE ON CARBON SEQUESTRATION IN SALT MARSHES USING DATA FROM JAMAICA BAY

Blue carbon is the carbon stored in coastal and marine ecosystems such as the salt marshes of Jamaica Bay New York. These ecosystems sequester and store large amounts of blue carbon in both the plants and the sediments. The potential of salt marshes to sequester carbon is of increasing interest to climate researchers in the effort to mitigate global warming. It is important to understand the various environmental parameters and how they affect the ability of salt marshes to sequester blue carbon. Jamaica Bay is an area of New York with many salt marshes. The size of the salt marshes in Jamaica Bay has been shrinking for many years, in part due to its environmental vulnerability. This study uses various environmental parameters such as water quality and vegetation to investigate the correlation between the carbon concentration in salt marshes and the elements of climate change.

▲ Zheng Feng is analyzing the salt marshes in Jamaica Bay, NY, to evaluate the correlation of carbon concentration and the elements of climate change.

GABRIELA AVILA

BS Applied Physics 2020

Queens High School for the Sciences
at York College
Queens, New York

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Michel Lobenberg

NYU Tandon School of Engineering

*Thompson Bartlett Fellow

EVALUATING EFFECTS OF POLLUTION ON OYSTER RESTORATION IN THE HUDSON RIVER ESTUARY

Oysters were once as ubiquitous to the Hudson River, as pigeons are to the New York City sky. Oyster reefs once covered upwards of 200,000 acres of Hudson River basin, constituting nearly half of the world's total oyster population. However, by the early 20th century, there were no oysters left in the river, the culprits being overharvesting and severely polluted waters. The oysters were not only a reliable food source for the city, but also a natural filtration system for the river and coastal protection for the island shores. The potential benefits in the bivalves' return has led policy makers, researchers, restaurants, schools, and citizen scientists to collaborate and partner with organizations like The Billion Oyster Project and The Hudson River Foundation in an effort to restore the oysters. Yet, in its current state, the Hudson River is still nowhere near an ideal habitat. While the Clean Water Act of 1972 resulted in the removal of much of the toxic sediments that lay on the harbor floor, new pollutants still enter the estuary every day. This study seeks to investigate the effects of the Hudson River's major pollutants: Combined Sewage Overflows (CSO), the Indian Point Energy Center, coastally located Superfund sites, etc. on water quality and how they may affect growing oyster populations. Data from government agencies and citizen scientists will be analyzed using statistical methods including the Mahalanobis-Taguchi System (MTS), a multivariate diagnostic tool.

YIYUE LIU

BS Mathematics 2021

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Chengdu, Sichuan

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Lindsey Van Wagenen

Other Mentor
Michel Lobenberg

NYU Tandon School of Engineering

EFFECTS OF CLIMATE CHANGE ON HUDSON RIVER OYSTERS

Oysters are one of the keystone marine species that can balance a marine ecosystem by cleaning the water and absorbing extra CO2. The number of oysters in the Hudson River Estuary decreased dramatically in 20th century due to overfishing and pollution. Aiming to restore oysters to a sustainable population, programs like Billion Oyster Projects (BOP) and the Hudson River Foundation have put 25 million oysters in New York Harbor since 2010. These oysters have filtered 19.7 trillion gallons of water and removed 72,500 tons of nitrogen. The BOP aims to restore 1 billion oysters by 2035. To effectively restore oysters, it is necessary to investigate the different factors that affect their life. This research study will investigate environmental factors involved in successful restoration projects by analyzing the extensive data available from BOP and from other sources such as the Hudson River Environmental Conditions Observing System(HRECOS). Statistical methods, including the Mahalanobis-Taguchi System(MTS), will be used to analyze the data sets and determine the optimal environmental variables. Additionally, the Educational Global Climate Model (EdGCM), will be used to predict the effects that climate change might be expected to have on the oyster restoration project.

MECHANICAL AND AEROSPACE ENGINEERING

EUNHA (GRACE) PARK

BS Mechanical Engineering 2020

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MICROFLUIDICS-BASED CEREBROVASCULAR TESTING BED FOR ASSESSING PEDIATRIC STROKE RISK ASSOCIATED WITH ARTIFICIAL HEART DEVICES

Artificial heart devices for pediatric patients provide mechanical circulatory support, but the flow dynamics, in particular the differences of continuous and pulsatile flow, may not be biocompatible and advantageous for cerebrovascular structure and function. Disruptions to the brain blood barrier (BBB) caused by various flows and conditions could induce stroke. To assess the risk of stroke for artificial heart pump users, we can integrate the mechanical circulatory support to our 3D BBB microvessel device and compare pulsatile (physiological) and continuous (artificial) fluid dynamics. This is possible due to PDMS (Polydimethylsiloxane)-printed microchannels that support microneedles in a surrounding hyaluronan hydrogel. As a result, a 3D lumen can be templated within a 3D brain-mimetic scaffold to pattern endothelial cells and recreate a 3D BBB microvessel. By designing a 3D-printed well plate insert, oxygen and pressure levels for each microvessel device can be independently-controlled on a single-chip system for multiparametric and spatiotemporal control. Altogether, this 3D BBB testing system will create a high-throughput and physiologically-accurate analysis of BBB structural and functional changes in response dynamic flow and pressure profiles.

OLIVIA LEAVITT

BS Biomedical Engineering 2019

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Faculty
Weiqiang Chen

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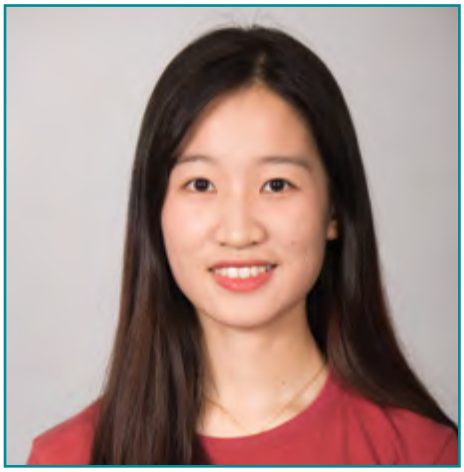
Worcester Polytechnic Institute

DEVELOPMENT OF STROKE-ON-A-CHIP MODEL FOR DYNAMIC MONITORING AND DRUG SCREENING

Stroke is the fifth leading cause of death in the United States, with 800,000 patients experiencing ischemic strokes annually. The gold standard models for the testing of stroke treatments are in vivo animal models, which can only provide a pre- and post-stroke visualization of the effects of various treatments. There are only limited human-based models to explore this in vivo and current in vitro models lack the capacity to integrate dynamic physiological parameters such as oxygen and fluid pressures. We propose creating a microfluidic device using relevant cell types to mimic the acute and post-acute effects of stroke on a cellular level in real time. Principal components of a stroke-on-a-chip would include: a brain analogue that includes nerves, glial support cells, and immune cells; a vascular network made up of blood vessel endothelial cells that can demonstrate post-stroke angiogenesis; and a blood-brain barrier. All of these components would be suspended in a hyaluronic acid hydrogel that mimics brain extracellular matrix. Stroke would be modeled by temporarily reducing the oxygen supply to the chip system, mimicking hypoxia in a real-life stroke. Cells could then be imaged both in real time under dynamic stroke conditions with calcium imaging of neurons, as well as post-treatment using immunocytochemistry for damage and repair markers. This device could eventually be used for high-throughput testing of treatments to advance therapies and improve rehabilitation after stroke.



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MECHANO-MODULATION OF CELL CONTRACTILITY TRANSMISSION DRIVES CANCER STEM CELL PHENOTYPE

Cancer cells with stem cell-like properties, termed 'cancer stem cells' (CSCs), play a crucial role in the aggressive nature of cancer by avoiding chemotherapy and establishing metastases. While it is broadly researched that CSCs display distinct properties and aggressiveness, identification of the cues that promote the CSC phenotype is yet to be deciphered. In this study, we investigated the crosstalk of mechanical cues in tumor environment and discovered that the imbalance of a bidirectional (intercellular and extracellular) transmission of cell contractility drives and measures the CSC phenotype. We found that micropatterned glioblastoma (GBM) cells that reside in peripheral regions showed elevated expression of the stem cell markers (Nestin, Nanog, CD133). Percentage of CSCs increased from the center to distal end of micropatterned GBM clusters. Finite element analysis and traction force microscopy showed an increase in sheet traction from the center to distal end of micropatterned GBM clusters. However, MSM analysis revealed a spatially opposite distribution of intercellular stress, indicating that an increased bias of cell contractility transmitting to ECM, but not neighbor cells. Collective cellular responses to selective perturbations of the intercellular and extracellular interactions conform distinct biomechanical regulation of CSC emergence. Overall, we examined the biomechanical attributes in the cancer microenvironment that contribute to the evolution of CSCs and discovered that the magnitude of the imbalance between extracellular and intercellular transmission of cell contractility measures the CSC phenotype in tumor. Our results may help to provide important insights into the origin and regulation of CSCs and develop cancer therapy.

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POST-PROCESSING EFFECTS ON ADDITIVELY MANUFACTURED PRODUCTS WITH EMBEDDED CODES

Additive manufacturing (AM), commonly known as 3D printing, has been gaining increased interest among the aerospace, automotive, medical, and even fashion industries in recent years. This technology is favored over traditional manufacturing techniques for its low labor costs, low assembly requirements, and high design freedom. However, the ease and benefits of adopting an AM system have also imposed several security concerns due to the nature of its digital process chain. Like other cyber-physical systems, the AM system is vulnerable to cyberattacks including, but not limited to, stolen intellectual property, design tampering, and reverse engineering. Taking steps to make this technology more secure will make it more difficult for people with malicious intent to cause severe damage.

The current research proposes the use of embedded identifying patterns in a 3D printed part to prevent counterfeiting reproductions. The identifying patterns are incorporated into the original product model such that it will be printed together with the part, allowing it to be used for authentication. The effects of post-processing, such as heat treatment, on these embedded codes are investigated. In addition, the effects of these embedded codes on the product's structural integrity are investigated by standard tensile testing procedures. These experiments will allow the carefully designed and embedded identifying patterns to survive post-processing treatments without sacrificing the product functionality.

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MODELING OF WIND POWER GENERATION FROM VORTEX SHEDDING OFF DELTA WING

Static aerodynamic devices can augment natural wind into more complicated flows. By carefully choosing the device geometry, natural winds of low power density can be used to create local vortices with high power density, which can be used to more efficiently generate power. A triangular flat plate known as a delta wing is a geometry that is known to shed two such vortices when introduced to moving air at an angle. This condition is modeled in the open source computational fluid dynamics software OpenFOAM. The thermodynamic properties of the air coming off the wing are then to be analyzed and optimized for power generation.

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COMPUTATIONAL FLUID DYNAMICS SIMULATIONS IN AEROSPACE ENGINEERING

CFD (Computational Fluid Dynamics) is a powerful tool that is used when governing equations are impractical (or impossible) to solve, or when physical experiments are too expensive or too dangerous. By giving engineers a better understanding of the physical behavior of a fluid, they can improve and optimize their designs. While there are several approaches to this topic, we focused on the finite difference formulation of the governing equations. This method has a mature mathematical basis and can cover a wide range of problems, from basic fluid flows to flow over entire an entire aircraft.

As an introduction, we considered the 1-D wave equation, which is a canonical problem in fluid physics. By simulating the behavior of the fluid with our own code, we were able to understand its behavior and predict what it will do in the future. We then considered more advanced problems, the planetary reentry problem and the flow over a delta wing. These problems required considering the Navier-Stokes equations. We used commercial open source software to perform these simulations. The ultimate goal is to develop a database of the flow field (i.e. to find the fluid velocity and pressure at every point in the domain). Practical questions can then be answered, such as what is the optimum reentry angle for a returning spacecraft, or what is the maximum circulation caused by flow over the delta wing. These, and other important design questions, will be considered in the future.

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3D GENERATION OF EMBEDDED IDENTIFYING CODES FOR ADDITIVELY MANUFACTURED PRODUCTS

With the additive manufacturing field expected to grow into a multibillion-dollar market by the year 2020, there is an ever-increasing need for security measures which can defend against cyber-attacks due to the nature of this digital process. “Automatic 3D Generation of Embedded Identifying Codes for Additively Manufactured Products” aims to protect product IP by embedding an identifying code within a product at the 3D modeling stage. The embedded code serves as an authentication measure when the product is made by the additive manufacturing process.

Current research focuses on the automatic 3D generation of these embedded codes for security purposes. This is realized by working with QR codes, for example, where image analysis is performed to analyze the code pattern and obtain information such as the relative position and dimensions of the QR code data. The information is then used to segment the QR code into a grid consisting of multiple unit cubes which are converted to 3D models in the standard tessellation language file format. The segmented code is then embedded into the product with varying depths for each cube. When viewed from a specific orientation, the correct QR code can be visible. However, the code pattern becomes faulty when viewed from other orientations. The embedded code provides a unique signature to the product, without compromising the functionality of the genuine product.

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DEVELOPMENT OF LIGHTWEIGHT POLYMER MATRIX COMPOSITE MATERIALS

With the recent growth in interest for additive manufacturing (AM), or 3D printing, because of its ability to manufacture parts that traditional manufacturing methods cannot, a subsequent interest in materials able to be used by a 3D printer has been created. Another area of recent development, syntactic foams, has been targeted as a potential material for 3D printing. Polymer matrix syntactic foams have been studied for their high strength-to-weight ratios, environmental and economic benefits, and low moisture absorption. Previous applications can be seen in marine vehicles, aerospace technologies, and sports equipment. However, the AM process can potentially cause defects in the material leading to the degradation of mechanical properties. This research project will investigate the influence of microparticle fillers on the mechanical properties of 3D-printed polymers. High-density polyethylene (HDPE) will be used as the matrix material of the composite, with glass microballoons (GMBs) as the filler. HDPE is not a common polymer for 3D printing due to its high coefficient of thermal expansion, but can be used nonetheless with optimized parameters. The compressive strength and modulus of the 3D printed samples will be tested for increasing GMB volume fraction, and compared to 3D-printed neat HDPE. Additionally, SEM and micro CT scanning will be used to compare the failure mechanism of the material and microstructural effects that the AM process has on the material.

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MODULUS PREDICTION AT VARIED STRAIN RATES

Characterization of polymer over a wide range of temperature and strain rates requires expensive and time consuming experiments campaign due to its viscoelastic nature. As a widely used testing method for viscoelastic properties on frequency domain, dynamic mechanical analysis (DMA) is underutilized due to the lack of correlation between frequency, temperature and strain rates. A simple transform has been established on isotropic material with single transition in the Composite Materials and Mechanics Laboratory.

The aim of this project is to expand the transform to the more complex media. Time-temperature superposition (TTS) principle is used to develop an extrapolation for the results beyond the test parameter range. For anisotropic material system, the model is established based on the viscoelastic theory and continuum mechanics theory. For multiple transition media, the addictive model could be built to automate the process. Then the TTS curve is transformed to a time domain relaxation function using integral relations of viscoelasticity. Finally, the strain rate sensitive properties on time domain is extracted and compared to the tensile test results. An open source software is developed to automate the process and let everyone enjoy the transform.

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RELATION BETWEEN A BIPED'S DESIGN PARAMETERS AND ITS BALANCING PROPERTIES

Bipedal robots are becoming increasingly popular due to their physical similarities to human beings. This similarity makes them popular across industries particularly in performing dangerous tasks. One of the greatest challenge in bipedal robots is in achieving the desired balancing properties with respect to its mechanical design. This requires extensive study and knowledge in the system's balancing properties as well as a detailed understanding of the complex interactions of the robot with its environment. And hence, we consider the necessary constraints that allow us to model a realizable system that is within the physical and system boundaries which can include the position of the centre of pressure and the frictional force experienced by the area of contact. In order to better understand the impact of these constraints on the balancing capabilities of the biped robot, we use optimization theories to determine the extent of the effects on the balancing properties due to various design choices. These results are verified by solving an optimization problem using the software package SNOPT. Based on the results obtained on a 1-Degree of Freedom (DOF) system, we then seek to extend and validate the results of a 2-DOF model, and finally on the model of the research robot, DARwin-OP. With this knowledge, the application can even extend to the improvement and design of exoskeletons and prosthetics with regards to their balancing properties.

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WIMDA—WEARABLE INTEGRATED DEVICE FOR MOTION DATA ACQUISITION

The purpose of this study is to design wearable device that is capable of measuring the body kinematics and foot contact forces for various subjects and gait types. The custom designed exoskeleton measures joint kinematics of both legs at the hip, knee, and ankle, obtaining the angle, velocity and acceleration, and foot insole foot contact forces with the ground and its center of pressure, during walking gait. Traditional foot contact force measurement tools are mainly force plates, which are limited to a flat and fixed surface and are expensive; however, the custom designed foot insole not only can be tested on any terrain conditions, but it also is low-cost. However, there is still more data analysis required for the calibration of the foot insole. Two different methods have been used for the calibration process: the force values obtained from the fsr are corrected based on area and phase coefficients. The phase-based correction seems to be reasonable, while area-based correction still needs more work. The exoskeleton hardware consists of six rotational encoders (HEDL-5640) with an accuracy of , eight IMU sensors (MPU-9250), attached on the upper body and the foot to track orientation of motion and linear acceleration values. With the experimental data from exoskeleton and foot insole, inverse dynamics is performed to calculate torque in each of the joints using an inhouse code developed at the Applied Dynamics & Optimization Lab. With the full gait data, better acknowledgment of human locomotion can be made outside the lab surroundings, testing different environment conditions and with fewer limitations. Future work requires validating the experimental data with accepted methods such as motion capture camera and force plate and performing experiments on wide range of people.

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SIMULATION OF THE 3D PRINTING PROCESS BY FINITE ELEMENT METHOD

In past years there have been incredible developments in the field of additive manufacturing due to its advantages of flexibility in changing or revising versions of a product, reducing production waste, and cost. These advantages make additive manufacturing an attractive option to many industries, especially in aerospace and biomedical applications.

This research addresses one of the most popular types of metal additive manufacturing known as metal laser melting. In the selective laser melting process, a thin bed of powder is laid down and a laser is used to melt specific portions of powder. This process is repeated layer by layer until a full part is formed. Conceptually this is a fairly simple process, but physically it is very complicated with multiple phase changes occurring and many different parameters affecting the process. Due to the complex nature of the process it can be difficult to obtain parts that are within required geometry and material property tolerances. One of the major reasons for build failure is the development of thermal strains that result from the transient nature of the melting process. When the part is no longer constrained these thermal strains result in deformations in the part and can cause cracks.

Finite element analysis is used to simulate the thermal loading of SLM and the resulting stresses and strains. The ability to adjust parameters in simulation provides insight that may help to improve the process and to obtain consistent and reliable results.

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SIMULATION OF THE 3D PRINTING PROCESS BY FINITE ELEMENT METHOD

Additive Manufacturing (AM), more commonly referred to as 3D Printing, has monopolized the news with its massive developments in almost every market, including automotive, aerospace, medical and even robotics. A recent breakthrough in the AM industry involves the association of syntactic foams with polymer filaments. Syntactic foam is plastic, stiff and strong, made up of tiny glass-encased air pockets that make it light and buoyant. Hence, the addition of syntactic foams in polymer filaments will not only decrease polymer density but will also increase polymer strength due to its material properties. However, to ensure homogeneity of the resulting polymer filament, uniform mixing of these syntactic microspheres within the polymer is essential. Therefore, addition of microspheres during filament preparation requires a lot of process control. Theoretical models are required to predict the best mixing controls, involving the mechanism, flow rates and volume for both phases, injection speeds etc.

The objective of this project is to devise a polymer-microsphere mixing technique that yields uniform composition of microspheres in the polymer. This project uses ANSYS Fluent, a software to investigate and simulate Computational Fluid Dynamics (CFD) research problems such as extrusion and molding in polymer processing. FLUENT is used for simulating the polymer-microsphere mixing mechanism and yielding theoretical results for composition of hollow particles within the resulting polymer. Each individual hollow sphere ranges from 0.04 mm to 0.07 mm in diameter. The mixing mechanism for these spheres is simulated through a 1.7 mm to 2.0 mm 3D printer nozzle for different case scenarios until uniformity is achieved. An example of a case includes simulating the polymer and microsphere flows through a helical static mixer and analyzing the composition of microspheres in the resultant mixed polymer. Similarly, mechanism is improved and revamped for the next case to yield increased homogeneity of the resulting polymer. This polymer filament development holds particular assurance for submarine and aircraft industries, enabling manufacturers to print joint-less components with complex shapes capable of surviving stresses at greater depths and greater heights respectively.

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EXPLORING THE CAUSAL RELATIONSHIP OF HUMAN EMOTIONAL RESPONSE IN TECHNOLOGY-MEDIATED INTERACTIONS

Virtual Reality (VR) is an emerging field of interest for the general public as well as for research professionals investigating human behavior. VR can simulate immersive real-world experiences while providing multiple metrics for the measurement of real-time user motion in three dimensions. Therefore, it can facilitate novel studies of technology-mediated human interactions. In this project, we developed an experimental framework for investigating the causal relationship between peer performance and user emotional response during competition. Specifically, we created a simple interactive aiming game with moving targets in VR in which users compete with a peer. The software tracks trajectories of the VR headset and controller. An electroencephalograph, coupled with the platform, measures cognitive and emotional responses as they are elicited in real time. The collected data will be analyzed using the information-theoretic construct of transfer entropy to infer the causal relationship between user movement trajectories and emotional response under competitive environments.

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CHARACTERIZATION OF THE COMPRESSIVE BEHAVIOR OF POLYMERIC FOAMS

The aim of this study is to characterize the compressive mechanical response of six different industry manufactured cellular materials called polymeric foams. Cellular materials are distinct in that they possess a solid phase and an either continuous or discontinuous gaseous phase, usually comprised of air. The solid phase (matrix) can be either polymeric, metallic or ceramic. The presence of a gaseous phase significantly reduces the density of these materials and makes them economical because of less material usage. Polymeric foams are popular materials widely used in impact protection applications such as in helmets, vehicles etc. The effective usage of these materials in such applications requires extensive knowledge of their mechanical properties and, particularly, their compressive mechanical properties under different loading conditions. In this study, 9 cylindrical samples per polymeric foam were cut for quasi-static testing whereas 3 cylindrical samples were cut per polymeric foam for dynamic testing. Unconfined compression tests were performed quasi-statically at three different strain rates: 0.1 /s, 0.01 /s and 0.001 /s. All foams were compressed to at least 80% of their initial thickness. To study the dynamic behavior, drop tower apparatus was used in which an impactor imparts uniaxial load on the specimen at strain rates reaching up to 200 /s. Preliminary results show that the strength of these foams increases at higher strain rates. However, further testing and analysis of acquired data is required to provide a deeper insight into the correlation between the compressive mechanical properties of these polymeric foams and applied strain rate.

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INFORMATION FLOW BETWEEN MUSICIANS IN JAM SESSIONS

Music is a complex and vaguely defined experience; yet almost everyone has come across some of its vast multitude of social and cultural forms. While music students may study and emulate hierarchical structures of form and meter in specific disciplines, it is fascinating to observe the spontaneous development of these features in improvised acoustic collaboration. This, often social, event arises ubiquitously in the clapping and cheering of excited crowds and the jam sessions of jazz musicians. However, the process behind how people collaborate acoustically without predefined arrangement is largely unknown.

This project aims to elucidate an underlying process of spontaneous collaboration during musical improvisation. To that end, behavioral experiments are conducted with pairs of human subjects who will collaborate to create improvised rhythmic music. Velocity sensitive MIDI controllers, playing a percussive virtual marimba instrument, are used to enable collection of acoustic information for analysis. Communication between players during this improvisational session is limited to the acoustic information of the instruments, as they face away from each other. This audio data is then analyzed to investigate the dynamics of collaboration and leadership between the pairs using several tools, including transfer entropy, event synchronization analysis, and phrase similarity analysis. Further, we will investigate the relationship between prior music experience of the players and their behavioral plasticity. This study will shed light on human collaboration and the process of adaptively responding to each other in an undefined setting, toward a shared goal. This may help increase understanding of the spontaneous evolution of social networks and their resilience to perturbation

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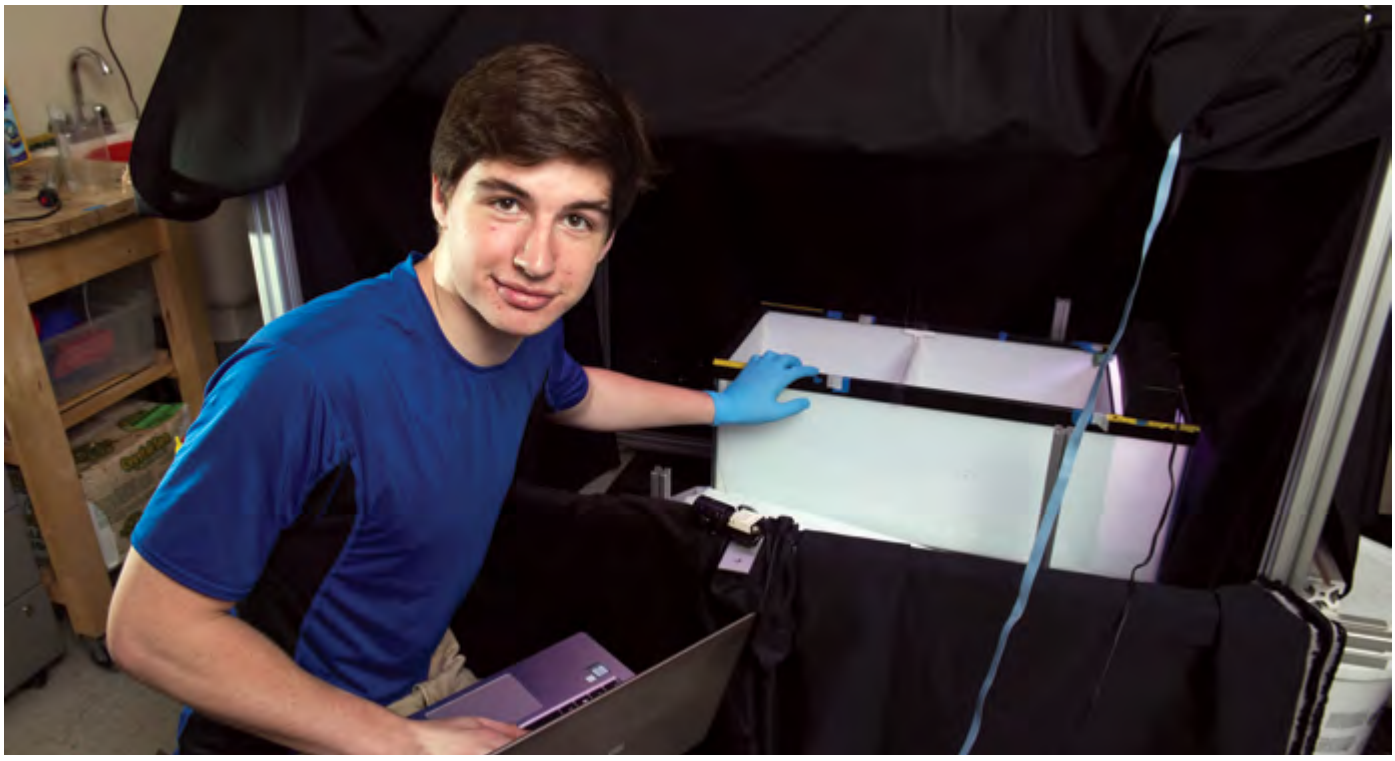
UNDERSTANDING SPATIAL LEARNING OF ZEBRAFISH

Zebrafish are widely used in behavioral research. Their high degree of genetic and physiological homology with humans, together with their small size and high breeding rate make zebrafish a model species across biological fields, including the study of behavior and cognition. However, the learning capabilities of zebrafish are still poorly understood, in particular spatial and social learning.

To study learning in zebrafish, a training platform was developed to investigate individual and social learning processes. In the experimental tank, an individual (focal) fish is separated from a shoal of conspecifics by one-way glass and a transparent partition, allowing the focal fish to see the shoal. Zebrafish being a highly social species, the shoal constitutes a strong stimulus that attracts the focal fish. In the transparent partition are two doors, one of which is programmed to open after the fish spends a predetermined amount of time in front of it, while the other door remains closed regardless of the fish's behavior in order to ensure accurate testing of spatial reasoning. This is automatically controlled using real-time tracking. By repeating this test over multiple sessions, the potential learning skills of each individual zebrafish are measured by examining the change in time taken to trigger the door. In addition to studying the learning of the zebrafish as individuals, a robotic fish replica is used to investigate the social learning of zebrafish. The robot behaves as an expert demonstrator that moves towards the correct door at the beginning of the experiment with as little delay as possible while maintaining natural motion.

The results of this study are expected to assist in understanding the learning abilities of zebrafish, comparing individual learning to social learning, and to provide a basis for other studies to expand on the neurological capabilities of the zebrafish.



▲ Brandon Lemay is investigating the learning capabilities of zebrafish through a series of experiments designed to explore both individual and social learning processes.

STUDY OF TRANSITION BETWEEN FISH SCHOOL PATTERNS

Schooling behavior is ubiquitous among fish species. Swimming in schools can help individual fish escape from predators, search for food, and mate. However, how and why fish align their bodies to achieve coordinated swimming is not well understood. A recent study revealed that fish transition from a diamond school pattern to a phalanx school pattern at increased flow speed. This transition has been attributed to a reduction in the energy expenditure during swimming. The aim of this study is to quantify the hydrodynamic interactions among swimming fish in the diamond and phalanx schools, and predict the onset of each school pattern. Specifically, we designed a swim tunnel that is capable of sustaining uniform flows over a range of flow speeds, which simulates natural fish swimming conditions. We will introduce fish groups of various sizes into the water tunnel, and record their swimming using high speed cameras. Diamond and phalanx school patterns will be induced by controlling the flow speed, which ranges from 0 to 5 body lengths per second. Locomotory patterns of individual fish in the school will be obtained through image analysis, and interactions among fish will be quantified using information theory. This study may elucidate the role of hydrodynamics during the transition between a diamond and a phalanx school pattern.

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EXPERIMENTAL INVESTIGATION OF IMPACT LOADING OF WATER-BACKED PANELS

Understanding the fluid-structure interaction of water-backed panels during impact is essential to the design of marine structures. In this project, we designed experiments to study the material responses and hydrodynamics during impact loading of water-backed plates. In our experiment, a flexible plate is clamped on the surface of the water, Impact is realized by a heavy load dropped from a certain height. Position sensors and accelerometers are used to accurately characterize the impact of the load. The fluid-structure interaction is captured through simultaneous measurement of the plate dynamics and fluid mechanics. The out-of-plane deflection of the plate is quantified through digital image correlation (DIC), which can afford subpixel accuracy for displacement measurement. Simultaneously, the velocity field of water is measured using particle image velocimetry (PIV), from which the hydrodynamic pressure is reconstructed based on the Navier-Stokes equations. Separate light sources and color filters are used for DIC and PIV to mitigate interference of lighting. Through the combined DIC and PIV measurement, we aim to assess the influence of water on the dynamics of the plate. The proposed experimental framework may offer insight into the study of fluid-structure interaction problems and inform the design of marine vessels.

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ADDITIVE MANUFACTURING OF IONIC POLYMER-METAL COMPOSITES

Ionic polymer-metal composites (IPMCs) are smart materials that have applications as actuators and sensors in the field of soft robotics. They consist of an ionomer membrane sandwiched between two metal electrodes. Standard manufacturing techniques of IPMCs are limited to planar shapes cut from precast ionic polymer membranes. For this reason, additive manufacturing has received considerable attention in recent years as a customizable, cheap, and fast alternative to these techniques. The additive manufacturing process starts by extruding ionomer pellets into filaments using a high temperature filament extruder. The filament is then printed using a 3D printer outfitted with a high temperature heating pad and a dual extrusion head compatible with flexible materials. Adhesion is promoted with the print bed using double-sided Kapton tape and with the polymer on successive layers using gratings. The printed ionomer membranes undergo an electroless plating process, which deposits a thin platinum layer on the surface. Performance of the 3D printed material is evaluated through comparison with a conventional sample. To illustrate the unique design opportunities of IPMC 3D printing, we create an IPMC torsional actuator by printing a composite laminate with an ionomer as the matrix and a material with different mechanical properties forming the fibers. The inherent limitation of conventional IPMCs to sole bending motion can be overcome by promoting a bending-torsion coupling through the introduction of the fibers in an asymmetrical configuration, demonstrating the possibility of engineering novel IPMCs with additive manufacturing.

STUDY OF SYNCHRONIZATION OF MECHANICAL OSCILLATORS WITH TIME-VARYING COUPLING

Synchronization of coupled mechanical oscillators was serendipitously discovered by the Dutch physicist and mathematician, Christiaan Huygens. Since then, the phenomenon of synchronization of coupled oscillators has been studied with considerable rigor, numerically and experimentally, and recently some advances have also been made in the study of synchronization of oscillators with time-varying coupling. These studies have been predominantly theoretical.

As part of our project, an experimental setup capable of imposing time-varying coupling between two mechanical metronomes is developed using which the aforementioned synchronization phenomenon can be studied. The setup consists of two platforms which are free to move along a set of linear motion shafts. Two metronomes are affixed on these platforms. A Serial Elastic Actuator is built in-house and used to provide time-varying coupling between the metronomes. In the experiment, video processing is used to infer the platform positions and oscillator phases. The collected data is used to quantify the effect of the coupling strength, temporal structure of the coupling, initial conditions on the onset and type of synchronization (i.e. in-phase/anti-phase) observed.

The experimental effort is complemented by a theoretical study of the aforementioned experiment. We aim to show one of the different occurrences of synchronization amongst natural and technological settings with this project and help us explain this phenomenon.

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HYDRODYNAMIC COEFFICIENTS FOR AN EXTRATERRESTRIAL SUBMERSIBLE

The Titan Submarine was proposed by NASA as a submersible autonomous vehicle that would explore the hydrocarbon lakes of Titan, one of Saturn's moons. The project's aim is to use the submarine to study Titan's oceanographic phenomena in situ, including the lakes' molecular compositions, currents, tides, and waves. The purpose of this particular study is to obtain the hydrodynamic coefficients acting on the submarine as it travels through Titan's lakes. First, an input file is created describing the general run control information, body and wake geometry, and other relevant parameters. The geometry is obtained by designing the streamlined shape of the submarine body in LOFTSMAN. Following that, a three-dimensional panel code, CMARC, is used to solve for potential flow around the submarine. CMARC then provides the relevant hydrodynamic forces and moments acting on the submarine as functions of its shape. Fluid-solid interactions are also accounted for in this study, in the form of added mass and damping coefficients. Once results are obtained, power requirements to overcome drag forces can be evaluated.

This research is an extension of a larger project concerning the optimization of the submarine's design through the use of multiple computational fluid dynamics and smoothed particle hydrodynamics programs. The results obtained from CMARC will be compared to those of other CFD and SPH approaches, including PMARC, ANSYS-Fluent, and DualSPHysics. After comparison, results from this study can be used to improve upon the submarine's design through body geometry modifications to reduce stresses.

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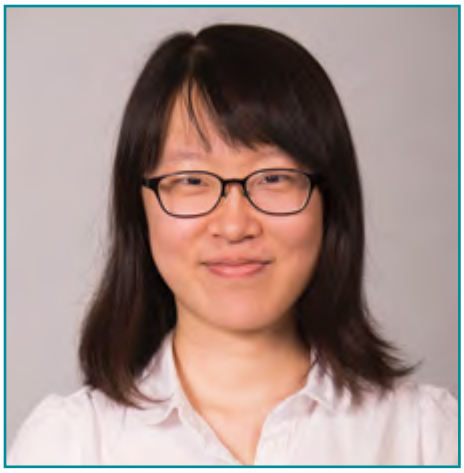
TECHNOLOGY, CULTURE AND SOCIETY

HOLOGRAPHIC SPACETIME AND QUANTUM ERROR CORRECTION CODES

This project seeks to understand the nature of spacetime as an emergent phenomenon in holographic duality.

Can we construct a hologram of an object in a d-dimensional "bulk" spacetime from a subregion of its (d-1)-dimensional boundary without any loss of information? This turns out to be possible if we add constraints on the bulk and boundary, resulting in the AdS/CFT correspondence—-the conjecture stating an equivalence between a d-dim bulk theory of gravity in Anti de-Sitter spacetime and a (d-1)-dim boundary conformal field theory. This duality is surprising since the two theories seem completely different on the surface; but it is meaningful because we can potentially solve analytical difficulties in one theory by mapping them into the other theory. Still, the conjecture itself is not complete because aspects of the "hologram" exhibit a non-uniqueness that calls for explanation. One attempt at such an explanation involves interpreting the hologram as a quantum error correction code: the non-uniqueness of the boundary representation amounts to a redundancy required by the error-correcting nature of the bulk spacetime.

In this project, we will attempt to understand holographic duality using the language of quantum information theory, and consider the implications of the emergence of geometry and spacetime from a quantum error correction code.



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P5.JS ACCESSIBILITY WITH THE USE OF OPENPROCESSING

P5.js, currently in active development, is an open source client-side JavaScript library used widely in creative fields and media arts education. It is also a core technology used in NYU programs in applied media, including Integrated Digital Media. As a metaphor of a software sketchbook, p5.js has many drawing functionalities which allow interactions with a digital canvas, or even in browser with other HTML5 objects like text, input, sound, and video. Third-party libraries can be used to further expand its capabilities. In order to make p5.js more accessible to creative coders, artists, designers, educators and beginners, examples were created using existing p5.js libraries and tutorials were written for programming topics, including JavaScript objects, program/event flow, and others with the correct syntax. Existing tutorials were ported from the Processing website to be made applicable for JavaScript and p5.js. These tutorials and relevant examples will be published on the p5.js website.

Meanwhile, the p5.js libraries such as p5.DOM, p5.Speech, p5.Play etc. and their functionalities were tested in OpenProcessing by creating example sketches. These examples are added to the OpenProcessing site to help beginners gain a better understanding of the capabilities of each library. ML5.js is a machine learning library created for JavaScript that is also in development. Existing ML5.js examples were ported and converted to p5.js sketches, and are made available to the OpenProcessing community. OpenProcessing is constantly updating and potential features like finding similar sketches require new algorithm to be developed.

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USER EXPERIENCE IMPROVEMENT OF P5.JS AND OPENPROCESSING

P5.js is an open source client-side JavaScript library used widely in creative fields and media arts education. As a metaphor of a software sketchbook, p5.js has many drawing functionalities which allow interactions with a digital canvas, or even in browser with other HTML5 objects like text, input, sound, and video. Third-party libraries can be used to further expand its capabilities. In order to make p5.js more accessible to creative coders, artists, designers, educators and beginners, existing tutorials such as tutorials on images and pixels were ported from the Processing website to make them more applicable for JavaScript and p5.js. These tutorials and relevant examples will be published on the p5.js website.

OpenProcessing uses licensed and open source components to create an online community for artists, designers, educators, students, and software developers. OpenProcessing allows for creating sketches online using Processing/p5.js and viewing community creations. It provides an easy and friendly online sharing environment for people to learn, experiment, and create using Processing and p5.js. To improve the user interface of the site, especially the filtering interface, user research including online surveys and one-to-one interviews were conducted to learn the strengths and weaknesses of the user interface of the site. Wireframes will be created based on the users' feedback for redesign of the interface which allows the users to have better searching and browsing experience while using OpenProcessing.

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PUBLIC ENTREPRENEURSHIP

Public Entrepreneurs use private and public institutions to work towards the good of the public and are not limited to exclusively market-based solutions in order to do so. This type of entrepreneurship is centred around progressive tools such as big data, open solutions, and predictive analytics. Success is measured based on community benefit and individual impact rather than profitability or connections created. Through Public Entrepreneurship, solutions that traditional government connections and methods wouldn't be able to achieve are possible through these newer technological methods.

This summer has been spent researching different methods of problem solving. That is, how these problems are approached by professionals from different disciplines. This includes investigating the steps involved in solving issues, beginning with problem definition and ending with prototyping and testing the solutions. This, along with an in-depth analysis into strategies such as human centred design, crowdsourcing, positive deviance and design thinking, has all been done in an effort to determine what a public entrepreneur can add to this discussion. That is, what does a public entrepreneur do differently when it comes to solving problems and when we figure this out, how do we teach this strategy to public servants and future leaders alike.

THE MANTA ROVER: AN AUTONOMOUS AQUATIC MONITORING AND SHADING SYSTEM FOR CORAL REEF REMEDIATION

Coral reefs are crucial aquatic ecosystems that sustain about a third of all described marine species. Due to climate change, corals experience unprecedented thermal stress from rising water temperatures. As a result, corals suffer from bleaching, a phenomenon that potentially leads to coral death. It is known that excessive light levels can also be harmful for corals. For this reason, our project aims to develop a novel aquatic shading system for automated remediation of coral reef ecosystems that are facing threats from coral bleaching.

The Manta Rover system combines experimental design with environmental monitoring and remediation into one integrative system. The design for the Manta Rover consists of a 625 m2 flotation fabric that works as an optical filter. The Manta Rover is intended to reduce the irradiance that reaches the corals while allowing Photosynthetic Active Radiation (PAR) to reach the symbiotic algae that carries out photosynthesis and feeds the coral. Simultaneously, the Manta Rover would analyze readings from a hyperspectral camera and a spectrometer to assess coral health and make decisions (stay and shade the coral reef, relocate, request human intervention, etc.) through a machine learning algorithm.

The project's goal is to provide a proof of concept of the Manta Rover by demonstrating the feasibility of implementing two essential components of the system: optical filters and machine learning models for coral recognition. The optical filters will be tested in a small-scale experiment, employing artificial lighting, samples of the coral Pocillopora damicornis, and dichroic filters to assess the benefits of reduced irradiance on the coral. A deep neural network capable of automatically classifying coral images will be developed using the BENTHOZ-2015 public dataset.

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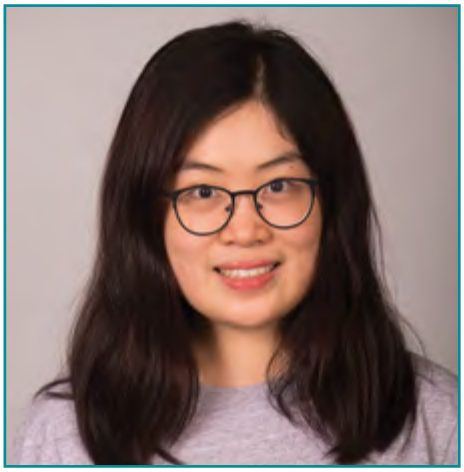

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LEGISLATURE 2.0: CROWDLAW

Governments worldwide are facing a dual crisis of legitimacy and efficiency. As a result, the relevance of traditional forms of lawmaking, typically done behind closed doors, has been called into question. In response, several new technologies and processes have been developed to open up the law and policy making process- beginning with setting the legislative agenda to drafting laws and even evaluating existing policy- to the general public. But in order to be impactful, these processes must be designed to work well not just for the public but also for the institutions that seek their input. The GovLab (an NYU Tandon-based action research lab which studies how technology and data-driven decisions can be used to improve public institutions) calls this open, participatory and institutionalized policy-making process, CrowdLaw.

The GovLab is creating a CrowdLaw Playbook to serve as a how-to guide for governments that want to implement their own CrowdLaw projects, but lack the know-how to do so effectively. Our role in this project was drafting in-depth case studies of how municipal and national governments in Europe and Asia have used crowdsourcing platforms in the lawmaking process, the successes and failures of those projects, and how the lessons learned should be applied to future CrowdLaw initiatives. This was done through a mixed-methods research process, beginning with secondary research of the existing documentation before moving toward primary interviews with key stakeholders and other experts to fill the gaps in the publicly-available information. The work will be published online in fall 2018 at crowd.law

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SOLVING PUBLIC PROBLEMS WITH DATA

As the internet becomes more ingrained into our culture and everyday life, it is easy to forget how incredibly revolutionary it is as a tool to distribute information. It has empowered a new generation of public problem solvers, who the GovLab calls "Public Entrepreneurs", to learn specialized skills like data analytics from leading experts all over the world. Massive open online courses (MOOCs) have become the standard by which knowledge is distributed online, as they allow for individualized learning through extensive course documentation, external shareable and free resources and community tools that allow for online learning communities to thrive.

Our research over the summer involves reshaping of the GovLab's public training platform, "The GovLab Academy", by implementing modern design elements, updating content and providing uniform integration with other GovLab platforms, such as the skill-sharing Network of Innovators platform. We are also working on adding the full scope of The GovLab's academic material to the platform, incorporating syllabi and additional resources to further our goal of teaching public entrepreneurs how technology,data and collective intelligence can be used to solve urgent public problems. By providing free online courses and project clinics focused on cutting-edge tools and processes for evidence-driven and participatory governance, we believe that we can help to make governance more effective, inclusive and innovative. We hope users look to these platforms as jumpstarts to potential projects aimed at bettering their communities, employers and local governments.

▲ Joel Urena is reworking the GovLab's public training platform and providing public entrepreneurs with the technology, data, and collective intelligence to apply to solving vital issues.

TECHNOLOGY MANAGEMENT AND INNOVATION

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SOUND AND ITS CAPACITY TO INFLUENCE THE EFFECTIVENESS OF EMAIL PHISHING SCAMS

Being so widely used, electronic mail (email) has been adopted as a medium for malicious attempts to compromise individuals' security on the internet. One of these security risks, phishing, is the use of a misleading email message to coerce the recipient into revealing personal information or navigating to a compromised website. Phishing is an example of how malicious attacks on the internet are increasingly performed through "social engineering," or online deception as a means of manipulation. As social engineering heavily relies on an individual's perception, which in turn is a product of various environmental stimuli, it is subject to variations in effectiveness, hence the tendency of scammers to distribute millions of fraudulent emails across a large population for a narrow chance at success.

The purpose of this project is to determine whether environmental stimuli, specifically sound, affect an individual's ability to decide whether an email is legitimate or an attempt at phishing. The investigation tests this relationship by manipulating the soundscape that each individual is exposed to, and requiring participants to decide whether to report an email as phishing or not. The first component of the project is the development of the study's interface that closely simulates an individual's natural exposure to phishing emails and records each participant's subjective perception of the soundscapes' pleasantness. Then the study is distributed to a participant sample and the results analyzed for correlation between the observed variables.

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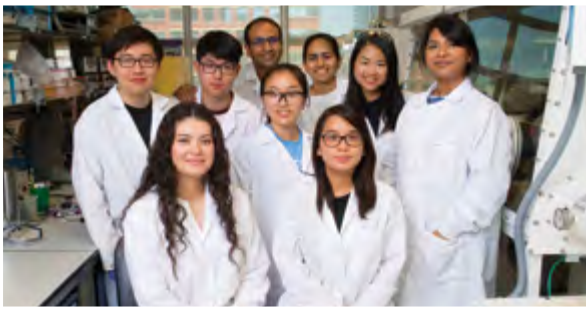
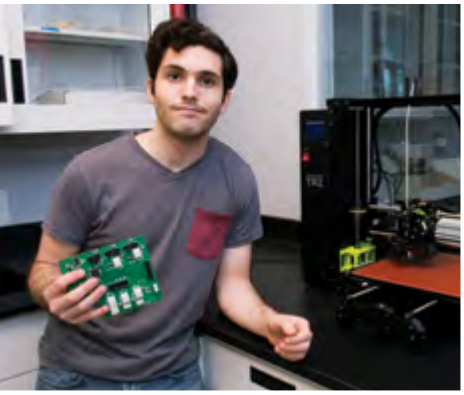
HUMAN-COMPUTER INTERACTION: USER INTERFACES FOR CONSUMER FINANCE

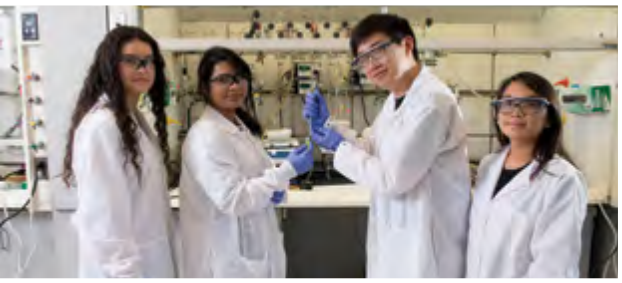
How can economics be applied to the study of user interfaces in understanding user behaviour? What are the most suitable ways to quantify and represent user preference? Ongoing research in the field of human-computer interaction and consumer finance seeks answers to these questions. They will not only allow researchers to understand what features users value in user interfaces, but also provide designers with direction in making design decisions. This is of great importance, seeing as both users and designers are restricted by scarce resources, namely time, attention, patience and effort. Moreover, allocative efficiency can be achieved by understanding how users respond to the availabilities and the limitations of features in user interfaces.

In the current stage of the project, we are expanding the work done by O. Nov and H. Su (2018), who concluded that the demand by users for a sorting feature in an investment allocation UI is downward sloping. By using economic tools such as budget lines and indifference curves, we are interested in understanding how users compare and choose between two or more features of varying cost levels. The challenge is inferring the utility that users gain from a particular feature. The outcome of our investigation can provide designers with more in-depth knowledge of users' preferences under the condition of scarcity. Design decisions can become more evidence-based, thereby encouraging the efficient allocation of scarce resources.






SARA-LEE RAMSAWAK

UG Summer Research
Program Coordinator

Associate Director of Academic Affairs
Office of Undergraduate Academics

NYU Tandon School of Engineering

Sara-Lee Ramsawak has coordinated the Undergraduate Summer Research Program since the summer of 2013 and has expanded the program from 61 students to over 100. Faculty participation has also increased and expanded to include professors and research projects from NYU Wireless and the NYU Center for Urban Science and Progress. It now includes students from NYU Tandon, the NYU CAS 3+2 Program, NYU Shanghai, NYU Abu Dhabi, and select students from outside universities who participate in the Summer Research Program for College Juniors. Aside from the hands-on research that students do with the faculty, they also attend career development, academic enhancement, and social events and gatherings, including engineering industry panels, Wasserman Center for Career Development and Graduate Admissions seminars, and poster sessions. Sara continues to dedicate herself to this program and all of the opportunities it affords students.

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