TANDON UGSRP

Fourteenth Annual

Undergraduate Summer Research Program Research Abstracts

2020

NYU | TANDON SCHOOL OF ENGINEERING

NYU Tandon School of Engineering's Undergraduate Summer Research Program (UGSRP) provides a unique opportunity for NYU Tandon, NYU Abu Dhabi, NYU Shanghai, NYU College of Arts and Science + NYU Tandon Dual Degree Program, and other select students to engage in research over the course of the summer semester. This program offers far more than the traditional classroom experience; it allows students to work alongside faculty mentors as well as PhD and masters students on cutting-edge research projects. Aside from this, they get to interact with other students of all different levels from various fields of study within NYU and outside of it over a 10-week period. Aiming to enhance and broaden students' knowledge base by applying classroom learning to solve practical and contemporary problems, this program better prepares them for lifelong learning.

Close interaction with faculty and research staff promotes an educational experience that advances Tandon's i2e model of invention, innovation and entrepreneurship. As such, Tandon's faculty participation in this program is essential. Along with the faculty, other Research Staff have extensively mentored the students, helping them to learn what research is and what the best practices are for their specific subject areas. In addition to the research performed, students participate in various workshops, lectures, and seminars throughout the summer. Matthew Frenkel and Azure Stewart were involved in the program through the provision of the Student2Scholar (S2S) Series. A tremendous thanks to both them and the other guest speakers and lectures that provided the students with pertinent information and resources to ensure their future success. Detailed information is included towards the end of this booklet.

Financial support from NYU Tandon, faculty research grants, and outside donors is also essential to the program's maintenance. This year marked the ninth year of the Thompson Bartlett (TB) 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, faculty mentors, and further strengthen this truly unique summer experience. The program has housed additional fellowships, including the Tandon Honors Fellowship, The IIIE Fellowship, and the Visiting Student Fellowship.

The coordination of this program takes a tremendous amount of effort. I would like to acknowledge Sara-Lee Ramsawak, Director of Undergraduate Academics & Global Programs, who has coordinated the UGSRP and ensured that the program's daily operations run seamlessly since 2013. Jen Piro, Assistant Director of Undergraduate Programs, joined in on the coordination efforts for the last year and took charge of the program's administration, especially the summer participant placements. Ishan Krishan, Tandon's UGA Administrator took charge of the program's various modifications and developments, working tirelessly to enhance the application system and other software applications. De'Ane Kennedy created this year's Abstract Booklet and served as a TA and point of contact throughout the summer. 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, remaining in contact with these students over time often bringing them back to engage with younger TB Fellows.

COVID-19 disruptions provided the group of coordinators with several challenges for the 2020 Program. That said, technology has allowed for it to run completely remote for the summer of 2020, including the various events. At the end of the program, all students participated in a poster session and select students provided more detailed presentations. The abstracts published in this year's volume are representative of the research done this summer and celebrates the accomplishments of the undergraduate researchers. Congrats to all of the student researchers who participated in the 2020 Undergraduate Summer Research Program. I look forward to future summers of more intellectual and scholarly activities.

Peter Voltz
Associate Dean for Undergraduate and Graduate Academics

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SCHEDULE OF
EVENTS

Jun 3 - Jul 27
Student to Scholar Series (S2S)
Presented by Matthew Frenkel & Azure Stewart

- What is Research?
- Developing a Literature Review
- Writing a Research Statement
- Ethics in Research
- Developing a Research Proposal
- Constructing a Research Poster
- Applying to and Finding Funding for Graduate School
- Writing for Publication

Jun 17
Global Information Session
Presented by Colby Hepner

Jun 25
Black & Latino Men Virtual Meet & Greet

Jul 1
NSF GRFP
Presented by Prof. Vikram Kapila

Jul 10
Diversity & Inclusion Session
Presented by Sooah Kwak & the NYU Office of Global Inclusion

Jul 13
Makerspace Session
Presented by Christina Lafontaine and Elizabeth New

Jul 15
Vertically Integrated Projects (VIP) Information Session
Presented by Amy Dunford

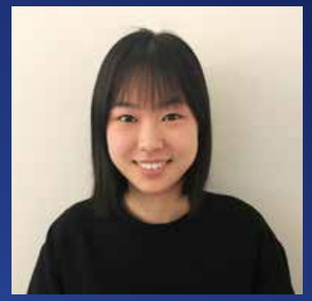
Jul 22
Graduate School Information Session
Presented by Leanna Kowallis

Jul 29
WEST FEST
Moderated by Cindy Lewis

Aug 5
Wasserman Presentation
Presented by Shan Meisner

Aug 7
Poster and Presentation Session

Technology, Culture, Society



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Stella Yu
BS Electrical Engineering
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Great Neck South High
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Michael Zachor
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NYU Tandon

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Faculty
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Jonathan Bain
Amy Hurst

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Bethesda-Chevy Chase HS
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NYU Tandon
Thompson Bartlett Fellowship

Other Mentors & Research Staff
Anirudh Dinesh
Dane Gambrell

Sensory Tools: Museum Access

Student(s): Cathy Xu
Faculty & Mentors: Amy Hurst

The Sensory Tool project is a collaboration between the Ability Project and the Intrepid Sea, Air & Space Museum. Due to COVID-19, the Intrepid Museum is temporarily closed. Our research is focused on designing accessible BYOD (Bring Your Own Device) for museum reopening. Greeted by a changing world, the Intrepid Museum is seeking a gradual approach to prioritize health and safety while taking progressive steps to restore regular operations. Our research goal is to find a tailored solution within existing frameworks in a timely manner to meet the planned reopening date in mid-August. In order to instill confidence and minimize the risk of infection by the COVID-19 virus to visitors and staff, we research and design "no-touch" visit, in which carefully elaborated protocols and technologies are harnessed to create a frictionless visitor experience. Wireframes and prototypes will be created to allow the users to have better touring experience in the museum with the mobile app. Another benefit from the app is it helps the visitors to better practice social distancing with others by allowing them to view exhibit information on the phone rather than crowing in front of the exhibit.

NYU Dentistry Oral Health Center for People with Disabilities

Student(s): Stella Yu, Michael Zachor
Faculty & Mentors: Amy Hurst

Technology is continuing to expand and improve as many people start to appreciate how modern-day technologies have become a bigger part of their daily lives. However, many times, people forget to think about how technologies affect and help people with disabilities. It is important that as our society gradually becomes more sophisticated, technologies that assist people with disabilities must be developed and improved as well.

As strengthening inclusivity and diversity is crucial in the culture of NYU, along with many other universities, it is even more important that engineers and researchers study and design technologies that assist people with disabilities. The purpose of this project is to develop technologies to be placed at the multisensory room in NYU Dentistry Oral Health Center for People with Disabilities. The technologies utilizes different sensors on a circuit board to interact with the patients in order to help reduce patients' anxiety and distress. Sound sensor was utilized and programmed to pick up sound in the room and emit colored LED lights in the room that patients may interact with. Through developing and studying technologies, we strive to help patients have less stressful experience at the dental office.

Improving People's Lives by Changing How We Govern

Student(s): Frederico Levy
Faculty & Mentors: Beth Noveck

The COVID-19 pandemic presents governments and other institutions with a series of novel challenges. The pressing nature of these challenges has meant that governments can't afford to the the long, iterative decision making processes they generally use. Instead, innovation and agility are essential. The expertise and know-how to solve these challenges, however, is widely dispersed through different sectors, and across the world. The Smarter Crowdsourcing in the age of Coronavirus project attempts to tackle this issue by using modern telecommunications to bring together widely dispersed expertise and decision makers from Latin America. In a series of six online advising sessions, curated experts from around the world offer insights and brainstorm together with health officials from countries of Latin America and the Caribbean. The final product will be a series of reports containing actionable solutions to six key challenges posed by the pandemic, with key insights from the very governments facing these challenges. The implementation plans will aid any government interested in implementing these solutions.

GovLab's CrowdLaw Catalog

Student(s): Nandita Kohli
Faculty & Mentors: Beth Noveck, Anirudh Dinesh, Dane Gambrell

Successful governing practices have the potential to significantly improve people's lives. However, in order to successfully govern the public, it is important to incorporate both the public and expert opinions into implementable policy action. CrowdLaw is the practice of using technology to tap the intelligence and expertise of the public in order to improve the quality of lawmaking. With trust in government at an all time low, the traditional model of law-making, shrouded in secrecy and distorted political party agendas, is being called into question, now more than ever. Increased public participation in the law-making process, in the form of CrowdLaw projects, could help to improve both the legitimacy and effectiveness of government institutions across the globe by introducing more robust data and diverse viewpoints at each stage of the lawmaking process. GovLab is supporting legislative bodies in investigating, designing, implementing, and testing new CrowdLaw initiatives.

ER=EPR? Topology and Quantum Entanglement

Student(s): Nigel Shen
Faculty & Mentors: Jonathan Bain

Currently, Einstein's General Relativity and Quantum physics are considered contradictory to each other. Over decades, scientists were thinking about how to make a connection between the two. One prospective hypothesis is Maldacena & Susskind's (2013) "ER=EPR" hypothesis, which claims that two physical systems in a quantum entangled ("EPR", or Einstein-Podolsky-Rosen) state are connected by an Einstein-Rosen ("ER") wormhole. More generally, it claims that spacetime topology is the "dual" of quantum entanglement: physical systems in a quantum entangled state can be redescribed as systems connected by a wormhole, and vice-versa. Our project's goal is to first address the main motivations of "ER=EPR" hypothesis, including AdS/CFT theory and the Black Hole Firewall Paradox; Then, we construct a conceptual map that relates the characteristics of ER wormholes to the characteristics of quantum entanglement; Finally, we aim to assess the ER=EPR hypothesis with the conceptual map, and evaluate its possible influence to our understanding of physics in a philosophical point of view.

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Paul Lee
Kimia Ghobadi

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Hospital Supply Chain Management Practices in the US: A Scoping Review

Student(s): Yiming Huang, Danielle Sorscher
Faculty & Mentors: Cassandra Thiel, Timothy Roberts, Kimia Ghobadi

One approach to increase the value of the US healthcare system is to reduce healthcare costs. Previous studies have analyzed reducing unnecessary or excessive care, but overtreatment is estimated to account for only 6% of healthcare costs. Few studies focus on reducing or optimizing the direct costs of all care, such as the cost of supplies, which account for 15-40% of hospital expenses. Spending on healthcare supplies is driven by multiple interrelated factors: contextual factors such as payment structures, regulation, and manufacturer terms of use; organizational factors such as procurement strategy, internal policies, and infrastructure; and individual factors such as clinician training, preferences, and behaviors. To reduce spending on medical supplies, we must understand the interplay of these factors and assess opportunities for change.

In this study, we aim to understand the scope of existing literature that describes, analyzes, or assesses US hospitals' procurement, distribution and management practices of disposable or consumable medical and surgical supplies. From this review, we expect to highlight gaps in the existing literature and develop a preliminary conceptual framework that identifies the individual, institutional, and contextual level factors driving medical supply spending in order to identify possible methods for making hospital supply management more efficient.

Covid-19 and PPE Conservation

Student(s): Pallavi Sreedhar, Meenakshi Seetharaman, Hannah Greene, Genevieve Silva
Faculty & Mentors: Cassandra Thiel, Sarah Hochman, Rajesh Vedenthan, Gizely Andrade, Paul Lee

The novel coronavirus that emerged in December of 2019 in Hubei Province, China has put immense pressures on the supply chains of healthcare systems, especially in regards to the production of Personal Protective Equipment (PPE). PPE, such as masks, gloves, and gowns, are essential to keeping both healthcare workers and patients safe. However, the healthcare industry's heavy reliance on PPE importation from China and increased consumption of PPE during the pandemic has resulted in massive supply shortages. Hospitals have had to adapt their PPE usage in order to conserve supplies in part by limiting access to PPE stocks, limiting/optimizing usage of PPE, and disseminating guidelines for reusing disposable PPE. This study performs a literature review on PPE usage in other areas and times that present(ed) a PPE shortage in order to encourage safe conservation of PPE during Covid-19. Literature might include: conservation efforts during previous pandemics, supply shortages by climate events, military or remote medical services, or PPE practices in resource-constrained settings such as low and middle income countries. In the future, this literature review can be used to build more resilient medical supply chains while also mitigating the healthcare industry's footprint on the environment.

Waste Audit in Hospitals Literature Review

Student(s): Hannah Bockius, Yiming Huang, Hannah Greene
Faculty & Mentors: Cassandra Thiel

The United States healthcare system produces over 5.9 million tons of waste and spends $10 billion on waste disposal annually. By performing a waste audit, or a physical analysis of waste composition, the healthcare sector can better quantify the amount and type of waste being produced. However, there is currently no specific procedure or set of guidelines provided for performing a waste audit in a medical setting.

This review surveys current literature on hospital waste audits by focusing on manual or automated physical measurement of waste conducted within a medical facility that quantifies the waste generally and/or the characteristics of waste produced. Waste types included general waste, regulated medical waste, recycling, chemical waste, pharmaceutical waste, chemotherapy waste, pathology waste, and sharps. Additionally, studies are included if performed in countries where medical wastes are defined and their treatment is regulated. The current goal of this project is to produce four papers; (1) outlining guidelines and best practices for conducting a waste audit, (2) summarizing current literature, (3) comparing practices between multiple hospital systems, and (4) focusing on individual departments and procedures. To achieve this goal, students for this summer are performing data extraction, consolidation, analysis, and paper writing.

Environmental Footprint of a Whole Hospital

Student(s): Meenakshi Seetharaman, Hannah Bockius
Faculty & Mentors: Cassandra Thiel

With the rise of COVID-19, many consumers are concerned about the potential spread of the virus from the use of reusable bags in grocery stores. As a response to these concerns, there are many statements being made by the plastic industry discussing single-use bag legislation. COVID-19 is a disease caused by the SARS-CoV-2 virus, and there exists literature examining its ability to remain viable on plastic surfaces. There is limited information regarding fabrics and other materials. Conducting a literature review analyzing the transmission risk of SARS-CoV-2 from common surfaces and materials is beneficial in many ways including expanding our collective knowledge on the subject, improving agency recommendations, and furthering ongoing policy decisions. Specifically looking at common surfaces and materials such as single-use and reusable takeout food ware/bags, we analyzed literature in the field to determine how they can act as a vector of COVID-19 and other such viruses. The results from the literature review will give researchers a more comprehensive outlook on the transmission process and allow them to assess how different types of plastics can serve as vectors of transmission.

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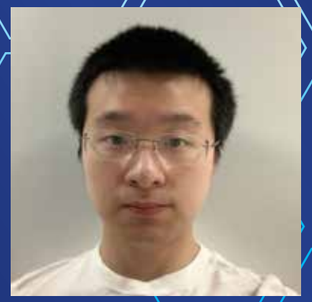

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Roni Barak Ventura
Giovanni Polverino
Gary Mac

Balanced Region Analysis for Standing Push Recovery with Ankle and Hip Strategies of ROBOTIS-OP3 Humanoid in Simulation

Student(s): James Marbaix, Rana Mohamed
Faculty & Mentors: Joo H. Kim, William Peng, Hyunjong Song, Hyun Seok Shin

The potential of humanoid robots to perform demanding tasks across various industries has led to increased interest in their development. Currently, the principal challenge of humanoid research is the difficulty of achieving balance in a biped system. In order for a biped robot to navigate its environment safely, it must be able to stabilize itself or prepare for a fall when falling is unavoidable. To achieve self-stabilization, existing balance controllers for bipeds are often based on center of mass (COM) state. While sensors and algorithms exist for real-time COM state estimation, COM-based fall prediction remains an active area of research. This work investigates the balanced region of a biped robot for standing push recovery in COM state space — the set of all initial COM states from which a biped can maintain its balance while standing. Within the open-source Webots simulation environment, various initial COM states are imposed on the Robotis-OP3 humanoid robot to determine the magnitudes of the velocity perturbations required for it to fall, which provide a numerical estimate of the balanced region. Both ankle and hip strategies were considered for push recovery control. Once computed offline, the balanced region obtained can be used within a real-time COM-state-based controller. The approach of this research can be applied similarly to other legged systems: humanoids, exoskeletons, and prosthetics with regards to balance stability.

HumanToHuman, a contact tracing smartphone application

Student(s): Albert Liu
Faculty & Mentors: Maurizio Porfiri, Francesco V. Surano, Agnieszka Truszkowska

Predicting disease spread within a population requires complex epidemiological models; accurate assumptions about everyday interactions are crucial to the accuracy of these models. However, estimating how often individuals interact with each other in a community is challenging, and models are often forced to rely on aggregated data of infections and casualties. We develop a mobile application, Human To Human, to collect in-person interaction data in a reliable and accurate way. This tool does not require any equipment to be purchased, and thus will be easily accessible for researchers. This application will be deployed on both Android and iOS, accompanied by backend server software, all of which are open source. Our application leverages Bluetooth Low Energy 4.2 to infer the relative distance between smartphones; the inferred data is anonymously stored in the backend server. During post-processing, we convert the data between phone pairs into distances between participants to create a dynamic graph of physically accurate and time-resolved face-to-face interactions. The ability to study interaction with such accuracy will lead to a better understanding of frequency and duration of contacts between people. Additionally, the time resolution of collected data can be leveraged to estimate communities' structures and their evolution over time.

A virtual reality environment to test electronic travel aids for the visually impaired

Student(s): Claire Ma
Faculty & Mentors: Maurizio Porfiri, John-Ross Rizzo, Alain Boldini

Visual impairment is a disability that is becoming increasingly burdening on modern society due to the aging of the population. Currently, no technological solution allows the visually impaired to effortlessly navigate obstacle-rich environments. Recently, we proposed an electronic travel aid (ETA) consisting of a wearable device that can provide the visually impaired information about the position and distance of obstacles in their surroundings. Information is acquired by a computer vision system and transmitted to the users through vibrotactile stimulation on the abdomen. Designing and tuning the device control system would require extensive testing with visually impaired patients, which could be frustrating and even dangerous. To address these issues, in this project, we implement a virtual reality (VR) environment, which can simulate the most common visual impairments with a varying degree of severity. By interfacing the VR environment with our device, we can test its performance with healthy individuals in a safe and controlled framework. In addition, the VR environment will help raise awareness of visual impairment in the general public during outreach activities, and assist in the training of the visually impaired to interpret and get acquainted with our device. Our work will lay the foundations for the integration of VR into safe ETAs testing and training.

Efficient agent-based model for simulating infection spread

Student(s): Kyle Payen
Faculty & Mentors: Maurizio Porfiri, Agnieszka Truszkowska, Jalil Hasanyan

Understanding how diseases spread poses a vital challenge for reducing infection within society. Agent-based modeling (ABM) is a computational framework for modeling the dynamics of complex systems by leverging the interactions between different units or agents. In these models, the aggregation of multiple interactions between agents allows for significant population-wide observations. Agents represent individuals in a society, while the underlying models simulate how their interactions can propagate information or viral infections. Using efficient computational methods, we implement epidemiological models of the ongoing COVID-19 epidemic in the United States. A susceptible-infected-removed (SIR) model lays the foundation for the ABM, where all agents are initially susceptible to a particular infection. Through interactions, these agents can become infectious, but upon recovery, they cannot be re-infected. Using a dataset representative of New Rochelle, NY, we also implement the ABM to examine the best testing practices in combatting the spread of COVID-19. Our models provide efficient and accurate examinations of the epidemic, thereby serving to help healthcare and government leaders make well-informed, science-based decisions to contain the spread of the virus.

Hydrodynamics of a fish swimming with physics-based machine learning

Student(s): Daniel Tang
Faculty & Mentors: Maurizio Porfiri, Mert Karakaya

By swimming in schools, fish find several advantages such as predator avoidance, foraging, and energy conservation. Flow physics plays a crucial role in the schooling patterns, as they can affect the effort required for swimming. In order to study these flows, tools like particle image velocimetry (PIV) are used to obtain vorticity and pressure data. However, PIV systems are expensive and limited to experimental assays in the laboratory settings. Several studies have used machine learning techniques to capture flow data without using PIV, but almost none account for bidirectional fluid-body interactions, like that of a fish swimming. In this study, we use video recordings and PIV data of a zebrafish swimming in a flow to train a physics-informed neural network. The network is trained on both the videos and flow data, but additionally has its loss function defined by mathematical models, such as the Naiver-Stokes equation, to ensure quicker training and realistic results. The result is a network that can generate flow data from videos of zebrafish swimming without the need for PIV imaging. This approach opens the door to studying fluid-body interactions in fish schooling and other dynamical systems.

Mechatronics Enabled Smart Solutions for the Geriatric Community

Student(s): Jonathan Miles
Faculty & Mentors: Vikram Kapila, Hassam Wazir

Currently the global geriatric population is 617 million and is expected to grow to 2.1 billion by 2050. The elderly live with many ailments; ranging from cognitive illnesses to physical disorders. For an elderly person to receive adequate care the amount of nurses and hospital staff would need to raise rapidly, as the elderly population already outnumbers nurses 10:1. To help supplement the demand for care that the geriatric community requires it is important to develop intuitive mechatronics. Here we know that the needs of the exponentially growing geriatric community can be met by assistance from mechatronics. Through mechatronics an elderly person with dementia can undergo meaningful reminiscence therapy that leads to a feeling of fulfillment. Mechatronics also allow for real time gait analysis which could lead to a knee brace that can detect when an elderly individual may fall. This research proves that there are manufacturable smart solutions that improve the quality of life for the rapidly growing geriatric community. We anticipate that this research will lay the framework for future research as the products need to be continuously re-worked to make them simple and easy to use for the elderly.

Estimating Gun Prevalence in the United States

Student(s): Gianluca Astudillo
Faculty & Mentors: Maurizio Porfiri, Roni Barak Ventura

Accessibility to firearms has been repeatedly correlated with incidences of gun violence. In the U.S., the number of firearms has reached 385 million in 2016; 20% higher than the country's population. The U.S. also has the highest firearm homicide and suicide rates among developed countries. In order to properly study the effects of firearm prevalence on violence and to legislate effective firearm laws, researchers and policymakers need to accurately comprehend gun prevalence. However, the exact number of guns in the United States remains unknown; indirect measures such as rates of suicides committed with guns and the number of hunting licenses are commonly used to approximate gun prevalence. We sought to analyze the viability of previously studied proxies of gun ownership. We collected data on 15 proxies, between 1999 and 2016, and conducted a statistical analysis to evaluate their correlation with gun ownership, as reported in a national survey. In addition, we explored the viability of background checks and Google Trends word search as proxies. Our efforts will contribute to the validation of proxies, as well as lay the foundation to future longitudinal research on gun prevalence.

Real-time machine learning based tracking and data-driven modelling of fish behavior

Student(s): Vrishin Soman
Faculty & Mentors: Maurizio Porfiri, Giovanni Polverino, Mert Karakaya

Accurate, efficient tracking methods are essential to study the behavior of animals, including zebrafish – a common model organism. Many computer-vision methods are based in image processing and require precise manual thresholding and tuning of detection parameters, often specific to experimental setup and lighting conditions. However, recently developed object detection tools can run in real-time, adapt to the changing shape of fish during swimming, and cope with noisy or augmented input images after training through machine-learning. One such tool, YOLOv3, further optimizes scale-invariant detection, which may benefit identification of many visually similar species of fish at varying life-stages. In this project, we attempt to combine this tool with state-of-the-art particle filtering techniques, often used for nonlinear estimations on stochastic datasets. A particle filter informed by a jump-persistent turning walker (JPTW) model – a motion model frequently utilized in the research of social dynamics and collective behavior of zebrafish – may increase the accuracy of tracking, compared to the standard constant velocity model. This project aims at developing multifaceted object-detection software to accurately track visually similar and commonly studied fish in controlled conditions. The project also aims at determining significant statistical parameters of the JPTW model automatically, offering a new framework for behavioral modelling.

Virtual Reality Interface for Citizen Science-Based Telerehabilitation

Student(s): Kora Hughes
Faculty & Mentors: Maurizio Porfiri, Roni Barak Ventura

Stroke survivors commonly suffer from hemiparesis- unilateral muscle weakness that limits limb mobility and encumbers the performance of daily activities. Recovery from hemiparesis requires adherence to a rehabilitation regimen, consisting of high-intensity exercises. While these exercises are often perceived as tedious and boring, the integration of citizen science can motivate patients to adhere to their prescribed regimen. Furthermore, by interfacing rehabilitation with a commercial gaming controller, patients can receive remote feedback from therapists, significantly reducing the temporal and fiscal costs associated with outpatient rehabilitation. In this project, we develop a platform to enable hemiparetic patients to participate in a citizen science project while performing bimanual training within an immersive VR environment. The Oculus Quest and Touch controllers' built-in accelerometer and gyroscope sensors gather data on the patients' movement all while providing the user with haptic feedback. These data are then used to intuitively control the cursor and menu within the interface. While the game's difficulty is calibrated relative to the patient's physical ability and motivation, the patient and therapist can manually adjust the difficulty of the game as they see fit. This affordable platform could benefit not only stroke patients but also the scientific community through the recruitment of citizen-scientists.

Steganography in stereolithography design files for additive manufacturing product authentication

Student(s): Angela Yi, Phoebe Zhu, Caleb Beckwith, Johnny Yang
Faculty & Mentors: Nikhil Gupta, Ramesh Karri, Gary Mac

Additive manufacturing has exploded in popularity and efficiency of use in industry over the past several years. Starting off as a simple tool used to create photopolymer prototypes of potential products, it has since become an efficient and effective tool necessary for some parts to be created and implemented in products in just about every industrial application. As this technology evolves, so does the risk of losing data. Throughout the process of additive manufacturing, data can be lost through malicious action or sheer accident. Our project focuses on our research into stereolithography (STL) files for product authentication against counterfeits as well as methods of encryption and obfuscation of important data within. Using methods of encryption such as steganography and embedding code within STLs or other computer aided design (CAD) files, we can hide either the files themselves or sensitive information within the files allowing the manufacturers to safely hide files when sending them and validating the files' authenticity when receiving them. Certain pieces of metadata or design parameters are often contained within these STL and CAD files which can be observed and retrieved using a simulation process known as finite element analysis (FEA). Design parameters such as mass and volume are highly sensitive to any changes to the geometry. Changes in the mass and volume can inform the engineer whether there has been a modification made to the geometric design parameters or material. If we can store this information within the STL file and hidden from adversaries, it can be a good validation method to determine if the product has been changed. This technique can be expanded to FEA simulation results. Simulation analysis is sensitive to the input parameters and the geometry of the part. The research focuses on hiding acceptable simulation analysis into the STL file to be used as a method of authentication. A new FEA analysis can be run on the STL file and compared with the hidden FEA results to determine if there has been any sabotage attacks performed on the design file before sending it to be manufactured.

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3D Printed Biomedical Devices

Student(s): Sofia Chavele-Dastamani
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This project closely researches the use of 3D printing for crisis response and healthcare, exploring best practices in large-scale rapid prototyping for humanitarian relief and community assistance. From hurricanes and earthquakes to COVID-19, 3D printing provides an affordable, sustainable solution to decentralizing manufacturing, providing a more community-based, large-scale approach to disaster response. It can simplify supply chains and logistics for urgently needed equipment in isolated areas, allowing professionals to fix and prototype specialized medical devices in hours. We explore methods, tools, materials, and approaches to 3D printing in crisis relief, working towards the development of a comprehensive guide of best practices.

Using a hands-on approach to the exploration of 3D printing, and in cooperation with Occupational Therapists at NYU Langone Hospital, we researched and designed biomedical devices that directly address needs of patients, such as a zipper pulls for patients with movement issues. In response to COVID-19, a general use assistive clipping device that can aid patients with telecommunications while hospitalized and isolated during the pandemic was designed, prototyped using 3D printing, and provided for use at NYU Langone.

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Optimal Modulation in Quantized Wireless Systems: A Machine Learning Approach

Student(s): Xinran Yang
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Millimeter wave (mmWave) is a promising candidate for high data rate transmission in the next generation of wireless networks. However, mmWave systems suffer from high power consumption which is an obstacle for the practical implementation of these systems. High resolution analog to digital converters (ADCs) have been identified as the major source of power consumption in these systems. Therefore, to reduce power consumption, it is suggested to use low resolution ADCs instead. Nonetheless, using low resolution ADCs negatively affects the performance of the system and lowers the achievable rate. In this project, we consider a multiple-input multiple-output mmWave system with low resolution ADCs at the receiver side and investigate the achievable rate of the system. Finding the optimal encoder and decoder that maximize the achievable rate of the system is a complex optimization that is not mathematically tractable. As a solution, we use a machine learning approach to solve this problem. More precisely, we model the communication system as an autoencoder and train the system to learn the optimal encoder and decoder that maximize the achievable rate of the system.

Establishing a Digital Crowdsourcing Platform for First-Hand Data Collection and Information Sharing on Availability and Prices of Critical Resources in COVID-19 Affected Areas

Student(s): Zijie Wu
Faculty & Mentors: Quanyan Zhu, Junaid Farooq

During the spread of viruses with no known cures such as the COVID-19, uncertainty can generate fear and anxiety, which may spread faster than the disease itself. This is resulting in panic-buying and over-reactive consumer behavior. It involves behaviors such as overstocking of preventive equipment, e.g., masks, sanitizers, etc., and theft of supplies from public facilities such as hospitals and shelter homes, leading to lack of resource availability for emergency managers and those in dire need. Moreover, when these behaviors occur in a large and dense population such as NYC, the resulting shortages in supplies may further aggravate the spread of viruses instead of pacifying it.

The goal of this project is to collect data from multiple sources such as news articles and web trackers to process and analyze the changes in consumer behaviors in New York state. We aim to identify the buying patterns and correlate them to information availability and news reports. The research can help to predict future panic buying and shortages, which can help the government to plan ahead and develop a more effective resource distribution during the COVID-19 outbreak.

Understanding brain functions through analyzing neural activity signals

Student(s): Diana Gomez, Asma Khursheed
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In the brain, speech production and recognition has been researched to involve the frontal and temporal cortex regions of the brain such as the Superior Temporal Gyrus and Broca's area. Our research strives to further investigate how these regions react to 5 different language tasks that include - picture naming, sentence completion, visual word reading, auditory word repetition, and auditory naming using ECoG data. With this ECoG data, we are now interpreting the data and applying Deep Learning methods to this data and decoding speech. I am focusing on applying Deepspeech to transcribe the audio and then using the transcribed audio with the program Gentle to detect the onset times for each word. There are also other students that are focused on obtaining onset times using different approaches. Spectrograms would then be made for each approach to compare how the results (such as onset time) differ. We are focusing on getting the most accurate onset time and the cleanest audio as possible in order to use this for the main idea of this research project, which is further investigating how brain regions function with different language tasks by using neural activity signals.

STIMULUS SPEECH DECODING FROM HUMAN CORTEX WITH GENERATIVE ADVERSARIAL NETWORK TRANSFER LEARNING

Student(s): Asma Khursheed
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The speech stimulus from a neural activity can be read via electrocorticography (ECoG Signals) from the electrodes placed on the surface of the cortex. This signal data can be used to construct a brain-computer-interface (BCI) application that translates the active neurons in the ECoG signals to what words the brain is "thinking" of producing. Patients with intact temporal and motor regions of the cortex can comprehend and produce speech. But damages to the inferior frontal lobe leads to an inability of speech articulation and muscle movement in the speaking apparatus of the body. These patients can benefit from a BCI that can read what the patients want to say and outputs their speech for them.

However limited training data for these deep learning models have downgraded the quality and accuracy of speech produced from these BCI. This project's approach uses a pretrained generator to predict realistic spectrograms of the spoken word, from the representation space. Thus overcoming the problem of limited training data. This project focuses on improving the encoding of ECoG recording, generating spectrograms, and transforming it into audible waveforms using Generative Adversarial Network (GAN) transfer learning.

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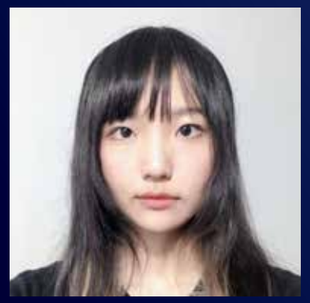

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Subsurface Testbed

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The city of New York has been prosperous for years, yet a rich history often comes with aging infrastructure and previous generations of construction. While the information and problems for over ground constructions are common and relatively well understood, collecting and integrating information and problems for subsurface constructions pose major challenges due to the complexity, opaqueness, and inconsistency of the data. These are in addition to technical difficulties in processing, storing, and integrating the data. The goal of this project is to harvest and integrate existing data about existing construction, utility failures, and storm information (both historical and predicted) and to use this information as the basis for future, neighborhood-level, performance, as well as infrastructure investment planning. This summer, an integrated subsurface map will be created in a Geographic Information System. The immediate goal is to show the horizontal and vertical relationship between underground structures of Sunset Park, Brooklyn. Self-reporting from 311 calls from 2010-present will then be overlaid on this data. A risk prediction will then be made from a combination of historical, water-related damage with respect to newly published FEMA maps.

BIM for Subways: an Ontology of Subway Stations

Student(s): Gabriel Agostini, Sandy Zhang
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Building Information Modelling (BIM) allows architects, engineers, and policymakers to collaboratively consolidate data on several aboveground urban systems. This technology has no correspondent in underground systems such as subway stations, although they represent an important part of the urban experience. Since subway stations need constant maintenance and upgrading, having a comprehensive framework for asset management is a logical step for a system that transports over 5 million people daily. Current BIM systems cannot be directly applied because they lack rules to represent underground constructions. To overcome that gap, this project will devise a systematic way to represent the more than 1500 items that were recently catalogued in the inventorying of the passenger areas of 8 New York City subway stations. The representation will be in the form of an ontology: each item will be described by its physical characteristics, spatial location, and relationship to other items in the inventory. We will also address the uncertainty that exists when dealing with items in the underground, and incorporate this probabilistic aspect into our ontology to facilitate asset management. With that, we believe our ontology will become a user-friendly language for those dealing with underground systems just as BIM is for the aboveground.

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

Student(s): Marija Trifkovic
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Light Detection and Ranging (LiDAR) technology produces information about the shape and surface of an object or region. The scanner emits light beams, which reflect off the target's surface. This technique gathers data sets with billions of points. Thus, storage, processing, and visualization of such data sets is computationally demanding. To resolve this issue, traditionally data sets have been gridded and divided into tiles. This data management strategy results in discontinuities and/or redundancies at tile boundaries and limits accuracy of data retrieval to a single tile. Consequently, a platform that allows precise data retrieval and avoids unnecessary data processing is needed.
This project focuses on developing a Graphical User Interface (GUI) for LiDAR data retrieval and visualization for such a system. The GUI is an access gateway to a distributed spatio-temporal database system. It allows selection of a two-dimensional area of interest and visualization of the three-dimensional model of that area. To improve the application, functionalities of data retrieval and visualization platforms have been identified and compared and one has been selected for implementation. The feature currently under development will offer information on area location and shape and location modification tools, preventing redundant information selection and insuring desired point collection.

Aerial Lidar Data Restoration with Convolutional Neural Network

Student(s): Angie Zhao, Dongdong Sun
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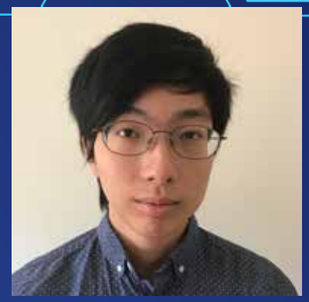
The constant presence of vehicles (parked and in transit), interferes with obtaining complete documentation of urban areas when using line-of-sight technology such as light detection and ranging (LiDAR). Resulting scans are both incomplete due to parked vehicles and can contain high degrees of noise due to vehicles in transit, which then requires extensive cleaning of the datasets. Thus, the goal of this research is to implement a machine-learning algorithm to automatically detect vehicles, remove them, and restore the road surface. Contrary to ordinary machine learning algorithms that convert point cloud data to voxels or downscale them through a two-dimensional (2D) conversion, the proposed algorithm directly employs the original three-dimensional (3D) coordinates and the points along with their intensity values. The proposed vehicle detection model is based on a directionally-constrained, fully convolutional neural network (D-FCN), which was trained on a fully labeled, publicly accessible aerial LiDAR data set of 4 pts/m2. dataset. The algorithm is then implemented on a denser dataset in Brooklyn New York. The output of this algorithm is highly appropriate for urban planning and road asset management.

Computer Science and Engineering



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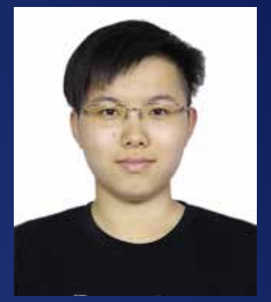

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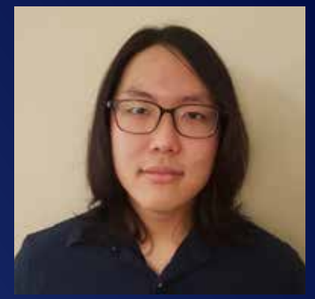

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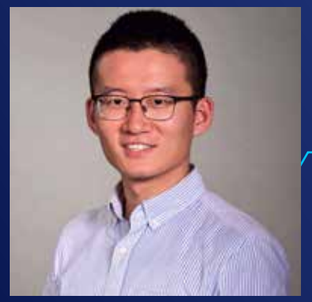

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Making Clustering Interpretable with Surrogate Decision Trees

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Clustering is a technique that groups members of a dataset such that members within the same cluster have similar characteristics. However, clustering does not communicate which attributes define a cluster or distinguish two clusters. This creates a problem in interpretability when there are tens or hundreds of attributes, which is true of many real life datasets. Moreover, models are less likely to be adopted if their method of assigning clusters is unclear, even when the model otherwise performs very well. Our proposed solution is to use a decision tree as a surrogate, trained on the same data as the clustering model, with the goal that the two models will give the same outputs for a given input. At each interior node, there is a rule involving a specific attribute and threshold. A data instance continues left or right depending on whether it follows the rule. The tree can be visualized in an interactive interface, which allows users to set tree complexity and see how well it approximates the clustering model, and find patterns in the dataset more easily than with the traditional method of a Parallel Coordinate Plot.

Debugging Multi-labeled Sound Data

Student(s): Ayden Wang
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Training a machine learning model for classification typically requires a set of data whose ground truth labels are known. This training set is often labeled by crowdsource workers who are typically not domain experts and might make mistakes. In order to improve the performance of the machine learning model, we need to identify and correct the mislabelled instances in the training set.
In this project, a platform is developed to aid the user in debugging a dataset where one instance can have more than one label. A visual representation of the dataset is constructed and the system will help users identify and validate possible incorrect labels. Then, the batch of validated instances is fed into a correction module that adjusts the rest of the dataset based on the validated labels. The system will iteratively validate more labels and propagate the changes until the user is satisfied with the accuracy level of the dataset. The efficiency of the platform will be validated via a case study with the Sound of New York City (SONYC) data, which are recordings of urban street noise in New York City.

Cachecash

Student(s): Ge Yang
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CacheCash is a decentralized, cryptocurrency-based CDN (Content Delivery Network) solution for different purposes and usages. Modern companies or individual users can take advantages of Cachecash to avoid attacks happen during the retrieval of certain content on the internet. Without a central control, CacheCash allows end users to set up new “caches” in exchange for cryptocurrency tokens when their caches happen to serve others’ content retrieval request. This model also allows the publisher to throw away the expensive traditional data center for content delivery; instead, the publisher can now “hire” end users’ caches as needed. CacheCash also takes ideas from papers such as CAPnet, a defense mechanism against cache accounting attacks, and MicroCash, a way to make micropayment more suitable for delay-sensitive applications, such as this one.

We have successfully deployed the service on Edgenet, a kubernete-based internet testbed and are currently improving the performance of the model as well as debugging on Edgenet.

Agent-based modeling for epidemics

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Agent-based modeling has been used to simulate complex systems that cannot be defined by a set of equations or pure statistical analysis. By defining the behavior of individual agents, agent-based modeling allows us to simulate the behavior of the whole system.

Indra is an open-source agent-based modeling system that seeks to create a way for users to easily create new models or configure pre-existing ones. The system is designed and updated to allow new and returning users to do so without extensive knowledge of the whole system.

The newest addition is the epidemics model that simulates the spread of an epidemic in a population. The model is highly configurable, letting users set various characteristics of both the virus and the behavior of the individual agent(person) in the population. The model calculates the R0 value of the disease, using the data generated by the model, documenting the intensity of its spread. The model simulates the effectiveness that preventive actions, such as social distancing, can have on the spread of a disease.

Indra is built using Python, AWK, Bash, and YAML, Javascript. Additionally, the system has a web front-end to allow users without programming experience to run the models.

Practical Software Supply Chain Security

Student(s): Benjamin Wu
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In the software development process, code is first written and tested, then packaged, and finally distributed to clients. This sequence of steps, known as the software supply chain, verifies the state of the project in order to drive it to a final product. But what happens if an attacker controls a step in the software supply chain? A supply chain breach potentially allows an attacker to affect multiple users at once by introducing backdoors in the source code to including vulnerable libraries in the final product. Although many frameworks exist to ensure security in the last mile (e.g., software updaters), they may be providing integrity and authentication to a product that is already vulnerable or compromised.

To prevent supply chain breaches, in-toto is designed to ensure the integrity of a software product from initiation to end-user installation. It does so by making it transparent to the user what steps were performed, by whom, and in what order. As a result, in-toto allows the user to verify if a step in the supply chain was intended to be performed and if the step was performed by the right actor.

Efficient Candidate Generation in Search Engines

Student(s): Kejian Shi
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The goal of a search engine is to return most relevant documents quickly and efficiently. Scanning through all documents (web pages) with monotonic complex ranking functions creates too much efficiency issues. Accordingly, cascading ranking architectures use progressively complex ranking functions to generate top candidates rapidly while retaining relatively good quality. Appropriate index structures and the ordering scheme of postings are key components cascades' design. Traditional impact-score based ordering (such as BM25) sometimes become intractable, in which term dependencies might impair the quality of the results. Though not gaining much research attention, Predictive Indexing is a framework that learns an ordering of index postings, by canonicalization of queries and other strategies. Improvements have been empirically observed in settings such as internet advertisement and approximating nearest neighbors. Our work is to answer the question: Is Predictive Indexing viable for general web search? Particularly for our project, could it be a solution for the candidate generation problem? Concerns exist because the algorithm is expected to require running huge numbers of queries to observe useful patterns, and the scoring of documents need to be carefully designed. Our objective is to analyze and experimentally evaluate different variants of techniques, by addressing 1) how to cover a query space Q with a subset of queries, with foreseeable sparsity of the data and associated computational burdens, and 2) how to compute the ordering of documents within each subset, possibly via the aggregation of weighted ranks.

Load Balancing and Query Routing in Large Search Architectures

Student(s): Jingxian Xu
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Interactive online services, such as web search, social networks, and messaging applications, need to provide fast responses to user requests. For example, as often specified in Service Level Agreement, 95% of requests should have response within 100ms. To satisfy a user request, an interactive service issues one query, or several queries as components of the request where the response can only be returned to the user if all queries have been answered. But it is always possible that some components get answers later than others. One solution to meeting the requirement on response time is to replicate the resources and reissue requests to some different machines with the same data. Reissuing requests too often will put too much load on the system. But if requests are reissued too late, they will not finish before the latency target.

We build upon previous work on optimal reissue policy in cases where each request consists of one query. Kaler, et.al. showed that under certain restrictions reissuing once is simpler but at least as effective as reissuing for multiple times. We generalize their result, look for the cases where reissuing more requests perform better, and design an online algorithm that approximates the optimal choice.

Securing the Software Supply Chain using in-toto

Student(s): Isha Dave
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A 'software supply chain' is a complex process to develop software that involves the release of code, quality assurance, build, and deployment by end-user. Securing this supply chain is crucial to the overall security of a software product. If an attacker is able to control any step in this chain, they may be able to detrimentally tamper with its functioning and output. To enforce the integrity of the software supply chain, 'in-toto' is a framework that gathers cryptographically verifiable information about the chain itself. It ensures that only authorized steps are performed, and only by authorized personnel. Specifically, an in-toto layout establishes the steps of your software supply chain, specifying the roles of the members (functionaries) and the coordinated working, to ensure to clients that the software was produced exactly as intended.

Currently, a filesystem-snapshot is being set up and further enhanced to give the user a sense of how the filesystem they were working with changed before and after carrying out a step or modifying the code-base. Moreover, a functional testing framework for the layout-web-tool is also in the works.

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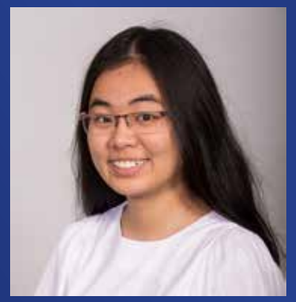

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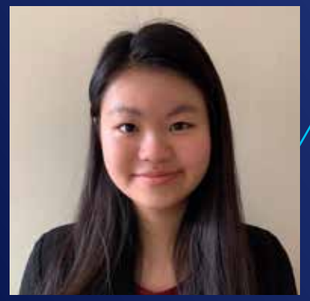

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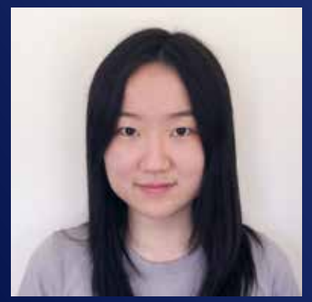

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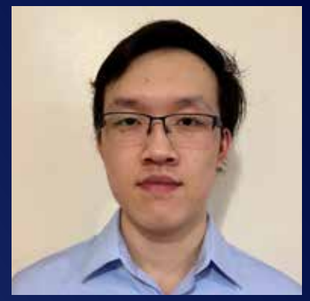

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Variability in the Photodegradation of Pollutants and Microbes Due to Cloud Cover

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Photodegradation by sunlight is an important pathway for the decay of microorganisms and manmade pollutants in the natural environment. In order to model this process, the sunlight that actually reaches the surface of the Earth, known as irradiance, needs to be quantified. Variation in the quantity of sunlight that reaches the surface depends on the composition of the atmosphere and other environmental factors. In particular, cloud cover is expected to have a substantial impact on irradiance. This research study aims to quantify the impact on the photodegradation of pollutants and pathogens due to cloud cover. The National Renewable Energy Laboratory (NREL) has consistently collected data on cloud cover and sunlight intensity since late 2017 at high temporal resolution (i.e., every ≤10 min). Data were downloaded and processed by truncating times when the sun was near or below the horizon. Models were created to show the correlation between variation in irradiance and cloud cover and to predict the impact of this variation on degradation in the natural environment. Results are expected to show that increasing cloud cover causes a decrease in irradiance with a larger decrease in irradiance observed at UVA wavelengths compared to UVB wavelengths. Consequently, as cloud cover increases, the modeled photodegradation of pollutants and photoinactivation of pathogens decreases.

Physics-based Simulation with Mobile Robotics for Collective Additive Manufacturing

Student(s): Uljad Berdica, Yuewei Fu
Faculty & Mentors: Chen Feng, Ruoyu Wang, Wenyu Han, Xuchu Xu

Simulation of manufacturing processes has become increasingly more necessary as they provide a systematic study of the possible issues and help minimize costs. Mobile 3D printing is an emerging technology that overcomes the inherent disadvantages of classic static 3D printing. Given the nature of mobile 3D printing, simulating the process of printing of various types of materials and the integrity of the resulting structure becomes of paramount importance. Current advancements in this field are based around chunk-based slicer methods that do not take into account the change of material behavior over time. This research looks into the most innovative material simulating techniques like Material Point Method, Smooth Particle Hydrodynamics, Finite Element Methods, and their hybrids in order to create a reliable plugin that can be used in Gazebo to enable the simulation of realistic visual of viscous materials output and allow mobile 3D printing robots to operate with respect to spatial and physical restrictions. This work aims on combining existing simulation software with remeshing algorithms and more efficient integration schemes to optimize computational cost and provide a useful tool for future mobile 3D printing developments.

Image-based Place Recognition in Urban Areas

Student(s): Chaerin Lim
Faculty & Mentors: Chen Feng, Ruoyu Wang

Place recognition in computer vision has many real-world applications, such as navigation in outdoor environments and self-driving. In this research, we focus on improving the current pipeline that utilizes three methods PoseNet, VLAD, and NetVLAD. We aim to solve the disadvantages in the baseline methods—inefficient COLMAP reconstruction of outdoor urban settings and non-scalability.

To improve the pipeline, we collected our own dataset and conducted various field tests to reproduce results from an urban environment. We investigated and tested two methods: visual SLAM (Simultaneous Localization and Mapping) and deep-learning-based feature extraction. We approach the aforementioned problems with a SLAM tool, ORB-SLAM2, to easily reconstruct the camera pose and trajectory as a replacement for COLMAP, and convolutional neural networks (CNN) for feature point detection, such as SuperGlue and SuperPoint. Implementing these new methods into the pipeline will make place recognition more scalable and applicable in the real world. This system can further be tested and deployed to help visually impaired persons to navigate through a complex urban area.

Coordinated Intersection Control for Autonomous Vehicles

Student(s): Zev Nicolai-Scanio
Faculty & Mentors: Li Jin

With the potential for the widespread adoption of autonomous vehicles becoming technologically and economically feasible in the mid to near future, there is a need to consider virtual traffic policing mechanisms that will manage self-driving vehicles on the open road. In particular, intersections are a point of interest, as they are currently major contributors to congestion in urban transportation. The concept of Internet of Vehicles (IoV), which is a system that connects autonomous or non-autonomous vehicles with wireless communications, is expected to lead to significant improvements in traffic flow. Traditional intersection traffic control systems such as stop signs and traffic lights are greatly limited by the fact that (i) they must clearly communicate signals to human drivers and (ii) drivers can only communicate with very restrictive channels such as vehicle lights and horns. With coordinated, autonomous control, however, there are numerous novel algorithmic intersection management possibilities. In this project we attempt to leverage these new possibilities. Working within the open source Simulation of Urban Mobility (SUMO) traffic simulation package, we design, implement, and test a series of different intersection control algorithms under a diverse array of traffic conditions. We also simulate existing intersection management systems as a performance baseline for comparison. The expected products include a quantification of the potential benefits of intersection coordination as well as an empirical comparison between a class of coordination algorithms.

Modeling City Level Demand Patterns for Micro-transit Operations Planning

Student(s): Harpreet Kaur
Faculty & Mentors: Joseph Chow, Srushti Rath

Transport system analysis requires the study of different transportation networks and activity patterns of a city. Studying this is imperative as they are significant contributors to transport modeling. To develop travel options, in this project we are have studied a specific on-demand microtransit known as VIA. VIA is a public transit company that takes many passengers heading towards the same direction and books them to a shared vehicle and also offers private ride options comparable to taxis. In this project, we examine six specific cities and make use of zone attributes and the movement of people to define city structure and determine which microtransit operation should be provided in that region. The operation types include fixed, flexible, door-to-door, virtual stops, first-mile access, and last-mile transfer. Previous studies have analyzed the quality of the services when compared with ride-hailing services and fixed-route bus lines. To build upon this we will be analyzing key attributes in each city to determine the optimal service for that region. The goal is to create city level models for deployment decision making. We gather city-level attributes by making use of the publicly available American Community Survey data which considers social, economic, housing, and demographic characteristics, National Transit data, and the National household travel survey to understand a city's structure and develop aggregate mode choice models for each region. This is useful for multiple microtransit companies who can apply this model to understanding demand patterns in each region.

A Bike Count Forecast Model with Multimodal Network Connectivity Measures

Student(s): Divya Bade
Faculty & Mentors: Joseph Chow, Bingqing Liu

Studies show that the continued increase in active mobility such as bicycling will improve public health while simultaneously reducing air and noise pollution in congested areas. In order to meet policy goals and performance measurement guidelines encouraging this trend, states, regions, and cities increasingly need to account for bike trips in planning and investment decisions. Accurate models of bike flow help agencies such as NYC DOT better understand the factors that contribute to increased bike demand on certain roadways and to carry out effective transportation planning and investment in bike facilities and built infrastructure.
This study aims to present a predictive modeling approach to forecasting bike ridership volumes at different links in a road network. In addition to location attributes such as population density, land use density, and proximity to transit stations, we calculate a measure of the connectivity, or importance, of each link within the road network. Representative bike trips for a set of origin-destination pairs were generated and optimized for bike-friendly travel to determine the probability of a link being traversed. Such a measure has not previously been included in bike flow modeling research and was shown to significantly improve the accuracy of the base model.

Resilient highway traffic control under cyber disruptions

Student(s): Ziyan An
Faculty & Mentors: Li Jin, Yu Tang

Traffic management is aimed at providing the optimal arrangement of all physical traffic, considering factors such as density, speedy, flow, and occupancy. Benefits of traffic management were numerous, including avoiding congestion, improving traffic efficiency, and maximizing road space. However, the result of traffic management relies heavily on the performance of sensors and the quality of data, which are undependable and hence adversarial to traffic modeling and analysis. Although previous work has been done on offline traffic data imputation with deep learning, this study presents an innovative approach by designing an online data imputation model to acquire qualitative data, which will further facilitate the traffic management process. We focus on training neural networks to predict missing values as well as comparing and representing the result with the original incomplete dataset. The imputed data will also be used as input of Cell Transmission Model (CTM), which predicts and represents highway traffic dynamically.

Electric vehicle operation simulation for a mobility-on-demand service

Student(s): Michelle Ren
Faculty & Mentors: Joseph Chow, Gyugeun Yoon

Mobility-on-demand (MOD) refers to the utilization of different modes of transportation in order to create more efficient and complete travels. These MOD systems vary regarding service types and user-system interactions. Door-to-door service is a type of MOD service that lies between conventional fixed route transit services and personal vehicles as it directly moves passengers from origin to destination with publicly shared vehicles. Typically, vehicles travel longer distances to process trip requests which results in higher operational costs. Using conventional vehicles in MOD services also increases carbon dioxide emissions due to the increased trip length from detours. This project aims to build a MOD simulation in Python for the operation of electric vehicles and compare its performance to that of conventional vehicles. The simulation will take into account not only the operation aspects, such as vehicle mileage and the location of charging stations, but also the user's experience, which is represented by wait and in-vehicle time. It is expected that utilizing battery electric vehicles can greatly reduce emissions, but the need to visit stations to recharge can cause inefficiency.

Cyber-physical security analysis of public transit systems

Student(s): Dorothy Ng
Faculty & Mentors: Li Jin, Xi Xiong, Yu Tang, Qian Xie

Dynamic routing is used to forward incoming jobs using an optimal path based on the current state of the system. However, the system can be subject to random failures and provide nonoptimal paths. This research focuses on the impact of a random fault on the system and the application of a state-dependent defense strategy to counter random faults. In the state-dependent strategy, a random fault is considered an attack. The system may choose to defend against an attack by using additional resources to ensure an incoming job is forwarded onto the optimal path. Using this strategy, the system only protects an incoming job if the cost of defending is cheaper than the cost of a successful attack. To demonstrate this, we attempt to design and develop an algorithm that can estimate the technological costs of an attack and a defense for any given state, and determine the best action the system should take.

Change detection using point cloud data

Student(s): Andrew Liang
Faculty & Mentors: Semiha Ergan, Zhuoya Shi

In metropolitan settings such as New York City, many deteriorating buildings pose hazardous risks to civilians; in the NYC Department of Buildings Façade Safety Report, 912 buildings were labeled "Unsafe" to pedestrians in the previous inspection cycle. These periodic inspections are necessary to assess building conditions and serve as a preventative measure for public harm. However, the established methods are laborious, time consuming, and potentially subjective: 1) Visual observations must be carried out individually by professionals on-site, 2) defect conditions are personally photographed and subjectively hand-documented, and 3) manual comparative investigation between current and previous building conditions is required.

To streamline the comparison process and uphold holistic analysis, this project aims to introduce a data-driven, end-to-end pipeline for automating the detection of structural transformations over time, and objectively identifying emerging spalling, cracks, and other deformities in individual façades. The proposed inspection approach uses three dimensional (3D) point cloud data collected by Light Detection and Ranging (LiDAR) remote sensors, and investigates a computational deep learning implementation for the task. The architecture is influenced by computer vision algorithms and image-processing techniques for 3D scene analysis, as well as the synthesis of surface geometry features between two or more epochs of point data.

Deep Learning for Soft Robots

Student(s): Nhi Pham Le Yen, Xianhui Zhu
Faculty & Mentors: Chen Feng, Ruoyu Wang, Yanfei Xue

Soft bodies, made from deformable and flexible materials, have shown significant potential in many robotics applications. With high flexibility and adaptability, soft robots can actively and passively change their shapes for safe and effective interactions while performing a wide range of tasks such as grasping and manipulation. However, the high-dimensional deformation of soft bodies, which can hardly be fully measured by traditional methods, poses challenges on their proprioception.

This project is a continuation of our lab's 2019 project which successfully developed a framework to measure the high-resolution 3D shapes of soft robots in real-time with embedded cameras. In this project, we focus on extending the current work to address some challenges, including occlusion handling and latent shape dynamics, in a simulation setting. In particular, for heavy self-occlusion for complex soft bodies, we cannot collect the complete full-body ground truth point cloud. We aim to design an algorithm to accurately reconstruct the occluded parts and use the simulated dataset to test our approach. We also hope to use the simulator to train the neural network to learn the dynamics in the latent shape space.

Mobile Robots for 3D printing

Student(s): Mohammed Adib Oumer
Faculty & Mentors: Chen Feng

Commercial 3D printing or additive manufacturing (AM) is a booming industry currently limited to an immobile box used as printer. However, if we were to set the printers free to work in mobile, collaborative teams, the AM business will have unprecedented applications including automated construction that can go as far as assisting research on extraterrestrial environment such as Mars. This project focuses on planning and localization algorithms devoid of GPS that can allow multiple robots to construct a given structure optimally in any environment. The primary steps include performing literature review on existing research on decentralized (distributed) multi-robot algorithms and running simplified numerical simulations on decision algorithms such as Bayesian and Benchmark Decision-Making Algorithms. Most of the relevant literature bases the algorithms on a close analysis of mound-building termites that resulted in probabilistic features that can be simulated on python conveniently such as decision on the location of other robots and the current and predicted transient state of the structure under construction. Future work aims to have robots able to move quickly to printing area with no collision, observe the real conditions such as uneven ground, then make compensations immediately with tolerable if not perfect accuracy.

Flexible data representation in BIM

Student(s): Andy Deneris, Andrew Liang
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Today's buildings require 24 hour maintenance and inspection to insure the structural integrity of the building and safety of those in it. More specifically facade inspection is a difficult, but necessary process and can be seen as a great base for whole building inspection. Our project looks into creating a user-friendly platform to easily enter in any damages discovered on a facade. Using point cloud data we can model the facade initially, and then take in certain information to generate any damages or deterioration found on the facade. This allows for inspectors to easily enter in their reports, which digitally updates the 3D model of the building to include important damages.

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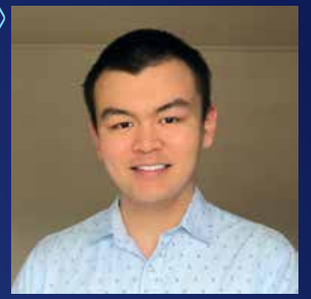

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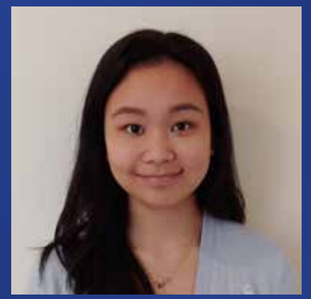

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Exploring the effects of non-canonical amino acids on catalytic activity of pesticide detoxifiers through computational design

Student(s): Bonnie Lin
Faculty & Mentors: Farbod Mahmoudinobar, Jin Kim Montclare

Organophosphates (OPs), a group of highly toxic chemicals that cause damage to the nervous system through inhibition of acetylcholinesterase (AChE), are often used in chemical warfare nerve agents as well as more commonly used herbicides, insecticides, and pesticides. Their undesirable side effects with human exposure have led to an increasing need for solutions to counteract the effect of OP toxicity. Many existing methods to detoxify OPs are inefficient and often require high doses, which directed us to a different approach using phosphotriesterase (PTE) from Pseudomonas diminuta that hydrolyzes OPs prior to its covalent interaction and subsequent inactivation of AChE. Although PTE presents itself as a more desirable candidate compared to traditional methods such as combination of atropine and oximes or butyrylcholinesterase, further modification is required to increase its catalytic efficiency. Previously, our lab has utilized computational modeling to generate PTE variants followed by experimental confirmation to explore and identify the candidate that hydrolyzes OP, specifically chlorpyrifos and paraoxon, at high catalytic rates. Further modifications of PTE variants through the global incorporation of non-canonical amino acids (NCAAs), specifically at the binding pocket, will allow added functionality and stabilization effects that are not possible with the naturally occurring 22 amino acids. We have previously shown that the replacement of phenylalanine outside of dimer interface with p-fluorophenylalanine (pFF) have beneficial effects such as enhanced activity in high temperatures. Here, we seek to re-design the binding pocket of PTE and improve its catalytic activity for acephate through incorporation of NCAAs by taking advantage of computational modeling software Rosetta. The goal of this project is to computationally identify the best PTE candidates based on their calculated binding energy from Rosetta simulations. Future studies will focus on experimental confirmation of these candidates with expression in bacteria followed by characterization studies.

Alignment of Urea Crystals in Non-Photochemical Laser-Induced Nucleation of Supersaturated Urea Solutions

Student(s): Angelica Moratos
Faculty & Mentors: Bruce Garetz, Omar Gowayed

When crystallization occurs in physical and chemical processes, there is usually limited spatial, temporal and morphological control over crystal formation. However, Non-Photochemical Laser-Induced Nucleation (NPLIN) of supersaturated solutions may provide better management over crystallization by increasing the speed of nucleation and improving control over crystal structure and size. In NPLIN, the electric field produced by a high intensity laser beam is suspected to impact the orientation at which the crystals form when supersaturated solutions are placed in the path of the beam. Researchers are currently exploring whether the Optical Kerr Effect—a phenomenon in which the electric field of polarized light is the primary factor that affects the refractive index of a material—is a mechanism for NPLIN. Studies have concluded thus far that a minimum laser intensity is needed for nucleation to take place and that a relationship exists between the supersaturation of solutions and nucleation with high powered lasers. There are two factors that will be analyzed from the data that are to be collected: the initial orientation angles of the urea crystals formed and whether the orientations change over time, rotating towards the electric field's direction of polarization. Here we will demonstrate any correlations observed between the laser beam's direction of polarization and the direction at which the crystals form and align. NPLIN can potentially provide greater control in localizing crystal formation, which is valuable in various fields like pharmaceuticals and cosmetics to improve product homogeneity.

Exploring effects of the dimer interface on the stability of pesticide detoxifiers through computational design

Student(s): Jakub Legocki
Faculty & Mentors: Farbod Mahmoudinobar, Jin Kim Montclare

Organophosphates (OPs) are a group of harmful chemicals that cause over stimulation of the nervous system by binding to the active site of acetylcholinesterase (AChE), an enzyme involved in the function of neurotransmitters, and preventing it from breaking down the neurotransmitter acetylcholine. A method for their removal has been devised using the enzyme Phosphotriesterase (PTE), obtained from Pseudomonas diminuta, which can hydrolyze OPs. This would prevent binding to the active site of AChE. However, more improvements can be made to PTE to increase both its stability and catalytic efficiency. PTE is only active as a dimer, and improvements in the effectiveness of the binding between the two monomers can potentially allow for a more effective and stable enzyme. Our lab has previously redesigned the binding pocket of PTE and improved its catalytic activity to hydrolyze paraoxon and chlorpyrifos using computational modeling via the Rosetta macromolecular package. In this project, we aim to computationally redesign the dimeric interface of PTE by employing oppositely charged residues on each monomer to form salt bridges between the two dimeric chains. Stronger binding at the homodimer interface increases the stability and shelf-life of PTE whereas higher dimerization rate may also improve the catalytic activity. Through computational modeling, we will identify the best PTE candidates based on their calculated free energy from Rosetta simulations. In further studies, the results of this project will be expressed in bacteria and characterized experimentally.

Large-scale Deposition of Quantum Dots for Commercial Applications

Student(s): David Sung
Faculty & Mentors: Ayaskanta Sahu, Haripriya Kannan

Since its first discovery, quantum dots (QDs) have gained interest in the research community for its unique electrical and optical properties and applications. Quantum dots, which are tiny semiconductors ~2-8 nm in size, have tunable bandgaps that allow them to absorb and emit light over a range of wavelengths depending on its size and shape. More specifically, adjusting the size of the QD particles in the synthesis process could control its optoelectrical properties. This has become particularly useful for devices such as solar cells, medical imaging devices, or LEDs, which require the absorption or emission of specific wavelengths.
Researchers have made promising progress in solar cell technology and X-ray imagining using quantum dots but were only able to achieve high efficiency in small lab-scale devices. Performance drastically decreased when these devices were scaled for commercial use, mainly due to quality defects that arise when depositing QD particles onto larger substrate surfaces. Different deposition techniques, including doctor blading, spray coating, and inkjet printing, have been developed to scale. This literature review will evaluate and compare the technical merit and usability of different deposition techniques to better understand which technique may be appropriate for different applications.

Computational Model for Amyloid Aggregation

Student(s): Yanmeng Liu
Faculty & Mentors: Jin Ryoun Kim

The project features a computational program designed to predict amyloid aggregation-prone hexapeptides under native conditions. The program is developed and to be optimized in MATLAB, for it has a set of built-in functions that are superior for processing matrices. The input to the program contains five different files, each helps to select hexapeptide candidates that meet the predetermined cutoff scores. The aggregation-prone sequences are then further analyzed and broken down into two groups: one that is solvent-exposed and the other that is embedded in the folded structure. The former is examined on its connection with protein flexibility and aggregation propensity. The latter is analyzed on its proximity to a flexible protein surface, which proposes risk for aggregation if near the surface. The program then synthesizes all the findings and categorically lists out aggregation-prone sequences. The accuracy is still to be improved by incorporating more recent literature data into the calculation of the cutoff scores.

Nanoparticle Electrochemistry

Student(s): Navkawal Mattu
Faculty & Mentors: Ayaskanta Sahu, Michael Scimeca, Shlok Paul

Nanoparticles (quantum dots) offer new materials that can have their properties tuned based on their size and bandgap. Properties that can be tuned include photoluminescence, electroluminescence, optical and electronic properties. In bulk materials, electrochemical reactions are used as sources for current, which can then be used for batteries to power up different devices. Although these are important uses, researchers have hypothesized that nanoparticles will be the basis of electronics in the future. This literature review focuses on the electrochemistry within these tunable quantum dots. Electrochemistry also plays an important role during nanoparticle synthesis, characterization, and performance testing. Nanoparticles can be synthesized using an electroplating mechanism. After synthesis, the particles can be characterized using electrochemical microscopy, which is an important step in increasing the fidelity of research studies. Along with characterization, the particle's electronic performance and its ability to transfer charge and generate current can be tested by probing it with a separate electrochemical reaction. This survey will also further examine the role of electrochemistry in the synthesis, characterization, and testing processes of nanoparticles

catalysis using earth-abundant materials

Student(s): Belinda Che
Faculty & Mentors: Ayaskanta Sahu, Steven Farrell

The development of renewable, clean, and economic energy sources has been in increasing demand. Between the possible options, hydrogen, which has a threefold energy density compared to gasoline, has demonstrated its potential to take the baton of energy resources. However, one of several unresolved restrictions that prevent the development of hydrogen economy is how to refine safe hydrogen storage and delivery system. Formic acid with a volumetric capacity of 53 g H2/L is seen as a safe candidate as a liquid hydrogen carrier. High-performance heterogeneous catalysts for the dehydrogenation of formic acid is a crucial factor in the development of hydrogen economy. Currently, hydrogen can be generated at ambient conditions using a precious metal catalyst such as platinum and palladium, however, we are investigating non-precious metal catalysts saving the costs of industrial production. We have previously doped MoS2 nano-catalysts with transition metals, and I am investigating how to apply these catalysts to formic acid, and how we can choose dopants to tailor the activity for this process. Currently, people have been used precious metal doped with copper, cobalt, and carbon, nevertheless, these metals are costly and how to tradeoff between selectivity and efficiency that is determined by turnover frequency remains worth thinking.

Non-Photochemical Laser-Induced Nucleation of supersaturated glycylglycine by optical tweezers

Student(s): Zosia Caes
Faculty & Mentors: Bruce Garetz, Omar Gowayed

Crystallization is a critical step in many industrial chemical processes, such as in pharmaceutical drug creation or consumable food purification, but it is not easily controllable or well understood. One technique of crystallization involves the use of optical tweezers, a tightly focused, high-intensity continuous wave (CW) laser beam that can manipulate particles in solution. It has been shown that some supersaturated solutions of amino acids and peptides nucleate in minutes, as opposed to days, when the focal point of a CW laser is directed at the air/solution interface, through a process termed Non-Photochemical Laser-Induced Nucleation (NPLIN). The nucleation of one such dipeptide, glycylglycine, may be controlled in supersaturated solutions with the use of optical tweezers. Here we demonstrate the nucleation of glycylglycine and explore the mechanism of NPLIN. Photon pressure from the trapping laser beam is likely a major contributing factor to particle movement, but there may be other variables that alter glycylglycine crystals. If this method of non-photochemical nucleation can be systematically understood and directed, it could lead to a novel pathway for crystal formation of glycylglycine, with broad applications toward the crystallization of more complex peptides.

Grain Structure Characterization for Block Copolymer-Salt Mixtures with Depolarized Light Scattering

Student(s): Ja Eon Cho
Faculty & Mentors: Bruce Garetz, Xin Wang

Block copolymer (BCP) - lithium salt mixtures have become promising solid electrolytes for lithium batteries because their robust mechanical strength can resist the dendritic growth which can shorten the lifespan of the batteries, while their high ionic conductivity reduces internal resistance. Analyzing the grain structure of the mixtures is important to determine their viscoelastic, adhesive, optical and electrical properties as electrolytes. However, the thermodynamics and kinetics for the grain growth of the mixtures have not been well established. Our group has developed novel methods to find parameters characterizing the grain size and structure of the mixtures using depolarized light scattering. Specifically, a mixture of polystyrene-b-poly (ethylene oxide) (SEO) with lithium bis(trifluoromethanesulfonyl)imide (LiTFSI) has been studied. As a major experimental procedure, the images of the diffraction patterns generated by light propagating through an ordered copolymer samples that is located between two crossed polarizers have been captured by a Lumenera CCD camera during annealing and quenching processes. Then, the intensity distribution of each pattern has been numerically processed and least=squares fit to both a Gaussian model and an exponential-decay ellipsoidal-grain model to obtain estimates of the average length and width of grains.

Exploring the effects of supercharging on pesticide detoxifiers through computational design

Student(s): Jason Chen
Faculty & Mentors: Jin Kim Montclare, Farbod Mahmoudinobar

Phosphotriesterase (PTE) is a dimeric enzyme capable of detoxifying harmful organophosphorus (OP) agents, which can be found in pesticides and chemical warfare agents. Exposure to OPs can be fatal and this hazard necessitates the development of effective OP detoxifying agents. Previous studies have demonstrated that mutating amino acid residues in the binding pocket or dimer interface of PTE can improve stability and catalytic function, thereby increasing detoxification activity. However, these PTE variants exhibited decreased soluble expression levels and were only able to hydrolyze a limited variety of OP agents. Recent findings show that “supercharging” proteins can enhance control of properties such as catalytic activity and solubility while maintaining the structure and desired functionality. Alteration of residues on the enzyme surface, beyond the binding pocket and dimer interface, may be crucial to enhancing such properties. Previously, our lab has identified supercharged PTE variants with increased functionalities for the OP agent chlorpyrifos through computational modeling via Rosetta, a macromolecular software suite. In this project, we aim to increase solubility of PTE variants which hydrolyze acephate, an organophosphate pesticide, through supercharging. Future studies will investigate methods to enable PTE hydrolysis activity for a wider range of OP substrates.

Amyloid Aggregation in Neurodegenerative Diseases

Student(s): Ryan L Lim
Faculty & Mentors: Jin Ryoun Kim

Understanding the kinetics of amyloid aggregation serves great importance in the study of many neurodegenerative diseases. The spontaneous aggregation of monomeric β-amyloid and α-synuclein to form fibrillar assemblies underlies the neurodegeneration associated with Alzheimer's and Parkinson's diseases, respectively. The kinetics of these two proteins can be characterized by two phases: a nucleation (lag) phase followed by a rapid elongation or growth phase. During the aggregation process, these proteins are denatured from their native state and self-assemble to form oligomers, which further elongate and laterally associate to form insoluble fibrils.

The goal of this lab was to use a set of differential equations to describe the transition rates between different assembly states, eventually developing a unique kinetic model for each protein that can be used to accurately predict individual protein behavior. While it was originally thought that the insoluble fibrillar product was the neurotoxic species, recent studies have shown that the accumulation of the soluble, oligomeric intermediate is responsible for the observed cytotoxic effects. Therefore, the study of amyloid kinetics can provide insight into possible treatments that may inhibit the conversion of monomeric species to oligomeric species or accelerate the conversion of oligomeric species to fibrillar species.

VIP IGEM

Student(s): Ankit Sharma
Faculty & Mentors: Jin Ryoun Kim

The increasingly prevalent issue of heavy metal contamination is defined by high concentrations in water that exceed quantities safe for consumption and can cause adverse health effects. Because water sources cannot be treated directly, researchers are working to develop methods for detection instead. While many successful detection devices exist today, none (a) detects multiple contaminants, (b) quantitatively and qualitatively measures contaminant levels, (c) is portable and affordable, and (d) reports results within the time of use.

To effectively combat this issue, the iGEM team at NYU is working to develop a biosensor capable of detecting heavy metals in drinking water. The biosensor consists of genetically modified E. coli that produces fluorescent protein in response to heavy metal detection and is fixed to a microfluidic "lab-on-a-chip" device that controls and showcases the detection reaction. Review of synthetic biology procedures, previous scientific literature, and previous iGEM team projects have guided key decisions regarding our biosensor design.

A preliminary gene circuit and mathematical model for lead (Pb) detection were developed along with a prototype for a microfluidic chip to evaluate the efficacy of our biosensor. Results showed that not only was the metal's operon design accurate, but that the concentration of metals can be estimated by the intensity of fluorescent protein. Similar research will be conducted for other heavy metals and experiments will then be performed to evaluate the biosensor's ability to detect these metals in real-time.

Catalysis using earth-abundant nanomaterials

Student(s): Hanlu Xia
Faculty & Mentors: Ayaskanta Sahu

Semiconductor nanoparticles, also known as quantum dots, have wide applications in many fields, such as photovoltaics, medical imaging, quantum computing, and energy storage. Perovskite structured quantum dots was believed to have supreme performance when applied in the photodetector, such as photodiode and phototransistors. This project was focused on the II-IV-VI class perovskite nanoparticles, such as BaZrS and SrTiS, and it is a class that has been barely explored for quantum dot applications. The Perovskite nanoparticle combinations in this project are designed to avoid costly rare materials in production and at the same time display comparable performance as their expensive counterparts. There are four proposed synthesis routes for this class: Thiol mediated, Dithiocarbamate decomposition, quantum dot seeds diffusion, and sulfurization. Among these four routes, the Thiol mediated and Dithiocarbamate routes were investigated in this summer. Although the application fields and properties of the II-IV-VI class Perovskite material remain unknown, they have displayed high reactivity under low temperature (100-200 Celsius) that is hundreds of degrees lower than their counterparts. For this project, our ultimate goal is to design a route that is the most cost-efficient, energy-saving, and has the highest yield of uniform perovskite nanoparticles.

Optimizing Organic Electrochemical Processes with Machine Learning

Student(s): Ju Hee Shin, Sunny Chantanakajonfung
Faculty & Mentors: Miguel Modestino, Angela Angulo, Daniel Frey

With the global initiative to reduce greenhouse gas emissions, the chemical industry has the potential to transition from thermochemical processes to electrochemical processes. Using machine learning algorithms can save time and resources to run experiments physically, accelerating the optimization of organic electrochemical processes. In the project, prior knowledge of mass-transport processes and kinetics are used to simulate the experiment with an active machine learning algorithm to find the hyperparameters with the best performance in the smallest number of experiments. These optimized hyperparameters are used to run the physical experiments, greatly reducing the number of experiments that need to be performed.

Electrification of the Chemical Industry: Where to Start

Student(s): Joseph Geniesse
Faculty & Mentors: Eray Aydil

The chemical industry produces 7% of global greenhouse gas emissions, and accounts for 10% of the US and global energy consumption. A center planned by NYU and ten other partner institutions, Center for the Electrification of the Chemical Industry (CECI) aims to reduce the carbon footprint of chemical manufacturing by innovating economic processes and systems where renewable electricity is the prominent energy source. CECI will achieve this goal through three strategies: (1) replacing traditional heating by fossil fuel combustion with electrical heating, (2) replacing thermochemical reactors with electrochemical reactors, and (3) replacing energy intensive separation processes such as distillation with membrane separations. This research aims to identify the chemicals and processes whose production emits the largest amount of CO2 and those that are high-value and high-margin. The first category being most impactful to the ultimate goal of decarbonization, and the second ensuring rapid implementation to promote long-term change. Using these metrics, 40 chemicals were identified and review research was conducted to determine their production methods, any barriers to electrification, and what attempts at electrification or CO2 reduction have already been made. This information will allow specific processes to be identified to guide the center with its future research.

Biosensors for Food Allergies

Student(s): Chase Rosenberg
Faculty & Mentors: Rastislav Levicky, Stephen Arnold , Vlad Frenkel, Yuxiang Gao

Biosensors are analytical devices capable of translating the binding of a target biological molecule and its capture site into a measurable signal. The Whispering Gallery Mode (WGM) biosensor is a device that utilizes the resonant wavelength shifts of an optical resonator to detect analyte binding. In this work, a silica microsphere acts as the optical resonator that is placed in the evanescent field outside the core of an optical fiber that guides light from a laser. When the laser is tuned to the right wavelength, WGM resonances are excited inside the microsphere. As the light from the fiber is coupled into the microsphere and circulates, it is captured inside by near total internal reflection. In a perfect microsphere, only one resonant wavelength exists; however, in a slightly prolate microsphere, many WGMs with unique resonant wavelengths can be formed.

The existence of multiple, spectrally distinct WGMs presents the possibility for a multiplexed biosensor. By attaching different food allergens to each mode on a prolate microsphere and observing their interactions with a person's antibodies, the immune response to food allergies can be analyzed. In this way, WGM biosensors can provide a real-time, label-free method for the characterization of a person's immune response.

Growth Factors and Nanoparticles as Critical Components of Synthetic Scaffolds for Bone Healing: A Review

Student(s): Priya Soni
Faculty & Mentors: Nathalie Pinkerton

Bone fractures are the most common injury in humans. It can take months up to years until a fracture properly heals. The current gold standard for large defect fracture healing is bone grafting, a surgical technique that uses transplanted bone tissue to repair damaged bones. However, this method is limiting in the amount of harvestable bone available and complications tend to arise with host-integration and vascularization. In recent years, the utilization of synthetic scaffolds combined with growth factors (GF) has shown to be a promising approach to accelerate bone healing. Previous research has shown that the use of nanoparticles within scaffolds can further expedite the healing process. The incorporation of nanoparticles improves the scaffold's mechanical properties, allowing it to mimic native bone. Nanoparticles also allow for a controlled release and protection of the GF to be delivered. This review aims to highlight various types of synthetic scaffolds, GF, and nanoparticles that can be used to create a sustainable hybrid nano-scaffold with controlled GF delivery to effectively promote bone healing. The fabrication of a hybrid composite system of this manner would improve current clinical methods for bone healing in the orthopedic field.

C2SMART

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Deep Learning-Based Object Detection For Pedestrians, Vehicles and Cyclists Density Approximation and Social Distancing

Student(s): Murat Ledin Barlas, Omar Hammami
Faculty & Mentors: Kaan Ozbay, Jingqin Gao, Fan Zuo

The fast-evolving COVID-19 pandemic has dramatically changed the traffic patterns and pedestrian behaviors. Recent advances in deep learning provide promising solutions to quantify crowd density through object detection and image/video processing techniques. A deep learning algorithm, based on a pre-trained convolutional neural network model, is developed to estimate pedestrian, vehicle and cyclist density based on information extracted from multiple real-time traffic cameras in New York City (NYC). The objective of the project is to improve the performance of the pre-trained algorithm by additional training using class-specific datasets and the application of a variety of pre- and post-processing filters. Improvements are then evaluated by object detection performance metrics. In addition, the distance between pedestrian pairs is calculated and compared with the suggestions from social distancing practices. The detection output obtained from the improved algorithm can help the public to have a better understanding of the actual reduction in social contact and the effectiveness of the social distancing policies. It can also provide authorities informative insight on tracking density trends during the reopening phases, to assist in developing effective response strategies or to plan for potential future scenarios.

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Exploring Mechanical Force Regulation of Asymmetric Vascular Cell Alignment

Student(s): Camden Rowe
Faculty & Mentors: Weiqiang Chen, Harry Peng

Cells interact with one other and the surrounding microenvironment in such a way that mechanical forces and external stressors (i.e. traction) are constantly experienced. Appropriate cellular responses must be maintained, including coordination on a multicellular level. This allostatic process can be observed in the asymmetric rearrangements of vascular endothelial cells (ECs) and is typically expressed as a collective clockwise or counterclockwise orientation around a physical boundary or region of high mechanical stress. This ability to adapt greatly impacts the physiological functioning of vascular systems; however, a gap in research prevents a complete understanding of disease impact on this asymmetric means of adaptation. This project compared the mechanical characteristics and multicellular coordination abilities of healthy and diabetic aortic-endothelial cells. Cultures were grown on mechanical force detecting substrates with a number of pharmacological treatments and varying glucose concentrations to simulate and regulate morphogenesis in-vitro. Imaging via traction force microscopy (TFM) of particle displacement in the substrate revealed that healthy and diseased ECs exhibited different cell alignments and forces. These findings were maintained across various tissue geometries and suggest that certain patterns of asymmetry relate to cardiovascular diseases.

Establishing a predictive and analytical model for CAR-T cell immunotherapy

Student(s): Kristen He, Zhenxing Wu, Siqi Du
Faculty & Mentors: Weiqiang Chen, Chao Ma

B-cell acute lymphoblastic leukemia (B-ALL) is one of the most common cancers in children. This is an aggressive type of leukemia in which too many B-cells are found in the bone marrow or blood. CD-19 targeted chimeric antigen receptor (CAR) T-cell has emerged as one of the most promising FDA-approved treatments, which works by binding the biomarker on abnormal B cells and releasing cytokines. Despite this, 30 - 60% of the clinical cases have unfortunately succumbed to leukemia relapse either of antigen-positive or antigen-negative (CD19+/-). In addition, we have a poor understanding of the relapse mechanisms. In order to understand how the interactions and competitions between leukemia blasts and other cell types drive CD19 CAR T-cell therapy resistance, and further predict the relapse probability of a given condition, we aim to establish an analytical and computational model to explore how CAR T-cell interacts with B-ALL and how other regulatory cells or factors may be involved. This model allows for the visualization of the disease progress, which could be further interrogated to elucidate the leukemia-immune interactions. We believe this model can be applied to optimize and predict CAR-T cell therapy, which will finally improve the long-term survival rate in B-ALL patients.

Exploring Single-Cell Mechanical Allostasis Through Ultrasound Tweezers

Student(s): Seojin Park (Lina)
Faculty & Mentors: Weiqiang Chen, Apratim Bajpai

Cells constantly respond and adapt to different external stressors to maintain homeostasis, a process known as allostasis. While allostasis is studied commonly within biology, it lacks research beyond the context of the broader theme in the field of science. The objective of this project is to differentiate between mechanical allostatic responses of different types of cells, which include vascular and immune cells. With the use of ultrasound tweezers, we were able to assess how a single-cell responds allosterically to external stressors without an advanced regulatory system in organismal level. Ultrasound tweezers create local forces to the cell via RGD-integrin binding of a microbubble bound to the cell membrane by shaking the microbubble. The mechanical force from ultrasound tweezers create a reaction, which allows us to observe the Ca2+ influx and any changes in the cytoskeleton (CSK) tension. The tension is measured through Cellogram, a software for reference-free traction force microscopy (TFM) images that creates force maps by using micropillar arrays to detect the typical length of basal stress fibers. The exertion of force from healthy and diseased cells were then compared to examine how they show mechanoresponsive allostasis differently.

TMI

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Human Computer Interaction in Noise Monitoring

Student(s): Modou Niang
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The SONYC research study involves the monitoring of noise pollution in urban areas such as New York City. By monitoring different sounds in urban areas, one of the topmost quality-of-life concerns, noise pollution, can be reduced. A variety of different techniques are used to monitor this noise pollution. The SONYC study uses a small acoustic sensor and cell phones to accomplish the task of noise monitoring. The study seeks to mitigate noise pollution by using effective noise monitoring and the analysis of the sound that has been gathered. In order to analyze the sound that has been collected, SONYC uses machine listening technology to properly identify and classify its audio data. During this research program, I will study the different avenues in which noise monitoring can be accomplished with cell phones and other small-scale sensors. The SONYC study also aims to use citizen science to monitor and report sounds by utilizing modern smartphones for noise monitoring, Therefore, I am currently working on an IOS app that will allow citizens to monitor and report the noise pollution they are experiencing. I will also further explore how noise can be reported efficiently in the context of human computer interaction(HCI).

Building orientation and mobility tools using human computer interaction

Student(s): Jin Kim, Adelle Fernando
Faculty & Mentors: Oded Nov, Graham Dove

Human computer interaction (HCI) is a multidisciplinary field of study that focuses on design and the use of computer technology. The purpose of HCI is to build beneficial tools and functional systems to enhance quality of life. With the exponential growth of smartphone technology, mobile phones have become a very powerful tool for HCI in key places such as the healthcare industry, specifically in the area of Orientation and mobility (O&M) training. O&M specialists work to familiarize patients who have blindness or severe vision impairment with their surroundings. By incorporating HCI into the realm of O&M training.

Our aim is to create an IOS application that can track motion-based data for low vision patients and their specialists. Rather than analyzing datasets in a controlled environment, we look into how datasets might look like in an uncontrolled setting. We explore a wide variety of sensors within the device such as the gyroscope and accelerometer to track everyday information about orientation and utilize algorithms that can be used to detect movement. In addition, we find how the data that we track can be visualized in a meaningful way for research.

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Automated Grading Platform (AGP)

Student(s): Lucy Shi, Ruiqi Tao
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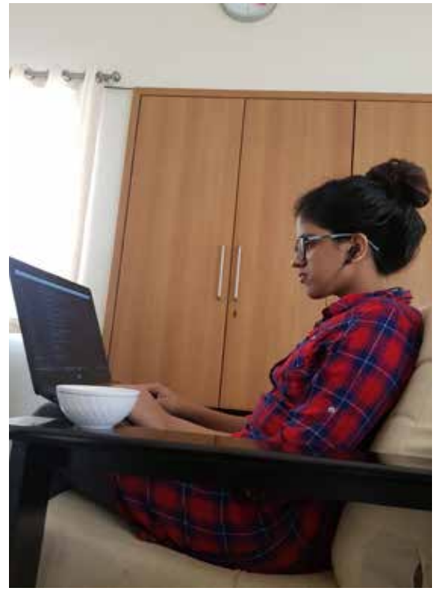
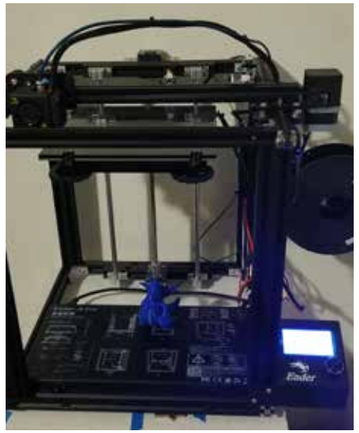
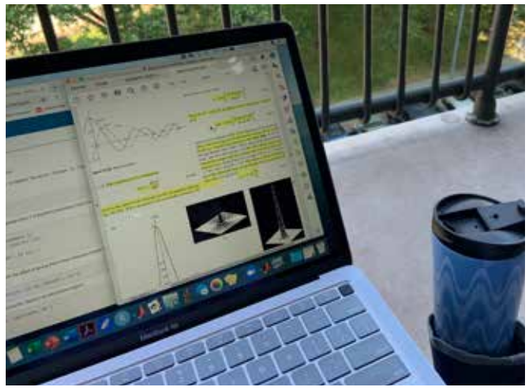
The Automated Grading Platform (AGP) provides an easier 3D CAD assignment submission and grading solution for both students and instructors. This project involves the implementation of a tracking system that allows users to view their submission history for assignments and notification system that informs users of the updated status of their submissions. These functions should improve users' overall efficiency and experience in their workflow. For this development, Django is used as the web framework, Bootstrap as the front-end framework, MySQL as the database, and Python, HTML, JavaScript, CSS as programming languages. GitHub is also used to do continuous integration during software development.

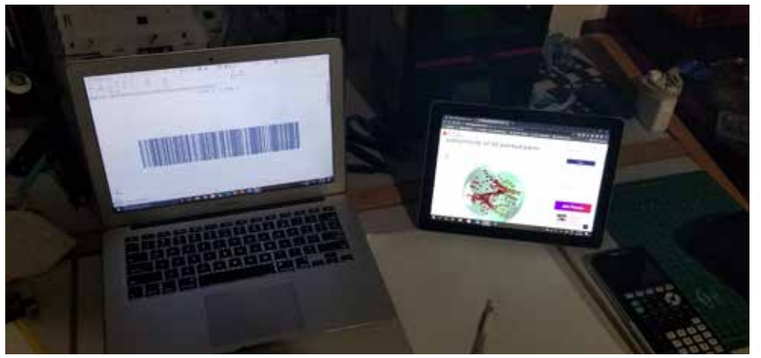
The AGP submission tracking system is able to display users' submission history, with filtering options enabling them to search using assignment name, submitted date, part, and assembly names. This allows users to view detailed information about their submissions in order to make inferences on their progress and focus on specific areas.

The in-built notification system of AGP, designed as a dropdown window containing the list of recent notifications, displays users' submissions as accepted or rejected. The system processes a submission and delivers the message through a popup window which fades away and automatically becomes part of the notification history.
This project gives students the opportunity to experience a standard industrial approach towards the development cycles. The use of Travis for continuous integration, black and flake code checking tools for consistency in code formatting, code linting across development machines, GitHub for merge requests and reviews, and writing test cases for completing the development cycle.









A Special Message from the Program Coordinators

The UGSRP was initiated at Tandon in 2007. The Office of Undergraduate Academics has coordinated the Tandon Undergraduate Summer Research Program (UGSRP) since 2011. The UGA Office is responsible for the expansion of the program from 61 student participants to well over 100 as well as faculty expansion that includes professors and research projects from NYU Wireless, the GovLab, the NYU Center for Urban Science and Progress, as well as the Center of Faculty Innovations in Teaching and Learning via the Undergraduate Academics Department. We have worked tirelessly to match the students with their best suited faculty mentors and research staff in order to ensure fruitful participation, to provide academic, career, and personal development seminars, lectures, workshops, and events so that students come out of the program with enhanced knowledge of both their research area and various opportunities and paths as they move forward in their professional trajectories, and to ensure that the program could continue to run remotely during a global pandemic. We have dedicated ourselves to this program and made sure to develop, maintain, and enhance it at every turn. We are thankful for all of those that joined in on this summer's program and assisted us to ensure a seamless program from start to finish. We congratulate all of the student participants on a successful summer and hope you enjoyed our program.

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