ASEE 2021 St. Lawrence Section Conference
Student Presentations

Breakout Room 1: Sensors and Robots

1-1 ***Hand Gesture Sensors***

Som Dhital ’21, Jose Rodriguez, Prem Kafley, Dylan Wooding
Faculty Mentor: Ilya Grinberg
The State University of New York College at Buffalo

Abstract: This project, titled Hand Gesture Sensor, will consist of two ultrasonic sensors (HCSR04) and an Arduino UNO. The sensors will detect a gesture being done by a person’s hand and have a reaction on the computer. Such reactions may include adjusting the volume, or changing slides on Microsoft PowerPoint. This project, with further improvements, can limit the amount of person-to-surface contact and reduce the spread of viruses. Another purpose for this project can be for people with disabilities, or the elderly. They might have a hard time adjusting the volume, scrolling up/down on a web browser, or playing/pausing a video. The two ultrasonic sensors will be connected to the Arduino UNO, and from there to the computer. Then a computer code is sent to the Arduino to tell the sensors what to do. The ultrasonic sensors can only sense distances, some method has to be developed to detect the different gestures, not only how far an object is. A poster had been made to further demonstrate the project and help get a better understanding of what is intended.

1-2 ***Stovetop Overheat Sensor***

Christopher D. Lonczak ’21, Michael T. Adanri, Monte J. Perkins, Kamali A. Henry
Faculty Mentor: Ilya Grinberg
The State University of New York College at Buffalo

Abstract: The Stovetop Overheat Sensor is part of a larger home monitoring system for assisting the elderly. The objective of the project is to monitor the elderly in their everyday home activity. It is known that the elderly population is more susceptible to a variety of significant medical conditions. These medical conditions may include Alzheimer’s disease, Huntington’s disease, dementia, and depression.

The project utilizes three separate sensors working together to monitor the overall status of a cooking area being used. The sensors being used include a volatile organic compound (VOC) sensor, air temperature sensor and infrared sensor. The VOC sensor detects volatile organic compounds which can be the result of burning, the infrared sensor detects heat being radiated by the cooking surface such as a pot or pan, and lastly the air temperature sensor detects the temperature of the air in the vicinity of the stovetop. The project uses the PIC16F18446 microcontroller to control the operation of the three sensors. The microcontroller is used to receive and process the data retrieved from the sensors and checks them against a set of predetermined parameters to ensure the safe operation of the cooking area. If the data from the sensors reach the predefined parameters, possible or immediate danger will be indicated and the system will then set off an alarm alerting the user of the danger. This project is a subsystem of a larger home monitoring system being developed by ESensor company and is intended to function as one of the main threat detection subsystems.

1-3 ***Adapting Single-Actuated-Wave Robots for Collaborative Motion***

Robby Huang ’20, Alexander Zhu
Faculty Mentor: Kirstin Petersen

Cornell University

Abstract: Instead of focusing on robots with advanced intelligence and computation ability, the Collective Embodied Intelligence Lab develops robots that achieve complex behaviors through physical implementation and cooperation. Inspired by the snake-like procession of swarms of Fungus Gnat Larvae, we aimed to build several Single-Actuated-Wave (SAW) robots, then design and explore the collaborative motion as a result of their physical interactions. The dark-winged fungus gnat larvae can achieve 1.5 times the speed of an individual larva through similar collaboration. By mimicking their behavior, we can theoretically enhance the maximum velocity and decrease the vulnerability of an individual SAW-robot. Meanwhile, we are also designing and building variants of the robot that includes features such as turning and gripping. Currently, we are still at the prototype stage. Weekly, we pursue the rapid design cycle of analyzing, prototyping, testing, and back to analyzing. Most of the data we collected right now is video footage during testing. We analyze the pose and movement of the robot under various conditions. Over the past one and a half-semester, we have designed and improved our robot so that we now have a Single-Actuated-Wave robot that can move both forward and backward and can maintain its speed with PID control while detecting distance in the front with TOF sensor. We have compressed the form factor, weight, fabrication ease, and robustness and started to investigate turning motion by a movable helix design or a double helix design. This is a collaborative project between mechanical and electrical engineering.

1-4 ***Attempts at Measuring the Center of Galaxy Magnetar PSR J1745-2900***

Pedro F. Guicardi ‘22
Faculty Mentor: Michael Niemack
Cornell University

Abstract: Magnetars are rapidly rotating and highly magnetized neutron stars, which are thought to be responsible for many types of signals in Observational Cosmology. Here, I attempt to observe the magnetar at the center of the Milky Way in the microwave wavelength using theoretical models to aid our search with the Atacama Cosmology Telescope (ATC). After our first attempts at observing the pulsar failed, I formulated a theoretical model by simulating the rapidly rotating neutron star in Python using many instruments from Linear Algebra, Complex Analysis, Differential Equations, General Relativity and Electrodynamics. We used former data to determine simulation parameters, and then optimized the time-domain analysis of the magnetar using the simulated data sets. My algorithm involved a series of data manipulations, including common mode removal, high pass filter, running mean removal, frequency bin zapping, and periodical stacking of data time streams. I am still updating the search algorithm, but our hope is that it will be able to successfully observe magnetar PSR J1745-2900 within the end of this semester.

1-5 ***Computer On-board Scientific Mobile Observatory System (COSMOS)***

Tek Powdyel ’21, Daniel Sakona, Madison Skinner, Aseel Shaibi
Faculty Mentor: Ilya Grinberg
The State University of New York College at Buffalo

Abstract: The COSMOS (Computer On-board Scientific Mobile Observatory System) project is a small-scale robot system of the Mars Rover used for the University Mars Rover Competition. This competition is the world's premier robotics competition for college students challenging student teams to design and build the next generation of Mars rovers that will one day work alongside astronauts exploring the Red Planet. Our team of 2020-2021 designed and built a rover platform prototype. The NI Multisim 14.2 was utilized to simulate the Speed Controller and

Joystick Subsystems as an initial step. Data recorded from instruments measurements include percent duty cycle, rise time, voltage, and current requirements for each component and entire robot system. Utilizing research of scholarly literature and technical documentation, the team designed the robot to be capable of maintaining constant velocity, turning all six wheels in the forward, backward, left, and right directions with user-controlled joysticks, with capabilities to handle severe temperatures. Based on voltage/current requirements, the robot system is set to operate at 12 Volts DC with a capacity of 2 Amp-hour. Subsystems designed by each team member (joystick-controller, motor-driver, power distribution, and parts installations) are combined as one system and are tested out.

Breakout Room 2: Materials

2-1 ***Dynamic Bond Approach to Improving Resin Transfer Molding Composites***

Shreyasvi Gowda '22
Faculty Mentor: Meredith Silberstein
Cornell University

Abstract: The growing use of composites in engineering applications has led to the need to produce parts with more complex geometries. Resin Transfer Molding (RTM), a closed-mold composites manufacturing process, is ideal for such purposes. However, the variety of geometries that can be produced using this technique creates challenges to optimizing the process. This research seeks to identify parameters of high-performance in RTM resins to facilitate the development of such resins to produce optimal parts through RTM without having to consider the part's geometry. To do this, it was necessary to identify shear-thinning as a category of resin behavior that could improve the RTM process. Then, a suitable model for this behavior was identified so that its parameters could be manipulated in Ansys FLUENT simulations of the RTM infusion process. In these simulations, the effect on fill time to measure process optimization was studied. The results revealed methods to reduce the time required for resin infusion, and thus achieve greater time efficiency of the process, by choosing resins with particular parameters. The implication of these findings is that RTM manufacturers could save time and resources by avoiding the need to optimize RTM tooling setups for each geometry. Instead, RTM manufacturers would be able to choose resins that allow them to manufacture parts efficiently, regardless of the geometry. Another implication is that RTM manufacturers would be able to identify how resins with varied properties respond differently to the same change in operational parameters, such as the pressure differential applied for manufacturing.

2-2 ***Simulating the self-assembly of zincblende nanoclusters***

Yifan Wang '23
Faculty Mentor: Julia Dshemuchadse
Cornell University

Abstract: Material properties can be separated into two parts: the surface properties and the bulk properties. Most atoms of a nanostructured material are at or close to the surface, which in turn means that the overall materials properties are dominated by surface effects. Thus, it is important to understand the surface properties of these materials. This project is a continuation of a past project. It extends the study of one-component systems to two-component (binary) systems. To understand how these systems form, the condensation and crystallization processes of different-sized zincblende nanoclusters (binary) were analyzed and studied via molecular dynamics simulations. The results were also compared to the results of one-component nanoclusters. The data differed substantially in their behavior: where the one-component systems produced a clear crossover number between nanoclusters that did or did

not form diamond-like assemblies, the two-component systems formed zincblende-type structures at all sizes.

2-3 ***Self-assembly of a Minimalistic Metal-organic Framework Model***

Claire E. Frank ’21, Maya Martirossyan, Julia Dshemuchadse
Faculty Mentor: Julia Dshemuchadse
Cornell University

Abstract: Metal-organic frameworks (MOFs) form a versatile material class with many applications, and defect-engineered MOFs in particular are capable of displaying a range of tunable properties controlled by the type and concentration of the defects that are introduced. Computational modeling has previously been used to explore a broad range of MOF structures, but these models have limited practical applications as they are restricted to particular chemical compositions. For greater generalizability, a minimalistic molecular dynamics model representing MOFs as assemblies of plus-shaped linkers and spherical nodes has been created using HOOMD-blue, and the potential energy landscape has been tuned to create self-assembling small crystals of square-lattice MOFs. Defective linkers with tunable concentrations and degrees of geometric mismatch in the linker angle (i.e., departure of the linker angle from 90°) have also been introduced and shown to self-assemble. Current work focuses on increasing crystal size to allow bulk analysis of the crystals’ structural order and assessing the amount and type of defective linkers that the MOF structure can support as dopants without destabilizing the crystal structure. The results of this analysis will predict the geometrical robustness of defect-engineered MOFs, enabling the design of a wider variety of multifunctional MOFs with tunable properties and the high levels of structural order required to maintain their functionality.

2-4 ***Computational Modeling of Binary Crystal Growth***

Joy L. Hendrix ’22, Julia Dshemuchadse
Faculty Mentor: Julia Dshemuchadse
Cornell University

Abstract: Computational modeling of crystal systems using molecular dynamics simulations is useful for understanding the mechanisms of crystal formation. Two binary crystal systems were studied to gain insight into their crystal growth mechanisms: cF8-ZnS (zinc blende) and cF56-Al2MgO4 (spinel). We simulated the self-assembly of these structures with molecular dynamics in binary systems of particles that interact via isotropic pair potentials. We applied both principal component analysis (a machine learning process used to identify the phases of certain particles) and bond angle analysis to quantify the different growth stages and trajectories of zinc blende and spinel crystals. We will discuss the intersection of the results from both of these techniques to understand the particle attachment and the local structural motifs during assembly.

2-5 ***Polystyrene-grafted silica hairy nanoparticles: aqueous synthesis and film characterization***

Florian Kafer, Allen Schantz, Nicholas Diaco ’21, Richard A. Vaia, Christopher K. Ober
Faculty Mentor: Christopher K. Ober
Cornell University

Abstract: Hairy nanoparticles (HNPs) consist of inorganic cores with tethered polymer shells. HNPs benefit from the opto-mechanical properties of inorganic nanoparticles and the facile processability of polymers, while resisting the aggregation and agglomeration inherent to

traditional nanocomposite blends. A previous report showed that ATRP with activators regenerated by electron transfer (ARGET-ATRP) in an aqueous emulsion could be used in conjunction with a halide salt and a nonionic surfactant to synthesize poly(methyl methacrylate) (PMMA)-shell HNPs. The present work extends this emulsion polymerization technique to synthesize polystyrene (PS)-shell HNPs with 25 nm-diameter silica cores. By varying the monomer addition rate, HNPs with a wide range of resultant polymer grafting densities and shell thicknesses were obtained. Furthermore, these HNPs were shown to form mechanically robust films with high inorganic loading content (40% to 60% inorganic volume fraction), demonstrating the potential of this green synthetic technique to produce HNPs for a wide range of applications.

Breakout Room 3: Biomedical Engineering

3-1 ***Controlling muscle stem cell and endothelial cell communication through engineering biomimetic systems***

Ben D. Cosgrove, Emily Laurilliard, Raina Kikani ‘23
Faculty Mentor: Ben D. Cosgrove
Cornell University

Abstract: Since muscle is highly vascularized, muscle stem cells (MuSCs) reside in close proximity to endothelial cells (ECs), so it is reasonable to conclude that there are important communication factors being exchanged between the two cell types. The goal of this project is to identify and examine the receptor-ligand interactions between muscle stem cells and endothelial cells that influence muscle regeneration. An existing single-cell-RNA sequencing dataset was analyzed to identify potential communication factors. Then, a novel co-culture method was optimized using microcontact printing. Microcontact printing generates adhesion patterns with specific distances between cell types through cell-adhesive “islands” which can lead to better insights into the role of proximity in MuSC-EC communication. The current results include successful EC adherence to printed BSA and fibronectin recorded through fluorescence microscopy images. Currently, ELISA assays and immunostaining are being conducted to see how the levels of EC secreted factors change as spatial distancing changes. Finally, by immunostaining for Ki67, a cell proliferation marker, as well as Pax7 and MyoD, which are markers of undifferentiated and committed MuSCs respectively, a map of communication and differentiation with respect to proximity will be created. These experiments will identify critical components for a novel muscle repair therapy, which involves MuSC and ECs co-encapsulated in a biomaterial with the identified communication factors. It is critical to understand the spatial organization of the two cell types and the identified communication factors to promote better muscle stem cell engraftment. The therapy has exciting applications including treatments for Duchenne’s Muscular Dystrophy and sarcopenia.

3-2 ***Exploring correlations between student scores on the PSVT:R and their motivations to complete it***

Jennifer L. Bailey, Pujan Y. Thaker ‘20
Faculty Mentor: Jennifer L. Bailey
Embry-Riddle Aeronautical University

Abstract: Spatial Visualizations skills are important for engineering students and are linked to increased retention rates and higher performance in calculus courses1. At RIT, freshman biomedical engineering students are required to take BIME 181, Introduction to Biomedical Engineering. This course underwent a restructuring in 2017, to include Spatial Visualization topics into the curriculum. To assess their SV skills, students took the PSVT:R (Purdue Spatial Visualization Test: Rotations), at the beginning and end of the course. In the pilot year, the course restructuring proved to be successful2. SV topics were taught twice to the 2017 cohort.

The average course score on the pretest was 21.295 and based on a t-test, the score statistically increased to 25.114 on the post-test, which was a learning gain of 0.45. However, in 2019, the cohort was split into two groups. One group was exposed to SV topics twice in the course, as done in 2017, and the other group was exposed to the topics only once. Unlike 2017, neither groups had statistically significant increases in their pre- to post scores. A t-test was performed to determine that the Fall 2017 and Fall 2019 cohorts started on the same level. For the Fall 2017 and Fall 2019 semesters, the instructor was the same and the method of instruction was similar, which has pointed to observing student motivations for completing the PSVT:R in order to make any comparisons. The pedagogical differences between the each year impacted the weight of the PSVT:R score on the student's final grade. In 2017, the PSVT:R score impacted a small percentage of the course final average. However, in 2019 the PSVT:R score only counted towards a participation grade. This may suggest that student's had more motivation to perform well on the PSVT:R in 2017. Fall 2018 and Fall 2020 semesters had been impacted by unforeseen circumstances and as a result, data is still being reviewed and will be discussed in the future.

3-3 ***Proteomics-Based Comparative Mapping of Regenerative Tendon Cell-Derived Secretomes Under Static and Dynamic Culture***

Author 1: Ethan J. Liu '21, Jason C. Marvin, Nelly Andarawis-Puri
Faculty Mentor: Nelly Andarawis-Puri
Cornell University

Abstract: Tendon injuries typically heal by forming scar tissue, which are mechanically and biologically inferior to uninjured tissue. To mitigate that, a promising area of research is the Murphy Roth's Large (MRL) mouse, which possesses tendons capable of regenerative healing without scar formation. Previous work has shown utilizing the extracellular matrix (ECM) of MRL mouse tendons the healing of canonical healing tendon cells can be improved. ECM does not fully capture the biological environment, so the goal of this study was to characterize the growth factor environment by using a quantitative proteomics analysis of conditioned media. The conditioned media was harvested from MRL and canonical healing (B6) cells cultured under loaded and static conditions. We hypothesized that MRL and B6 cells would have differentially expressed secretomes under both loaded and static conditions, and the two loading conditions would have comparable differential expression. Performing functional analysis on the proteins, we compiled an overview of the differential expression of all consistently expressed proteins and their related biological pathways and processes. We looked at both the number of proteins involved in relevant biological pathways, such as inflammation and ECM organization, and for each pathway we analyzed the differential expression of involved proteins. This analysis directs future experiments to areas of interest to help elucidate the drivers for the regenerative healing of MRL mice.

3-4 ***Leveraging subspace of mtDNA and miRNA as a biomarker for ME/CFS***

Jianan Li '22
Faculty Mentor: Zhenglong Gu
Cornell University

Abstract: This project is to explore the information behind the circulating RNA molecules in human mitochondria for a particular chronic disease: ME/CFS (Myalgic encephalomyelitis/chronic fatigue syndrome). While the mitochondrial transcriptome is not as well as the nuclear transcriptome, it still plays a very crucial role in regulating metabolism and disease control. The mitochondrial circulating RNA is another name for the mitochondrial non-coding RNA (ncRNA), which is the subset of the mitochondrial transcripts that are not turned into proteins. The current RNA-sequencing field can only provide good information about nuclear ncRNA, probably due to the sample preparation process having limited access to the materials within the mitochondria. Furthermore, as a 2018 paper (Mitochondrial double-stranded RNA triggers antiviral signaling in humans) showed, mitochondria have mechanisms that limit the transmission of ncRNA, making their detection.

3-5 ***Computational Optimization of 3D Printing Complex Morphology***

Parker D. Dean ‘22
Faculty Mentor: Jonathan Butcher
Cornell University

Abstract: While 3D Bioprinting now exists at the commercial level, its possibilities are still significantly limited by print height. Light-based printing suffers from heterogeneous crosslinking throughout prints due to the translucency of most bio-inks, making most tall and complex prints unfeasible. This report describes an important step in a proposed solution to this problem, where the transmissivity function of the bio-ink is used to pre-determine exposure time intervals algorithmically to achieve near homogeneous print results. Here we show our progress with computational light simulation (ANSYS Speos) in our efforts to simulate the exposure process, and use data from simulations to improve the time interval algorithm. We present irradiance contours from a single seven-layer simulation, using absorbance values, material properties, and UV source properties similar to our lab’s own bioprinting setup. Contours showed a pattern of a decreasing amount of light reaching each consecutive layer, with a diminishing change in the portion of light transmitting matching the diminishing change in absorbance coefficient by layer. As absorbance coefficients approached 0.78, the proportion of transmitted intensity approached just below 0.1. These results are consistent with our predictions, implying that the ANSYS Speos simulation platform is capable of producing relevant results once the full simulation process is developed. In the future, we plan to better approximate material surface properties to produce more accurate results, and incorporate this simulation process into another ANSYS product called OptiSLang, allowing for optimization of certain parameters to even further streamline the improvement of our algorithm. Eventually, we aim to validate our algorithm with real bioprints and test its efficacy at homogeneity improvements.

Breakout Room 4: Civil Engineering

4-1 ***Visualizing Large-Scale Ride-Sharing Data***

Doreen Gui ‘21
Faculty Mentor: Samitha Samaranayake
Cornell University

Abstract: Ride-sharing services provide an efficient and sustainable option of mobility, and many studies have focused on improving the mathematical models and algorithms to better match the riders with the vehicles. However, due to the sophisticated models and large datasets, it is sometimes challenging to evaluate the system purely based on calculations. And data visualization provides an accessible way to see and interpret the patterns in the data. It also allows researchers and engineers to communicate to a broader audience to facilitate collaboration and assist informed decision making.

This project aims to implement a code library that can visualize the fleet of vehicles on an interactive map and help analyze the performance of the system. Based on the sample input data from Professor Samitha Samaranayake’s research group, we have implemented scripts that interpolate the vehicle paths, calculate performance parameters, and generate an animation on a web-based application. As we plan to release the scripts as a package by the

end of this semester, we are currently working on a configuration file editor that helps users set up the application for their own simulation.

4-2 ***3D Printing of Fiber-Reinforced Concrete Using a Magnetic Approach***

Misha Dimmick '21
Faculty Mentor: Sriramya Nair
Cornell University

Abstract: Autonomously constructed concrete is a valuable industry to explore with payoffs including, but not limited to, increased worker safety, increased labor efficiency, and the reduction of material waste. COVID-19 makes automation an even more worthwhile objective. The goal of this project is to address existing challenges within the industry and offer innovative solutions that will ultimately allow for the 3D printing of more complex, and stronger, fiber-reinforced structures.

One of the main challenges with 3D printed concrete is the inability of existing pumping devices to extrude fiber-reinforced mixes. For this to become possible, the mix must have a thick enough consistency so that it retains the homogeneous distribution of the fibers while still being pumpable. The dimensions of the extruder nozzle and fiber length are both important factors to take into consideration.

From previous tests on 3D printed concrete, researchers have discovered that the weakest part of printed samples is in the interface between layers. It is assumed that the manipulation of steel fibers will be useful in increasing the bonding strength between layers because the fibers will span adjoining layers, creating a bond. Flexural, compression, and direct shear tests will be used to analyze the performance of samples.

There are currently no ASCE standards for 3D printed concrete, but ASTM specifications were followed when applicable. Thus far, mix design is nearly finalized and extruder modifications are in progress. Early samples have been tested as a proof of concept, but new samples will be created and tested this semester.

4-3 ***Characterization of cement-based magnetorheological fluids with suspended iron particles***

Ryan T. Schanta '23, Sriramya D. Nair
Faculty Mentor: Dr. Sriramya Nair
Cornell University

Abstract: Magnetorheological cement slurries utilizing carbonyl iron particles (CIP) can offer several advantages, especially where improved displacement of cement slurries is vital for ensuring zonal isolation in oil and gas wells to reduce emissions. The application of a magnetic field provides control over the displacement of the cement slurry to reach areas that cannot be reached with conventional techniques. When an external magnetic field is applied to cement slurries with suspended magnetic particles, the magnetic particles align in the direction of field, and enable real-time control over the slurries. When a stronger magnetic field is applied, the slurry instantaneously stiffens preventing migration of gases during hydration reactions.

The goal of this work is to produce a comprehensive profile of properties of slurries with 30% CIP. Previous work was conducted in characterizing similar slurries (with 4% CIP particles and up to 1 Tesla) by employing small amplitude oscillatory shearing (SAOS). Recent electromagnetic simulations have shown the maximum attainable field strength behind casings to be 0.1 Tesla, necessitating a higher particle dosage to prevent gas migration.

SAOS tests were conducted on a series of slurry mixes that vary in composition and dispersant dosage to ensure mixability and pumpability. These slurries were tested at a variety of downhole temperatures and external magnetic field strengths. Additionally, small-scale slump tests using

a mini slump cone were conducted on freshly mixed samples and were related to their viscosity and yield stress values. The results provide formulations that can act as a basis for well cementing applications.

4-4 ***Rheology and Strength Enhancement of Cement Slurries at High Temperatures/Pressures***

Joseph Friedman ’23, Hudson Scanni, Sophia Shapiro, Lyn Zemberekci, Sriramya Nair
Faculty Mentor: Dr. Sriramya Nair
Cornell University

Abstract: This study evaluates an improved cement slurry that can lengthen the life cycle of geothermal wells by increasing the durability of the cement slurry. Typical oil wells use a slurry containing type H cement and water. This mixture is inadequate for geothermal wells due to their increased temperature and pressure. Supplementary cementitious materials (SCMs) are used to augment the properties of cement and can be applied to geothermal wells to increase their longevity. This work aims to improve the rheological properties of the cement slurry to maintain pumpability and prevent strength retrogression at higher temperatures and pressures using SCMs. To maintain pumpability at deeper depths, Daxad, an additive, can be mixed with the slurry. Silica Flour is currently known to help prevent strength retrogression at higher temperatures.
A Rheometer, an Atmospheric Consistometer, and an Ultrasonic Cement Analyzer (UCA) were used to characterize the pumpability and compressive strength of the slurries. The addition of both Daxad and Silica Flour improved the rheological properties and prevented the degradation of the conditioned cement slurry. Future work will also be conducted to characterize the behavior of other SCMs such as fly ash, slag, and other waste materials. A complete replacement of cement with slag and fly ash will also be explored as an alternate cementitious material for geothermal well cementing. The research to date has proven that SCMs and other additives can be used to improve the performance and durability of cement slurries under harsh subterranean conditions.

4-5 ***In-Situ Micro-Reactor Cell for Novel Electrochemical Carbon Conversion Pathways***

Erin Huang ’21, Hassnain Asgar, Greeshma Gadikota
Faculty Mentor: Professor Greeshma Gadikota
Cornell University

Abstract: Scalable technologies for capturing carbon dioxide (CO2) from coal or natural gas power plants followed by storage in subsurface geologic reservoirs are being commercialized, but these technologies do not address how we can utilize this anthropogenic CO2. Adaptive pathways can produce clean energy carriers, chemicals, construction materials, and commodities from carbon capture and conversion. In particular, an ambient-temperature electrochemical process can convert calcium carbonate and water to calcium hydroxide, CO2, hydrogen, and oxygen. This project aims to optimize the conditions of this process in order to maximize the conversion efficiency and to explore pathways for other carbonates i.e., magnesium carbonate. The first phase of this project involved designing, creating, and testing an in-situ micro-reactor cell. The cell includes two electrode chambers and a glass capillary tube connecting them. The product forms in the capillary tube, which allows for in-situ measurements to be taken throughout the process. This capability enables the characterization of products formed during the process and is useful for understanding and optimizing the kinetics of the reactions occurring. The cell allowed in-situ WAXS, TGA, SEM, and FT-IR measurements to be taken for this electrochemical process. This proof of concept for the cell will allow for the

optimization of conditions for this electrochemical carbon conversion pathway and various other electrochemical processes.

Breakout Room 5: Mechanical Engineering

5-1 ***Protic Ionic Liquids used as Lubricant Additives for Aluminum-Steel Contacts***
Brandon M. Stoyanovich ’23, Hong Guo, Patricia Iglesias
Faculty Mentor: Patricia Iglesias
Rochester Institute of Technology

Abstract: Friction and wear are unavoidable phenomena responsible for important energy and lifespan losses in all machines utilizing moving parts. Lubricants have the potential to increase efficiency and durability of components. Much of the world’s leading lubricants used are petroleum-based which are harmful to the environment and cannot sustainably biodegrade. Alternative greener options have been found to help replace toxic chemicals altogether. In this tribological study, three ecofriendly protic ionic liquids (PILs), 2-hydroxyethylammonium p-toluenesulfonate (Ets), 2- hydroxymethylammonium p-toluenesulfonate (Mts), and 2-hydroxydimethylammonium p-toluenesulfonate (Dts) were synthesized and tested as lubricant additives. The three PILs were respectively mixed with a base biodegradable oil (BO) with a concentration of 1 wt.%. The wear and frictional performance of the three PIL blends, BO and a commercial biodegradable oil (BOA) were investigated by using a ball-on-flat reciprocating tribometer under aluminum-steel contact. The use of any PIL as additive to BO reduced the friction coefficient compared to BO and BOA. Particularly, an astounding friction decrease of 39.6% was obtained by using 1 wt.% Mts+BO with respect to BO. A 15.9% reduction in wear volume was achieved using 1 wt.% Ets+BO. Lastly, the objective of this study is to determine which protic ionic liquids serve as the most efficient lubricants for aluminum-steel contacts.

5-2 ***Design and Development of the Self Organizing Robot Team (SORT) System***
Jackson Hardin, Mengni Zhang, Johnell Brooks, Keith Evan Green
Faculty Mentor: Keith Evan Green
Cornell University

Abstract: This paper presents the work undertaken in the Cornell Architectural Robotics Lab developing the distributed, multi-agent Self-Organizing Robot Team (SORT) system. The SORT system aims to enable independent living at home for a variety of user groups, such as those aging in place with mild cognitive impairment, young adults with Autism Spectrum Disorder, and individuals diagnosed with severe illness such as COVID-19, through organizing, displaying, finding and fetching domestic items on vertical surfaces such as walls. Additionally, SORT aims to reduce stress and provide non-anthropomorphic companionship for the user. SORT autonomously alters the ambient environment, and activates vertical surfaces, which are historically underutilized architectural elements, anticipating and providing for the users’ needs in order to support independent living. We present the design process of physical and virtual prototypes of the SORT system that have led to its most current iteration. In addition, we describe design of the human robot interaction (HRI) through the creation of fabricated use cases with personas representing different possible user groups. This work on the SORT system represents a design exemplar, informing future work that combines human centered design, environmental design, and architecture with engineering fields such as swarm robotics, mechanical design, and controls simulation.

5-3 ***Fluidic Elastomer Beams as Energy Harvesting Pumps***
Yoav Matia, Anthony L. Fine ’24, Amir D. Gat, Robert F. Shepherd
Faculty Mentor: Robert F. Shepherd

Cornell University

Abstract: Oscillation dynamics of elastic sheets due to external forces are studied extensively in the context of wind-based energy harvesting. Commonly, piezoelectric materials, embedded within the elastic sheet, are studied as a mechanism to harvest energy from the sheet elastic deformations. In this work, we explore fluidic-embedded beams as an alternative energy harvesting mechanism. The elastic beam is embedded with a set of fluid-filled bladders interconnected via an array of slender tubes. Deformation of this beam both creates, and is induced by, the internal viscous flow and pressure-fields which deform the bladders and thus the surrounding solid.

In this work, we obtain a set of coupled equations relating the external forces and fluidic pressure within the bladders to the precise displacements of the beam. We show that by changing the viscous resistance of connective tubes, we modify the amplitude of oscillatory deformation modes created due to external excitations of the structure. Furthermore, rearranging tube configuration in a given structure is shown to give a degree of control and generate varying mode shapes for the same external excitations. Thus, we provide a novel approach to harvesting otherwise unused vibrational energy from the enveloping system - whether it be a chassis, fuselage, or underwater waves - and damping the system in the process. To validate these results we design and create a 3D printed elastic structure with parameters from the respective model. This research is conducted in the Sibley School of Mechanical Engineering Organic Robotics Laboratory under the supervision of Professor Robert F. Shepherd.

5-4 ***Compressible Turbulence in Jets***

Christopher S. Kartawira ‘21
Faculty Mentor: Greg Bewley
Cornell University

Abstract: The effect of compressibility on turbulent jets at small scales was investigated by developing a reproducible procedure to operate a novel experimental facility utilizing hot wire anemometry in a custom built pressure vessel. The design of this procedure focused on developing an up-to-date methodology that could be implemented when operating the facility to obtain consistent and accurate measurements that reflect contributions from velocity fluctuations, and hence turbulent quantities, rather than unwanted disturbances, such as electrical noise and temperature fluctuations. Jet profiles and center-jet data sets were collected in two sets of high Mach number flows at equal Reynolds number in both air and SF6 during the duration of the project, with data processing still under progress. The development of this procedure serves as a foundation in the operation and experimental robustness of the compressible turbulence facility and be beneficial in furthering the field of applied turbulence.

5-5 ***First Engineering Technology Classroom Design Experience on Catapult in a Deaf Classroom***

Keaton B. Bourdaux ’23, Hailey G. Snodgrass, Sean Z. Cosslett, Matthew J. Biggota, Jay K. Patel, Dylan Williams
Faculty Mentor: Dino Larry
Rochester Institute of Technology

Abstract: At the National Technical Institute for the Deaf at Rochester Institute of Technology, us deaf/hard of hearing (D/HH) engineering technology students receive our first formal education in engineering technology in NETS-101 Fundamentals of Engineering course. The main exercise was a final design project, which was worth 30% of the final grade. The instructor

provided the class with basic engineering technology theory, background information, tools, components, considering different mechanisms. We were asked to design, plan, and build a simple catapult which associates potential energy. The criteria for building the catapult were a limited budget of $100 for materials, limited measurement for catapult of 2 inches width x 2 inches length x 2 inches height and to be able to sling the projectile 20 feet and be able to make it into the corn hole. The class was exposed to a meaningful freshmen design experience that includes engineering ethics, decision making, communication, progressing through the Engineering Design Process framework, free-body diagrams, teamwork, time management, and creating an incidental learning environment for us new students. We have found creative solutions to the catapult to fix the design problems, and for example, team A found a solution of using latex tubing as a arm stopper cause the wood dowel is denser which means there is no elasticity to absorb the force, which causes it to break but ran out of time to change the stopper material. Team B came up with a solution of making a pull pin to prevent human error affecting the amount of potential energy that is being applied to the projectile. The final results were that team two were more successful than team A, because their arm stopper did not break during the corn hole competition and got around 16/20 (80%) shots. Team A had a human error caused by using our feet to push down the arm instead of using a pin-like what team B did. The catapult throwing arm was accurate but once the ½ inch wood dowel broke, we were not able to shoot the projectile into the corn hole which means that we got around 9/20 (45%) shots that made it into the corn hole. This experience will encourage us to consider Undergraduate Research Experience (URE) opportunities to support us to be able to transfer to the Mechanical Engineering Technology-BS program at RIT from NTID’s Applied Mechanical Technology-AAS program.

Breakout Room 6: Environmental Engineering

6-1 ***Macroplastics Accumulation in Roadside Ditches in the Finger Lakes Region Across Land Use, Traffic Patterns, and COVID-19***

Mary T Augenstein ’21, Olivia Pietz, Christine Georgakakos, Kanishka Singh, Miles McDonald, Todd Walter
Faculty Mentor: Jery Stedinger
Cornell University

Abstract: The goal of our research project was the study and analysis of the accumulation and distribution of terrestrial macroplastics in roadside ditch networks throughout our study area of Tompkins County, New York. The research was conducted to provide information on how macroplastics behave in the terrestrial environment due to the following factors: land use, traffic patterns, and the effects of the COVID-19 pandemic. Twelve roadside ditches were selected in the Tompkins County greater area and were purged of macroplastic pollution every two to three weeks. COVID-19 impact was assessed by comparing pre-COVID-19 and COVID-19 data. Once collected, it was imperative that samples were washed, dried, and measured for each piece of data. Measurements included length, height, width, and mass. To briefly describe the data collected, we collected any sort of macroplastic found in the roadside ditches, omitting other sorts of pollution. A total of 1145 pieces of macroplastic weighing of total of 2323.6 grams. The final outcome of our project allowed the observation of ditches with the highest traffic pattern in Commercial land uses were associated with the largest plastic accumulation rate, thus indicating there is a connection between the amount of human interaction with land use and the amount of macroplastics found in that location. Concerning the effect of a pandemic on macroplastic pollution, it was found that there was a general decrease in the total amount of

macroplastics collected for each site and land use. This research was conducted through the department of Biological and Environmental Engineering.

6-2 ***Town-Gown Stormwater Relationships: An assessment of Cornell University's Stormwater Contributions to the City of Ithaca***

Gabriela V. Sibel '22, M. Todd Walter
Faculty Mentor: M. Todd Walter
Cornell University

Abstract: Ithaca, New York, has been experiencing increased flood frequencies, the cause of which could be attributed to many factors. Regardless of the causes, Ithaca is seeking reparations from municipalities, individuals, and other landowners (including Cornell University) for their contributions to Ithaca's flood problems. The logical details of the attributions of reparations are not clear. However, Cornell has invested substantially in reducing its stormwater footprint by installing a variety of green infrastructure. The objective of this project is to quantify and document these efforts to help inform Ithaca about Cornell's stormwater contributions to the city and provide insights into how to further reduce campus stormwater problems. Specifically, it examines the established stormwater storage on the Ithaca Cornell campus. I will quantify the campus' capacity to absorb flood flows relative to pre-implementation. I will also incorporate stormwater mitigation systems planned by Cornell Planning, Design, and Construction (CPDC), as well as my own ideas that emerge during this research. The progress to date includes meeting with appropriate CPDC personnel to obtain stormwater system data and I have made an initial analysis of the impervious area on Cornell's campus. Rainfall data will be downloaded from the National Oceanic and Atmospheric Administration website. The final product will be a report illustrating the contributions of storm runoff from Cornell pre-campus, post-campus, and post-campus with stormwater mitigation in place. Both current and future climate scenarios will be considered.

6-3 ***Alternative Cementitious Materials for Geothermal Wells***

Sophia L. Shapiro '23
Faculty Mentor: Sriramya Nair
Cornell University

Abstract: Geothermal energy is a promising alternative to conventional fossil-based energy sources. Geothermal reservoirs are pools of water heated by magma deep below the earth's crust, the steam of which can be used to power turbines or pass through heat pumps. Recovering this heat to the surface requires construction and subsequent cementation of subsurface geothermal wells. Although the construction process of these wells is not vastly different from that of oil wells, the conditions to which the cement is exposed are frequently harsher and more extreme. Geothermal well cements are vulnerable to acidic and carbon dioxide-rich brine, in addition to temperatures above 500 °C. Overall, well failure is a consequence of cement degradation and cracking due to exposure to these severe conditions. Many new formulations using alternative materials have been developed in response to the identification of cement weaknesses. The literature review in progress summarizes the existing related work, organized by sections such as current cementing methods, silica flour additives, enhanced conductivity, calcium aluminate cements, and environmental impact. Such a literature review is needed to compile all works on geothermal wells cements, and identify relevant knowledge gaps for current and future research to fill. This review is written under the guidance of Dr. Sriramya Nair in the Civil and Environmental Engineering department.

6-4 ***Acoustic reception and emission of aquatic animals***

Gayatri Prakash ’21, Anupam Pandey, Aaron Rice, Sunghwan Jung
Faculty Mentor: Sunghwan Jung
Cornell University

Abstract: The swim bladder’s primary purpose is controlling the buoyancy of a fish; however in some fish it also plays an important role in sound production and source localization. So physical models mimicking various swim bladders will allow us to better understand sound source localization and sound production and to validate theoretical models. Furthermore we will be delving into other factors that affect underwater acoustics such as depth and size. Additionally wavelengths produced by aquatic animals change with depth depending on the purpose of the sound. Sound files of eight different fish (such as Opsanus tau, Porichthys notatus, etc.) have been gathered and analyzed. The spectrogram from each file was analyzed to find the maximum frequency as well as the frequencies at 75% the maximum frequency of the various fishes calls. Another frequency was calculated from the sound files and this was based on a minimum peak-to-peak frequency measure based on the change in value between the highest amplitude and the lowest amplitude. This experimental frequency as well as the real frequency was compared to the frequency from the theoretical equation created. This theoretical model was based on the research done on a spherical bubble and the compressibility of air in the bladder. It was varied to account for habitat depth, the confinement of the swimbladder, and the spheroidal shape of the swim bladder. All the frequency values were found to be close to each other and on the same order of magnitude. However the physical experiments will help reveal more about the morphology of swim bladders; understanding how the morphology of the swim bladder, and other environmental factors help give rise to better sound localization and production

6-5 ***Western New York Alternative Road Sanding: Buffalo Harbor Dredged Sediment Repurposing***

CPT Christopher Ross ‘21
Faculty Mentor: Dr. Brian Thorn
Rochester Institute of Technology

Abstract: Confined Disposal Facilities (CDF) retain millions of cubic yards of both contaminated and uncontaminated dredged material within the Great Lakes region. The goal of this capstone project is to analyze the feasibility and organize the implementation of an environmentally friendly way to repurpose Buffalo Harbor’s dredged material stored at an adjacent CDF. A beneficial use proposal for accumulated sands and gravel is to divert material for road sanding operations for Western New York’s rural municipalities. This study will collect and review data on the toxicity and grain size of dredged material, determine which municipalities in Western New York predominately sand roads during winter months, assess the economic impact of subsidizing current procured sand with dredged material, and compare the environmental impacts of using dredged material to the use of mined coarse sand. The study suggests that it is feasible to repurpose a significant quantity of the biennial dredging of about 140,000 cubic yards of material within the Buffalo Harbor. The sand/gravel mix would then supplement rural dozens of municipalities within a 65 mile radius for wintery road sanding operations. Thereby dramatically alleviating burdensome volume consumption at Buffalo Harbor’s CDF. Additionally, this would provide a positive economic impact to rural municipalities in New York State. The work reported here was in fulfillment of degree requirements for a Master of Engineering in Sustainable Engineering at the Rochester Institute of Technology (RIT). A work was performed with the cooperation of the US Army Corps of Engineers (USACE), Buffalo District.

Breakout Room 7: Improving Engineering Education

7-1 ***The Virtualization of Engineering Education using International Student Teams***

Anuli S. Ndubuisi ‘23
Faculty Mentor: James Slotta
Ontario Institute for Studies in Education/University of Toronto, Canada

Abstract: As the world economy evolves and becomes increasingly digitized and interconnected, there’s demand for 21st century engineers who are globally competent and can collaborate with international partners from diverse cultures to tackle the world’s problems. Traditionally strategies for promoting engineering students’ global engineering education usually through study abroad programs, and international student enrollments (IIE, 2019) have been adversely impacted by safety concerns, financial constraints, potential delay in academic graduation, fear of negative stereotyping, and the recent the COVID-19 health crisis (Martel, 2020; Soria & Troisi, 2014). This has led educators to seek alternative virtualization solutions to help future engineers develop global and intercultural competencies that can prepare them to transition to the labour market. This study explores engineering students’ development of intercultural competencies within an International Virtual Engineering Student Teams (InVEST) project initiative. We report on two successive iterations of the InVEST Intercultural Competency Module (ICM) delivered within a global virtual team project setting, in which engineering students were engaged in collaborative technical projects. Employing a mixed-methods approach, each study iteration comprised of a pre-survey to gain insights into student’s prior knowledge and cultural background and a post-survey to determine students’ perceptions of their intercultural learning and experiences. The collected data were coded, categorized, and analyzed using a content analysis method and four themes relevant to students’ learning and experiences emerged, namely a) intercultural awareness and diversity appreciation, (b) project planning and coordination, (c) intercultural communication, and (d) social cohesion, trust, and commitment. We found that blending ICM with global virtual team projects was a successful approach for helping engineering students acquire international experience and global perspectives in addition to technical engineering knowledge.

7-2 ***Best Practices for Integrating External and International Collaborations into Multidisciplinary Engineering Design Courses***

Ndubuisi Anuli ’23, Vasudeva Ketan, Marzi Elham
Faculty Mentor: Prof. Elham Marzi
University of Toronto

Abstract: Policy makers, employers, and engineering educators have long recognized that in addition to technical skills that embrace engineering design, graduate engineers need to develop practical skills such as professionalism, multidisciplinary teamwork, global competence, and execution competence that can enhance their employability (ABET 2020; Shuman et al. 2005). Some strategies employed by engineering educators to support students’ development of these professional competencies include the augmentation of academic knowledge with virtual international collaboration experiences and the integration of external stakeholders including industry partners (Oladiran et al, 2011; Steghöfer et al, 2018) into design courses. The involvement of virtual international collaborators and external stakeholders in academic education can result in difficult experiences for all participating parties. Existing studies on virtual international teams and external stakeholder involvement in multidisciplinary engineering design courses are limited. This study reports on a survey of the literature on integrating multidisciplinary and virtual international teams into engineering design courses. A literature review was conducted on relevant engineering education articles published in leading academic journals on the intersection of engineering multidisciplinary teams and virtual international collaborations in academic settings between 2017 and 2020. Following the syntheses of the multidisciplinary teams' literature, we identified eight challenges from past course instances namely multidisciplinary communication, negative relatedness, course organization, virtual team communication, trust, stakeholder management, team formation and dispersion. Recommendations for designing and enacting multidisciplinary engineering design courses with external and international collaborations were also proposed. Our study highlights best practices that can support instructors to plan the involvement of external and international stakeholders in engineering design course settings.

7-3 ***Developing an enhanced model of experiential learning for engineering undergraduates***

Kaitlyn Summey '25
Faculty Mentor: Dmitry Savransky
Cornell University

Abstract: Undergraduate research opportunities and project-based learning courses are two ways that academic institutions contribute to an engineering student's future success in the workplace, but these opportunities come with inherent difficulties for students and professors. In the research environment, undergraduates often lack autonomy and often have limited involvement in the lab environment. With project-based learning, professors have a trade-off between prioritizing student experience and what is a realistic expectation of an engineering course. I am proposing a model that combines the best practices in undergraduate research and project-based learning to give undergraduate students "real-world" engineering experience through hands-on research tasks and problem solving. The objectives of this work are to analyze a unique undergraduate experience, compare and contrast this experience with both project-based learning and technology workplace environments, and develop an enhanced model for experiential learning through undergraduate research. I will provide a case study analysis of my undergraduate research lab as a framework for a productive, team-based learning environment that facilitates communication and knowledge transfer. This lab encourages creativity and productivity through its non-traditional research environment and team structure that promotes student autonomy and ownership of the research. Unlike the common model of a university research lab, all of the lab members are undergraduate students under supervision of a lab manager. I will be collecting data by interviewing lab alumni about their experience in the lab, how that experience affected their future career, and how the lab experience compares to other team-based learning methods from courses, internships, and other research labs. Ultimately, I will articulate a model for undergraduate student learning that instills confidence, enhances technical and communication skills, and provides a real-world engineering experience that helps graduates be competitive in the job market.

7-4 ***Automatic Counterargument Generation***

Kabir Walia '21
Faculty Mentor: Claire Cardie
Cornell University

Abstract: Computationally recreating the logic/patterns invoked in the human mind to create persuasive and coherent arguments is a non-trivial task. With the advent of Transformer networks in the last few years, there have been significant improvements in efficiency and control of text generation. Yet, there has been limited success in producing coherent and persuasive arguments, especially without external information retrieval systems. This work highlights baseline experiments run with the Conditional Transformer Language Model (CTRL) for the counterargument generation task. Specifically, we condition the CTRL on the aspect, topic and stance of input arguments (based on Schiller et al, 2020) on the Arguana dataset curated by Syed et al, 2018 and train it to generate counterarguments. We see topic-relevant arguments produced by the CTRL, albeit examples appear to be extracted from the training data and often lacking logical flow between sentences. We further propose a model to tackle such coherence issues. The produced results serve as baselines for our future work on employing CTRL and other such transformers to generate sentence-level phrases for better relevance and cohesion within arguments.

Breakout Room 8: Electrical and Computer Engineering

8-1 ***Radar Network Synchronization and Imaging using Semiconductor Laser System***

Meesha Gupta ’21, Chandra S. Pappu, Fan-Yi Lin
Faculty Mentor: Chandra S. Pappu
Union College

Abstract: A synchronized radar network with multiple transceivers (nodes) using the chaotic signals is proposed in this project. Instead of using traditional microwave circuits that require additional hardware to generate modulated waveforms, we utilize a semiconductor laser chaotic waveform that spans a frequency of a few GHz. Also, we propose to synchronize each radar node using the transmitted chaotic signals to increase the probability of detection of targets. Preliminary results show that the cross-correlation between the synchronized signal and the echo received from the target is of high quality thereby yielding high-resolution detection of multiple targets in close proximity.

8-2 ***OverQ Quantization Method for Neural Network Models***

Jordan Dotzel ’23, Preslav Ivanov, Zhanqiu Hu
Faculty Mentor: Zhiru Zhang
Cornell University

Abstract: Many NN models are facing the challenges of energy consumption, processing time, and memory usage. Quantization of weights or activations is proved to be effective in solving these problems, but it also reduces the overall accuracy of the NN models. We hope to improve the performance of quantization by proposing a new quantization method called OverQ. OverQ methods implement algorithms that improve overall accuracy of the NN models with normal quantization methods, and we hope that through all tests and optimization, OverQ methods could be widely applicable on various NN models with outstanding performance.

Tests on the OverQ methods are a simulation of OverQ methods on hardware implementations. With these test results, we are able to get a better understanding of the effectiveness of OverQ. We conducted tests on popular NN models such as ResNet18, ResNet50, MobileNetV2, and Densenet121 using OverQ and ImageNet dataset. In general, the difference between accuracy of tests using 8-bit OverQ quantization and the accuracy of tests using float point values is within 1%. However, the amount of improvements in accuracy differ among various models. For example, we can see significant accuracy improvements in ResNet18 and ResNet50 using low activations bits (3 bits, 4 bits, and 5 bits), but such improvements can hardly be seen in our tests on MobildNetv2 and Densenet121 using lower bits.

From these results, we know that OverQ methods have a good performance in improving NN model accuracy. In addition, we may also improve its performance by making the algorithm more dynamic so that OverQ can be more compatible with different models.

8-3 ***Low Bandwidth Video Transmission and Storage***

Henry Zheng '22
Faculty Mentor: Madhur Srivastava
Cornell University

Abstract: With Covid-19 becoming a pandemic and employees being asked to work from home, there has been a surge in the video streaming related to virtual meetings as well as for entertainment and gaming. This has led to an unprecedented load on communication networks with limited bandwidth infrastructure to support live-streaming and on demand videos. Streaming issues and poor video quality, including video freeze, is becoming common. Further, education institutions shifting to online classes is exacerbating the problem, including that of video storage for universities, as more content is generated. The proposed project is to develop an algorithm in the current video streaming process that can reduce the bandwidth requirement by a factor of 6 without comprising video quality, enabling 6 times more video storage and transmission. Henry will quantify correlation between video frames to eliminate redundancy using metrics such as structural similarity among frames. He will design the video data workflow, plan the project steps, develop the correlation metric, collect large video data sets, and conduct analysis on the correlation measures. The videos will be obtained from the Cornell library. This project is ideal for an undergraduate student because it requires adept coding skills and ability to work with big data. Undergraduate students also routinely interact with various types of online videos (including online learning) and can identify the information redundancy present in the different types of videos.

8-4 ***Analyzing the security of smart contracts using neural networks***

Minghao Li '21
Faculty Mentor: Elaine Shi
Cornell University

Abstract: Decentralized Applications (DApps) often handle cryptocurrency transactions, tying their security directly to users' property safety. As most DApps rely on smart contracts running on the blockchains, developing secure DApps depends on smart contract security. We approach smart contract security analysis through clustering smart contract functions. We hypothesize that by generating a model graph embedding for each function using neural networks, we could sort all functions according to their business logic by clustering. If a DApp claiming to perform a specific business fails to have all of its smart contract functions falling in corresponding clusters, the security of this DApp is questionable.

We gathered smart contracts by extracting data uploaded to and verified by Etherscan. Then we built a function model generation process on top of the open-source bytecode analysis tool Octopus. We also designed and implemented an embedding generation method inspired by DeepWalk. And we clustered the model graph embeddings using k-means clustering.

We clustered 49681 functions from 2469 smart contracts into 100 clusters. The five most populous clusters have 41532 functions, making up 83.6% of all functions. This matches our previous discovery that about 80% of the top 100 DApps on the DApp Ranking belong to one of the following five business categories: auction, wallet, gambling, trading, and voting.

Our experiment shows that functions from the same smart contract tend to end up in the same cluster, and the clustering result reflects the real-life distribution of DApps business categories.

The project topic belongs to the Computer Science field.

8-5 ***Integration of Microgrids and Nanogrids in Smart Grid***

Lara F. Bannister ’21, Aaron J. Potter, Zachary A. Wertz, Michael N. Forster, Matthew E. Smith
Faculty Mentor: Ilya Y. Grinberg
The State University of New York College at Buffalo

Abstract: A microgrid is defined as a group of distributed energy resources, including renewable energy resources and energy storage systems, as well as loads that operate locally as a single controllable entity. The goal of microgrid systems is to have the utility feeding one or more microgrids, which may be large buildings such as hospitals or campuses. These microgrids would have power generation and storage capabilities enabling them to go into “island mode”. Island mode refers to when the microgrid is completely independent from the utility grid, this feature is useful for reducing the utility grid’s load during peak hours and in the event of maintenance or a fault on the lines connecting the utility grid to the microgrid. Nanogrids may be connected to the microgrid. The nanogrid operates on a similar principle of being able to self-sustain during the previously mentioned scenarios. In a nanogrid, one customer would have solar panels and be interconnected with other houses in that nanogrid, enabling the home with solar panels to give other homes power once the original home’s demand is met. This microgrid/nanogrid integration system is a small-scale emulation of a real-world scenario, allowing for laboratory testing and data analysis. The end goal of the project is to replicate a practical system in which the utility, micro, and nanogrid will work in conjunction with one another as efficiently as possible.

Breakout Room 9: Chemical, Mechanical and Information Engineering

9-1 ***Endocytosis Dependent Glycosylation and Production of Species Specific Lubricin***

Rachel G. Eichman ’21, Matthew J. Paszek
Faculty Mentor: Matthew J. Paszek
Cornell University

Abstract: Mucins have a broad range of therapeutic applications as a result of the lubricating properties associated with extensive glycosylation. One mucin of interest is lubricin, which lubricates biointerfaces, including articulating joints, tendon sheaths, and the ocular surface. Although the tandem repeat sequence remains consistent, only varying in number, the N-terminal and C-terminal regions of the protein vary from species to species. The primary goal of the work was to develop a stable cellular production system for canine and equine variants of lubricin using the human embryonic kidney (HEK) 293-F platform, that could serve as treatments for conditions such as osteoarthritis. HEK 293-F cells were transfected with a piggybac vector containing the gene for species specific lubricin. After expansion, and selection, transfected high producing cells were sorted using FACS. Transfection, and protein production success was confirmed using western blots. Additionally, the process of protein o-glycosylation is highly complex, and the physical properties of lubricin can vary with glycan structure. Given the highly glycosylated nature of lubricin, experiments were also conducted to determine if endocytosis after initial secretion was necessary to achieve elongated glycans. Human specific lubricin was produced in normal culture, and in cells treated with dynasore, a pharmacological inhibitor of clathrin mediated endocytosis. The glycosylation pattern was then interrogated using lectin blotting, and preliminary data show that endocytosis was necessary for proper glycosylation. Future aims of this work are to produce and purify equine lubricin, to test its clinical effectiveness as an injectable biolubricants.

9-2 ***Nonlinear wave dynamics leading to the formation of singularities in sheared particle-laden flows***

Daniel Markiewitz ’21, Donald Koch
Faculty Mentor: Donald Koch
Cornell University

Abstract: We sought to understand the observed dynamics in the formation of tightly packed bands of particles or “sheets” as a result of a sinusoidal perturbation of the two-dimensional unbounded simple shear flow of a dilute gas-solid suspension . This flow can be viewed as a simplified model that allows us to capture the particle clustering dynamics, which are seen in fluidized bed reactors. This analysis requires a deeper intuition of how this structure is dynamically generated, the mathematical shocks in the system, and the dissipation through the fluid flow. We will mathematically manipulate and simplify the governing equation sets of coupled nonlinear partial differential equations (PDEs). This reduced set of differential equations should lead to changes in the quantitative design of packed bed reactors where the spatial distribution of catalyst is significant. Through developing the solution to the unperturbed suspension of dilute gas-solid fluid, we can decompose the unknowns into known functions and disturbed quantities along with nondimensionalization of these coupled PDEs.

Through our work we simplified our governing equation for this system. We first approached the inviscid flow subcase ($1/Re \rightarrow 0$), which reduces the second order PDEs to first order PDEs. We further simplified this set of coupled PDE by consecutive usage of exact differentiation. This resulted in a simplified system and the identification that the system of equations had a similar form by which the method of characteristics was applicable. This allowed us to numerically simulate the evolution of many key quantities characterizing the flow such as: the nondimensionalized disturbed particle density (n'), nondimensionalized disturbed parallel and perpendicular fluid velocity ($\tilde{u}_{\parallel}'$ and $\tilde{u}_{\perp}'$), and parallel and perpendicular nondimensionalized disturbed particle velocity ($\tilde{v}_{\parallel}'$ and $\tilde{v}_{\perp}'$). Through the current investigation and future research into the spatial variation in the nondimensionalized disturbed pressure field we will be able to better understand the mechanism behind the singularity in the number density, which is the result of a sinusoidal perturbation of the two-dimensional unbounded simple shear flow of a dilute gas-solid suspension.

9-3 ***Electrospun Inorganic Tetrahelix Fibers with Reversible Optical Activity***

Wendy A. Alwala ‘23
Faculty Mentor: Tobias Hnrath
Cornell University

Abstract: Prior to the discovery of the Cd37S20 magic sized clusters by the Hanrath and Robinson group, there were no known instances of chirality within inorganic nanostructures that exhibited reversibility. Chiral materials due to their high symmetry exhibit rotary optical activity which means they can rotate the direction along which the incident light passes. This research interrogates the nature of this chirality, specifically its relation to the internal structure of the Cd37S20 magic sized clusters together. This new found knowledge will enable us to engineer the optical properties of inorganic materials by shearing the filaments that connect the clusters together.

In determining the above mentioned relationship, my part of the project focuses on characterizing the structure-property relationship between optical activity and directional strain which is the second step in a three step plan to fully define the chiral nature of the MSCs(Magic sized clusters). I will apply different types of stress and measure the atomic structure and optical -properties using circular dichroism which will help establish the relationship between the chiral

and structural properties of the MSCs. These experiments probe the nature of the relationship between stress application and chirality which is unknown as at now by establishing the atomic chiral structure, its characteristics and the kinetics of the reversible chiral transformations..
The main question here is whether the chirality is brought about at the cluster or fiber scale. We are specifically interested in the reversible chirality of inorganic materials because they exhibit more optical activity than inorganic ones and so this research opens hitherto unopened doors, with interesting new studies and applications in areas like high-resolution holographic displays, and DFT(Density Functional Theory) modeling to explore how different configurations could result in new chiral atomic structure.
To date, we have been able to electrospin a few CdS samples but Bard Hall is temporarily closed for renovations and we cannot run Circular dichroism measurements.

9-4 ***Thermal Conductivity and Transport in Covalent Organic Frameworks (COFs)***

Zara Aamer ’21, Hao Ma, Zhiting Tian
Faculty Mentor: Zhiting Tian
Cornell University

Abstract: Covalent organic frameworks (COFs) are a new, growing class of crystalline polymers with exceptional characteristics such as low density and high porosity, mechanical strength, and flexibility. However, little research has investigated thermal properties and mechanisms of heat transport in these materials. This work aims to draw connections between structure and thermal properties by determining in-plane and cross-plane thermal conductivities for single-crystal three-dimensional COFs as a function of pore size using molecular dynamics (MD) simulations. In 3D COF-300 derivatives, thermal conductivity was found to decrease with increasing pore size due to reduced densities and fewer structural pathways for thermal transport. Further considerations of carbon chain alignment and rotation were investigated to explain asymptotic behavior in this trend. Overall, maximum thermal conductivity (k-in-plane = 15.1 W/(mK), k-cross-plane = 27.6 W/(mK)) was achieved at the smallest pore size (d = 0.63 nm) and resulted in an over 40-fold increase in both in-plane and cross-plane values from the original COF-300 structure. These findings provide a basis for structure-thermal conductivity relations and facilitate future research that extends these results to fully capture the unique thermal transport mechanisms and pathways in crystalline 3D COFs.

9-5 ***Harnessing Quantum Computing to Improve the State-of-the-Art in Solving Industrial-Scale Scheduling Problems***

Kumail Al Hamoud ’21, Akshay Ajagekar, Fengqi You
Faculty Mentor: Fengqi You
Cornell University

Abstract: This project introduces a hybrid quantum computing (QC) based parametric approach for the network batch scheduling problem with a fractional objective, an important optimization problem in chemical plants. Different from conventional classical computing-based methods, the proposed hybrid framework harnesses novel QC-based techniques as a supplement to established deterministic algorithms, providing orders of magnitude speedups over conventional off-the-shelf optimization solvers. This is done by developing an algorithm that uses an efficient inexact parametric method as a support framework for transforming the Mixed-Integer Fractional Program (MIFP) to a parametric Mixed-Integer Linear Program (MILP). A QC-MILP decomposition that leverages quantum search techniques to overcome the combinatorial nature of scheduling problems is used to solve the resulting MILP subproblem.

To illustrate the effectiveness of the proposed method in chemical engineering, we carry out

computational experiments based on network scheduling instances of various sizes. The data for these computational instances is generated using a Python script. All the classical computing operations are performed on a Dell Optiplex system with Intel® CoreTM i7-6300 3.40 GHz CPU and 32 GB RAM. All the quantum computing operations are performed on a quantum processor provided by D-Wave Systems.

The computational results show that the proposed hybrid parametric algorithm is significantly more efficient than general-purpose solvers. Several large-scale instances took the benchmark classical off-the-shelf solver more than 24 hours to solve. The Proposed hybrid method, on the other hand, solves these instances in under an hour.