12th Annual

Undergraduate Research Forum

For Engineering & Architecture

March 31, 2021

Hosted by:
Tau Beta Pi: Ohio Gamma Chapter
The College of Engineering
Knowlton School of Architecture

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Major: **Mechanical Engineering**
Advisor: **Dr. Clarissa Belloni**

Numerical Investigation of One Hydrokinetic Turbine Performance

As the usage of electricity increases, people are seeking ways to generate electricity in an environmentally friendly way. According to a study done by BP, the global hydroelectricity consumption in 2019 was 948.8 Million tonnes of oil equivalent (BP Stats Review, 2019), including hydrokinetic power. Comparing to traditional hydropower, hydrokinetic power has advantages such as considerably less construction work and a lower environmental impact. The 2019 Annual Report from Ocean Energy System organization shows the cumulative energy generated from hydrokinetic sources in 2019 was 50 GWh (OES Report, 2019), and the hydrokinetic installed capacity in 2050 is projected to be 300 GWh (OES Vision, 2017), so it's essential to find an efficient way to utilize hydrokinetic energy.

The proposed research will be focusing on performing Computational Fluid Dynamics (CFD) simulations on a full-size hydrokinetic SIT turbine model to obtain performance characteristics such as the power coefficient. The simulation is performed using the CFD simulation software ANSYS Fluent. The rotational working condition of the turbine is simulated using the sliding mesh method, and the calculated power generation is compared with the various power tested on-site (Jeffcoate, 2015). Finally, simulations under different settings such as rotational speeds and flow speeds are performed to find the optimum condition that produces maximum power and compare with on-site test results to validate the simulation to see if the on-site test has reached the full capacity of the turbine, and validate the simulation. The goal is to provide accurate power prediction using CFD for similar turbine using the same blade design and find out their optimal operating conditions.

Researcher: **William Mullin**
Major: **Aeronautical & Astronautical Engineering**
Advisors: **Dr. Mo Samimy & Dr. Nathan Webb**

Active Flow Control in an Aggressively Offset Inlet

Aggressively offset inlet systems are becoming increasingly important in the field of aerospace engineering, with many potential military and flight applications. Prospective advantages include reducing the radar cross-section of an aircraft and improving the integration of the propulsion and aerodynamic systems. However, due to the curved S-shape of the duct, an adverse pressure gradient forms around the inside of the turns in the inlet. This adverse pressure gradient causes flow separation and the formation of streamwise vortices which result in significant flow distortion and pressure loss at the aerodynamic interface plane. These flow characteristics are very undesirable; they can cause decreased aircraft performance and the high-cycle fatigue reduces the structural life cycle of the engine components. To counteract the unsteady flow, specialized plasma actuators may be used to reduce the effect of the streamwise vortices and crossflows throughout the duct through flow excitation. Many different types of plasma-based actuators have been proposed to excite the flow: localized arc-filament plasma actuators (LAFPAs), pulsed DC plasma actuators, and plasma synthetic jets are under consideration. The goals of this project are to investigate the effect of active flow control configurations on the aerodynamic performance throughout the duct and to gain a better understanding of the flow physics and dominant instability features of flow through an aggressively offset inlet.

Researcher: **Samuel Stevens**
Major: **Computer Science & Engineering**
Advisor: **Dr. Yu Su**

An Investigation of Language Model Interpretability via Sentence Editing

Pre-trained language models (PLMs) like BERT are being used for almost all language-related tasks, but interpreting their behavior still remains a significant challenge and many important questions remain largely unanswered. For example, how does domain-specific pre-training change the dynamics within a model? Is task-specific fine-tuning necessary for model interpretability? Which interpretability techniques best correlate with human rationales? In this work, we re-purpose a sentence editing dataset, where high-quality human rationales can be automatically extracted and compared with model rationales, as a new testbed for interpretability. This enables us to conduct a systematic investigation of the aforementioned open questions regarding PLMs' interpretability and generate new insights. The dataset and code will be released to facilitate future research on interpretability.

Researcher: **Dora de Melo**
Major: **Environmental Engineering**
Advisor: **Dr. Jeffrey Bielicki**

The economic and geospatial viability of CO2 capture and storage in shallow saline aquifers for geothermal energy in the Gulf Coast of the United States

Carbon dioxide (CO2) that has been geothermally heated due to emplacement in deep saline aquifers in sedimentary basin geothermal resources could be produced to the surface and used to generate electricity. This CO2-geothermal process is an extension of CO2 Capture and Storage (CCS) that could simultaneously isolate CO2 from the atmosphere and use it as a heat extraction fluid to produce geothermal energy. This approach may help to mitigate climate change by addressing to pressing problems for energy systems: (1) reducing CO2 emissions from existing facilities, and (2) increasing the deployment and utilization of renewable energy technologies. Since the CO2-geothermal process requires that CO2 from point sources be geologically stored and circulated in deep aquifers, it is necessary to understand how to transport the CO2 from the sources to the reservoirs. Assessing the integrated source-sink matching that considers the individual characteristics of each source and each potential reservoir is described as the viability of geologic storage capacity and provides the most comprehensive supply curve given economic and geospatial characteristics of the sources and reservoirs. In a case study of the South East United States, this project will investigate the viability of CO2-geothermal as it depends on. Using the engineering-economic geospatial optimization approach SimCCS—a fully integrated, holistic software package that considers all of the costs and capacities associated with integrated CO2 capture, transport, storage, and utilization systems—this project will investigate the optimal infrastructure deployment for CO2-geothermal. Analysis of these findings will define the ideal locations and networks for sequestration and geothermal energy production.

Researcher: **Tu Feng**
Major: **Industrial & Systems Engineering**
Advisor: **Dr. Theodore Allen**

Literature review on quality engineering in the context of Industry 4.0 and the Industrial Internet of Things

Introduction: In the last 30 years, industries have benefited a lot from Lean Six Sigma and Statistical Process Control to monitor and improve operational efficiency, but quality engineering needs to evolve and adapt to the coming Industry 4.0. In recent years, Industry 4.0 has penetrated many sectors of today's business world as well as enabling technologies such as the Industrial Internet of Things (IIOT), Artificial Intelligence, Big Data, and Virtual Reality.

Methods: This study selected 66 articles from over 2000 search results and reviews this literature describing the sources, trends, and suggesting topics for further research. The associated synthesis of the "Quality 4.0" literature emphasizes the practical implications for quality practitioners and researchers. Drawing on the literature, we answer: (i) What is Quality 4.0? (ii) What are its impacts on operational performance? (ii) What roles can quality researchers usefully play in relationship to Industry 4.0 and IIOT?

Results and conclusion: The results suggest a growing consensus that the body of knowledge for quality engineers is rapidly changing to emphasize topics including machine learning. Another conclusion is that the topics identified by ASQ in the body of knowledge are largely unexplored by research authors. These include methods to shift attention from variation reduction in operators to automatic process design for quality, the monitoring and design of self-managing machines, and an increased emphasis on methods for big data analytics. Also, attention to the dashboards and software explicitly related to IIOT such as PTC Thingworx, Siemens Mindsphere, and Power BI is conspicuously absent in the literature.

Researcher: **Andrew Bushman**
Major: **Chemical Engineering**
Advisor: **Dr. Jonathan Song**

Profiling the Biophysical Characteristics of Sulfated Glycosaminoglycans on the Extracellular Matrix

The extracellular matrix (ECM) enveloping cells in living tissue is comprised of signaling and structural support molecules. Two important types of ECM molecules are collagen and glycosaminoglycans (GAGs). The ECM is vital to the maintenance of normal tissue as it controls cell signaling and is a semiporous barrier to interstitial fluid flow. In malignancies such as cancer, the composition of the ECM is significantly altered. For instance, cancer ECM contains elevated levels of negatively charged GAGs, which causes tissue to swell, alters the ECM architecture, and limits interstitial fluid transport. This thesis uses a microfluidic approach to characterize the effects of hyaluronic acid (HA) and chondroitin sulfate (CS), two GAGs that are known to be unusually abundant in certain solid tumors, on fluid transport (hydraulic permeability), and matrix microstructure (pore size, fiber radius and alignment). The study used 3 mg/ml collagen gels as the control ECM and modified the composition of the gels by adding CS (0.5, 1mg/ml) and CS (0.5, 1mg/ml) with HA (0.5, 1mg/ml). The results of the study have shown significant changes in the reconstituted ECM microstructure with the addition of the GAGs. Specifically, all trials have significantly increased the pore size and fiber radius in comparison to the control collagen gels, while alignment had no significant change. Although significant changes in ECM microarchitecture were observed, there were no significant changes in the hydraulic permeability of the gels. The results show how the introduction of excess GAGs can significantly alter the physical structure of the ECM but has little effect on the transport properties of the microenvironment. This study provides further evidence that GAGs play an important role in the physical properties of the ECM and suggests further studies should be conducted to better understand how to counteract the effects of GAGs in the tumor microenvironment.

Researcher: **Brandon Cruz**
Major: **Mechanical Engineering**
Advisor: **Dr. Ruike Zhao**

Additive Manufacturing for Complex Structures with Magnetic Smart Materials

Stimuli responsive materials have shown great potential in the ability to add functionality to designs to achieve and complete certain tasks. While not ubiquitous, applications so far have been found in fields of soft robotics in the case of mechanical grippers to drug delivery for minimally invasive surgeries. These materials operate by exhibiting certain mechanical properties once under the stimulation from an external stimulus. In the case of Magnetic Shape Memory Polymer (M-SMP), it responds with a combination of magnetic field intensity and direction along with temperature control to allow shape locking and unlocking below and above the glass transition temperature, respectively. Current fabrication methods inhibit the ability to combine functional ability of configurable mechanical properties with functional designs such as those used in springs. In this thesis, a method of 3D printing, Digital Light Processing (DLP), is explored as an avenue to develop and characterize feasibility and quality of printing custom complex millimeter-scale components. In developing a custom DLP enabled setup, formulating photosensitive m-SMP resin, and demonstrating functionality combined with various complexity, it is shown that it is possible to combine design complexity with material functionality. This research effectively expands the ability to apply complex geometric designs that can be manufactured and allows a fuller range of ability of fabricated parts.

Researcher: **Katie Geers**
Major: **Mechanical Engineering**
Advisor: **Dr. Rob Siston**

Design of a 3D Printed Patient Specific Cutting Guide for use in Anterior Closing Wedge High Tibial Osteotomy

Anterior closing wedge high tibial osteotomy (ACWHTO) is a type of orthopaedic surgery in which a wedge is cut and removed from the upper tibia to decrease the posterior tibial slope (PTS). Decreasing the PTS reduces the risk of ACL injuries. Current ACWHTO surgical techniques result in poor surgical accuracy. 3D printed patient specific cutting guides have improved surgical accuracy in other types of surgical procedures; however, this technology does not currently exist for ACWHTO. The purpose of this research project is to design and test a 3D printed patient specific cutting guide for use in ACWHTO to make the surgery easier for surgeons and improve the surgical accuracy. The cutting guide was designed with clinical guidance and modelled in CAD software. It consists of a base guide design with parameters that can be easily modified based on a patient's anatomy and operative plan. Two rounds of testing were completed for concept validation and to assess the guide's ability to improve surgical accuracy. The first round of testing tested prototype 3D printed cutting guides on PVC pipe sections representing bones. This testing was a preliminary validation of the guide design and revealed improvements that needed to be made in the design like increasing the guide width and depth and decreasing the pin hole diameter. The second round of testing will use pork tibias to test 3D printed cutting guides in mock ACWHTO surgical procedures to evaluate the surgical accuracy achieved. This test has not been complete as of 3/1/2021. The 3D printed patient specific cutting guide developed in this project has the potential to improve surgical accuracy in ACWHTO procedures leading to better patient outcomes. It also makes the surgery easier and more accessible for surgeons who might not consider this technique for care of patients with elevated PTS.

Researcher: **Daniel Seals**
Major: **Mechanical Engineering**
Advisor: **Dr. Marcello Canova**

Novel Method for Lithium-Ion Equivalent Circuit Model Calibration via Model Order Reduction of an Electrochemical Model

Physics-based electrochemical models and heuristic equivalent circuit models (ECMs) are two well-established and widely used techniques to predict the current-voltage behavior in lithium-ion cells. While physics-based models are typically very accurate and require relatively little experimental data to calibrate, they suffer from high mathematical and computational complexity. Conversely, heuristic models are more computationally efficient and mathematically simpler, making them well-suited for applications in controls, diagnosis, and estimation of lithium-ion battery packs. However, these models are not predicting the physical and chemical processes occurring in the cell, hence they are less accurate and require extensive and costly experimental campaigns to properly calibrate. This research bridges the gap between these two classes of models, incorporating some of the physical insight of electrochemical models into the calibration process of heuristic models. To achieve this, the Extended Single-Particle Model (ESPM), an electrochemical model, was chosen as a foundation for the work. A Pade Approximation -- a frequency-domain approximation method -- was used to simplify the solid and liquid phase diffusion equations of the ESPM. From here, the ESPM was further simplified via linearization such that the mathematical structure of the ESPM matched that of a second order ECM, making ECM calibration straightforward. The newly calibrated ECM had minimal loss in accuracy compared to the ESPM, with only a 7% increase in RMSE across various validation test profiles. The new ECM calibration process eliminated the need for much of the costly and time-consuming testing typically required for ECM calibration. Additionally, since the ECM is constructed of the physical constants of the ESPM, the calibrated ECM has physical meaning, allowing for novel methods of battery performance exploration in future work, including an extension of the work to incorporate battery aging.

Researcher: **Nadja Marin**
Major: **Biomedical Engineering**
Advisor: **Dr. Manoj Srinivasan**

Strategies behind underlying bimanual force sharing in humans

Force sharing refers to the way that body parts work together to apply forces to complete tasks. In humans, it can occur between body parts such as the hands, arms, or legs. Force sharing allows humans to complete many daily tasks and they require a good deal of control. Even though force sharing is intuitive for many people, the concepts behind it are still not well understood. The inability to force share can decrease the quality of life since many daily tasks require force sharing and control. Diseases such as stroke or Parkinson's disease can decrease force sharing ability, making force sharing research clinically relevant. The goal of this research is to contribute to the current knowledge of force sharing by simulating a force sharing task between two arms on one person. To simulate the force sharing task, two force plates will be used. The subject will press on each plate with one hand with the goal of reaching a desired force. The forces applied to the plates will be added together to try to reach the goal force. In each trial, the goal force will be varied as well as the weight multiplier used when adding the forces of the plates together. By varying both of these parameters, a range of force sharing tasks will be simulated. The results will be analyzed to see if the subject relies more on their dominant arm by comparing the actual weights of the subject against the trial weights. To see if exertion level affects the results, trials with differing goal forces will be compared. This experiment will provide data on force sharing that could be used to develop force sharing models. In addition, this experiment will increase the understanding of force sharing, which could be useful in applications such as rehabilitation.

Researcher: **Jun Nishikawa**
Major: **Mechanical Engineering**
Advisor: **Dr. Ruike Zhao**

Kresling Origami-Based, Magnetically Actuated Robot

Origami, the Japanese art of paper folding, has recently been applied in fields such as metamaterials, aerospace engineering, and biomedical engineering. All these applications take advantage of origami structures' ability to deploy and change shapes easily while being lightweight and compact. Research has been done recently to develop bio-inspired, crawling robots that use the Kresling pattern, a deployable, column-like structure. The Kresling cells are actuated to expand and contract, and specially designed "feet" translate this to net motion of the entire robot. A disadvantage with these existing designs is that they are relatively large and heavy due to having motors and other electronics on-board. Also, they must be tethered with electrical wires to power and control the motors which limits their mobility. The goal of this research was to construct and characterize a Kresling-based crawling robot that is untethered and more compact. The robot has magnetically responsive materials installed on it and is controlled via an electromagnet. Magnetic actuation separates the power source and controller from the actuator, which untethers the robot and reduces the number of constituent parts. This allows the robot to be miniaturized and simplified in structure. By manipulating the applied magnetic field strength and direction, the robot can be controlled as desired. Characterization of the robot involved determining how parameters of the magnetic field profile affects performance such as the speed and motion efficiency. The resulting Kresling origami robot in this research can fit within a 1 cm by 1 cm by 3 cm box, weighs about 4 grams, and can be controlled freely in the horizontal plane through a magnetic field of up to 40 mT in strength. The robot's small form factor and untethered control gives it many potentials, such as navigating within bodies for minimally invasive medical procedures.

Researcher: **Kellen McCabe**
Major: **Mechanical Engineering**
Advisor: **Dr. Ardeshir Contractor**

Modeling Thermal Behavior of Vehicle Integrated Photovoltaics

With a changing environment and a massive push toward clean energy and green practices, the technological advancements of the electric vehicle (EV's) are an important step to improve as a society in this area. One current downside of EV's is the limited range they hold. With vast recent developments in solar cell technology, more technically referred to as photovoltaic (PV) cells, the idea of PV technology integrated into the roof of vehicles is gaining attention and becoming a focus for research in this field. Due to the reduced convective cooling on the backside of the panel, vehicle integrated photovoltaics (VIPV) experiences higher temperatures. Limiting cell temperature is important to PV technology as the efficiency of the PV cells decreases with higher temperatures. To further study this technology, understanding of the effects of parameters including drive cycle, latitude, season and PV material in this higher temperature application is key. The best method for studying these parameters is using numerical modeling and analyzing different scenarios with a range of parameters. To conduct this parametric study, the process began by creating a geometric model of the VIPV panel. Researching sizing and materials for normal PV applications, the problem was then set up with the thermal, electrical, and structural boundary conditions considered. After completing setting up the problem, the geometry and boundary conditions were added to COMSOL, a simulation software. To generate results, parameters were isolated while the rest remained constant. This process outputs plots that show the effects of each parameter on the performance of the VIPV concept. This study will provide an indication on the viability of VIPV with the current state of PV technology. Due to the temperature-based losses in efficiency and the costs of PV materials, understanding VIPV performance is important to see the next steps toward commercial use.

Researcher: **Trace Eberhardt**
Major: **Civil Engineering**
Advisor: **Dr. James Stagge**

Prediction of Agricultural Losses and Drought Impacts by Meteorological Drought

In the United States and around the world, the SPI (Standardized Precipitation Index) is used to quantify meteorological drought over timescales of months, using precipitation. In this study, SPI ratings are analyzed against drought impacts to determine if certain levels of drought correlate to documented drought impacts, focusing on the Midwestern United States, primarily Ohio, Kentucky, and West Virginia. Agricultural impacts are the primary focus of this study because these are the most prominent type of drought impacts in states of interest. Impact models are developed for two types of impact measures: qualitative drought impacts reported from a variety of news sources, and quantitative data on Ohio crop production from 1961 to 2018. Qualitative impacts are used to estimate the number of agricultural drought impacts per year. Quantitative data used in this study, Ohio crop production, is used to test how yearly variance in crop production is related to drought, measured by the SPI. Because crop production has increased over time due to advances in farming, this analysis first removes the increasing long-term trend to focus on yearly variance due to drought. This analysis will help determine which SPI ratings have the strongest relationship with the occurrence of drought impacts and decreases in agricultural crop production. In this study other climatic measurements are explored in relation to crop production such as Vapor Pressure Deficit, Temperature, and Evapotranspiration in addition to SPI. Finally, this analysis explores the potential relation between climatic measurements and agricultural finances. Overall, this research can help farmers prepare for the impact of drought conditions.

Researcher: **George Crowley**
Major: **Mechanical Engineering**
Advisor: **Dr. Haijun Su**

The Design and Fabrication of a Novel Soft Pneumatic Gripper

The purpose of this research is to develop and fabricate a pneumatic variable stiffness soft gripper using primarily additive manufacturing. A soft gripper is a type of manipulator typically constructed from compliant material. Due to their compliance, soft grippers are safer for operation around humans and adaptable to a wide range of tasks. However, they are unable to carry the higher loads that rigid grippers can.

Variable stiffness technologies such as layer jamming can provide a solution to this problem, allowing the gripper to retain the benefits of a soft gripper while increasing its payload capacity. Layer jamming uses overlapping sheets of plastic or paper attached at either end of a joint and enclosed in an airtight bag. Applying vacuum to the bag compresses the layers, producing an increase in joint stiffness positively related to the vacuum pressure. Because vacuum jamming is limited to 14.7 psi, positive pressure jamming was used in this research to increase the performance potential.

Proof of concept soft grippers were produced using additive manufacturing. These designs were used to develop best practices and settings for design and manufacture of such grippers. As there was little existing research on positive pressure layer jamming, numerous prototypes were tested to find an optimal design for integration with a soft gripper. Then a complete gripper was manufactured and tested to analyze its performance. The design was then iterated to improve metrics such as actuation time, load capacity, repeatability, and reliability.

The techniques developed for additive gripper manufacturing proved successful and allowed for rapid design iteration. Two final robotic fingers were produced and integrated into a handheld unit. This unit successfully picked up a wide range of irregularly shaped and heavy objects. The individual gripper was found to have higher load capacity than similarly sized, commercially available soft grippers.

Researcher: **Reilly Smith**
Major: **Mechanical Engineering**
Advisor: **Dr. Clarissa Belloni**

Numerical Modeling of a Small Hydro Kaplan Turbine

Although hydropower is already a significant contributor to energy generation in the US, there are still ways for it to expand. One of these ways is to enable existing small, low-head dams and weirs to generate energy through Kaplan-style turbines. This project develops a 3D Computational Fluid Dynamics (CFD) model of Rickly’s 92L32 PROPEL, Kaplan-style Turbine to optimize performance in low-head applications. This CFD model will help to save time and cost for the optimization of the turbine’s geometry. The flow through the turbine was simulated using ANSYS Fluent under various operating conditions to provide results over the turbine’s entire operating space. The main set of simulations look at the transient effects of the turbine blades rotating at different speeds. Torque and other data values will be outputted and calculated. These results will be compared to experimental and field results obtained from the manufacturer to validate the CFD model. Multiple simulations will be run to obtain a flow curve of the turbine under different operating conditions. Future work for this project will involve manipulating the geometry of the turbine to optimize its performance based off the operating conditions given. Specifically, propeller and wicket gate angles can be adjusted to optimize performance under certain flow rates.

Researcher: **Jacob Fillinger**
Major: **Chemical Engineering**
Advisor: **Dr. Andrew Tong**

Conversion of Polyethylene to Syngas with a Chemical Looping Approach

Large-scale plastic disposal has become an increasing environmental threat, and current recycling methods of the material are inefficient and underused. Thus, an effective conversion of waste plastic to usable products must be discovered. This project seeks to utilize chemical looping technologies to efficiently recycle polyethylene, the main component of plastic waste. Specifically, high density polyethylene (HDPE) pellets are examined as a chemical looping reactor feedstock. HDPE pellets are converted into a gaseous mixture of high purity hydrogen and carbon monoxide, which is known as synthesis gas (syngas). Based on the ratio of hydrogen to carbon monoxide in the syngas, specific fuel products can be made. This project seeks a hydrogen to carbon monoxide ratio of two, which is ideal for synthesizing gasoline. The syngas is formed by partially oxidizing the HDPE pellets with metal composite oxygen carriers, which also form small amounts of other gaseous byproducts. Initially, the reactor setup is modelled using Aspen Plus simulation software, in which a series of sensitivity analyses are performed to determine optimal reactor operating conditions. Next, bench-scale testing of the recycling process takes place in a moving bed reducer chemical looping reactor, in order to determine the efficacy of polyethylene to syngas conversion.

Researcher: **Shivangi Mohta**
Major: **Biomedical Engineering**
Advisor: **Dr. Thomas Hund**

The role of βIV-spectrin-dependent STAT3 phosphorylation in cardiac hypertrophy

Heart failure (HF) remains a major source of morbidity and mortality worldwide, with growing incidence and limited options for treatment. A common feature in HF development is hypertrophic growth of cardiac myocytes, which depending on the nature and/or duration of the stressor may be either concentric (predominant increase in myocyte width) or eccentric (increase in myocyte length). Typically, concentric myocyte growth is associated with an adaptive response to increase cardiac output in the face of increased demand. On the other hand, eccentric growth is usually associated with maladaptive remodeling of chamber dimensions (wall thinning, ventricular chamber dilation) loss in cardiac output, and advancement of HF. Although hypertrophy has been studied for decades, we know very little about the mechanisms governing the orientation of myocyte growth (concentric vs. eccentric) or their specific roles in pathophysiology. Here, we hypothesize that the therapeutic preservation of the adaptive, concentric state represents an opportunity for maintaining heart performance in the presence of sustained cardiac pressure overload. Interestingly, previous work in our lab identified a role for the structural protein βIV-spectrin and its interaction with the transcription factor, STAT3, involved in coordinating hypertrophic gene programs. In previous work, we reported that βIV-spectrin mutant mice (qv3J) expressing truncated βIV-spectrin lacking a critical regulatory domain were resistant to maladaptive hypertrophy and cardiac dysfunction following 6 weeks of transaortic constriction (TAC). Subsequent analysis revealed an interaction between the multifunctional transcription factor STAT3 and βIV-spectrin, which was associated with differential hypertrophic response and function in WT and qv3J animals in response to TAC. Further investigation revealed that mutant βIV-spectrin mice (qv4J) lacking the STAT3/βIV-spectrin binding domain showed reduced ejection fraction, thinning of the LV wall, and dilation of the LV chamber, consistent with parameters of eccentric remodeling, suggesting that STAT3/βIV-spectrin may be a critical regulator of maladaptive vs. adaptive hypertrophy. In order to test whether STAT3/βIV-spectrin complex regulates hypertrophy at the cellular level, we first probed STAT3 phosphorylation status at a critical regulatory site known to alter STAT3 activity/localization (Ser727) in WT and qv3J animals at baseline and following TAC. Interestingly, while WT hearts showed a decrease in STAT3 S727 phosphorylation and eccentric hypertrophic remodeling following TAC compared to baseline, qv3J hearts showed sustained STAT3 Ser727 phosphorylation and concentric hypertrophy. At the same time, knock-in mice expressing STAT3 with genetic ablation of the STAT3 Ser727 residue (STAT3-S727A), showed an accelerated transition to eccentric hypertrophy in response to TAC. Finally, stimulation of WT myocytes but not qv4J myocytes lacking βIV-spectrin/STAT3 interaction with lipopolysaccharide (to activate STAT3) increased STAT3 Ser727 phosphorylation. Collectively, these data reveal that βIV-spectrin is required for normalSTAT3 Ser727 phosphorylation. Furthermore, our data indicate that differential phosphorylation of STAT3 at Ser727 is observed in adaptive vs. maladaptive hypertrophic states. In future studies, we hope to evaluate upstream kinase pathways leading to STAT3 Ser727 phosphorylation and their dependence on βIV-spectrin expression. In addition, we will identify critical gene targets relevant to concentric versus eccentric growth profiles by targeting altered STAT3 activity, while also utilizing mathematical modeling for hypertrophic signaling networks pertinent to concentric and eccentric growth profiles.

Researcher: **Simon Conover**
Major: **Mechanical Engineering**
Advisor: **Dr. Clarissa Belloni**

Design and Validation of a Siphonic Hydropower Systems Tool

Small hydropower (less than 30 MW) provides a path to adding power to the current energy infrastructure in a clean, renewable way. Further, since the available resource is consistent, it can supplement other forms of more intermittent green energy, such as wind and solar power. A large reason it is not implemented more broadly is its high initial costs, especially due to civil works during construction and installation. To mitigate this, small hydropower can be supplemented using siphonic hydropower with non-powered dams. Non-powered dams are structures already built over a waterway, primarily used for river control. By constructing a large siphon overtop of these dams and placing a reaction turbine in the middle of the piping, one can quickly, cost-effectively, and efficiently construct further hydropower schemes without the need for extensive civil works. Rickly Hydropower is a company building siphonic hydropower systems, however, they are in need of a tool to be used in the design phase for initial calculations. In this work, the construction and validation of a siphonic hydropower design tool in Microsoft Excel is explored. The tool uses certain inputs such as characteristics of the site, dimensions of the dam, material of the piping, and the flow rate through the turbine. In turn, the tool calculates various outputs, such as sizing (including length and diameter) of the piping to be used, various pressure and cavitation concerns at several points, and the flow rate responses of the system. The developed tool was then validated through the construction of a scale model dam and siphon system within a flume on campus. Pressure values at two points of the siphon were found using manometers and compared to the predicted values initially produced by the tool. Results from this experiment will further confirm the efficacy of the tool, which will, in turn, aid in the design of these systems.

Researcher: **Zhengqi Dong**
Major: **Computer Science & Engineering**
Advisor: **Dr. Darren Drewry**

Image-Based Plant Leaf Disease Recognition with InceptionV3 Network

Most traditional plant disease diagnosis strategies depend on human visual observation and inspection. However, this approach is time-consuming and requires significant human effort and expert knowledge. The recent advances in computer vision and deep learning provide a potential pathway to developing a plant disease diagnosis system that allows rapid detection of disease across large spatial areas with minimal human intervention. In this study, we developed a deep learning approach for plant leaf disease classification problems and conducted a range of experiments to quantify the performance of several state-of-the-art neural network architectures, including ResNet50, InceptionV3, and NASNet. All of the experiments were trained on the PlantVillage dataset with 54305 images in total, spanning over 38 plant disease classes. We evaluated four different performance metrics to assess each architecture: accuracy, precision, recall, and area under the curve (AUC). Our results showed that the InceptionV3 neural network architecture outperformed all other Convolutional Neural Network (CNN) architectures (ResNet50, NASNet-Large, NASNet-Mobile, MobileNet-v3-small, and MobileNet-v3-large) and produced a training accuracy of 94.14% and 97.94% over 6 epochs and 40 epochs of training, respectively. These results suggest that CNN architectures broadly, and the InceptionV3 model specifically, is capable of remote and automated plant disease detection. These results point to exciting future applications in lightweight mobile phone applications or backend workstation developments for plant leaf disease recognition problems.

Researcher: **Jize Dai**
Major: **Mechanical Engineering**
Advisor: **Dr. Ruike Zhao**

Design and Fabrication of Multiple Magnetic Material Actuator

Magnetic Soft Materials (MSMs) have functions of reversible shape transformation, untethered, fast, and shape controllable under applied magnetic fields. Magnetic shape memory polymers(M-SMPs), as one of the MSMs, have a new type of function - shape locking. With temperature changing, it can increase or decrease its Young's Modules to change its stiffness which both achieved shape-changing and energy saving. However, its thermal curing fabrication method limits its design shape only to simple geometry shapes. Here, with our photo-curing method and developed multimaterial printing technology, we have designed complex structures contain both M-SMPs and MSMs. Under thermal and magnetic actuation, the complex structures are capable of shape-changing and shape locking. It accomplished multiple usages relative to different shapes in one construction. In this article, we introduce some design concepts in biomedical and robotic uses, like simple thermal coagulation robots and multi-shape honk. We expect that multimaterial printing technology opens a new field for multimaterial designing and further exploits their functions for applications.

Researcher: Caffrey Yu
Major: **Mechanical Engineering**
Advisor: **Dr. Ayonga Hereid**

Global Localization of Autonomous Underwater Vehicle Using Visual Odometry

Path planning and navigation are two of the main challenges for achieving autonomous driving. Simultaneously, localization has been considered the footstone for path planning and navigation because the high-level planning algorithms require odometry information. For autonomous underwater vehicles (AUV), expansive navigation sensors, such as deepsea sonar, have usually been utilized to get the location of the robot underwater. This project, however, is intended to introduce the potential application of real-time underwater visual odometry (VO) algorithms based on data retrieved from a monocular camera on both simulated environments and robots owned by the Underwater Robotics Team under the Ohio State University. The proposed visual odometry technique is based on the projected geometry theories. It will be combined with existing open-source localization libraries based on inertial measurement unit (IMU) data by data fusion methods, including extended Kalman filters (EKF). Aside from discussing the visual odometry algorithm's framework and usages, feature tracking algorithms on turbid underwater environments will also be addressed. Underwater robots' working environment is not always perfect. Different feature tracking algorithms were performed on real open-source underwater footage to determine the most suitable algorithm for this project. Comparisons of the ground truth odometry of a simulated underwater robot and the odometry calculated from the visual odometry algorithm will be presented. The Underwater Robotics Team will apply this research to compete in the annual Robosub Competition, one of the largest international autonomous underwater robotics competitions.

Researcher: **Jingyuan Wang**
Major: **Mechanical Engineering**
Advisor: **Dr. Carlos Castro**

Multiplexed magnetic actuation of DNA nanostructures on a low cost, portable platform

Having temporal and spatial control over the real-time motion of nanoscale devices is a critical goal in nanorobotics and nanodevice research. DNA origami is an emerging nanotechnology for the self-assembly of nano devices that provides unprecedented control over nanoscale geometry, providing an attractive platform for spatial control. In this approach, a long DNA “scaffold” strand is folded into a compact structure through base-pairing with many shorter DNA strands. Our recent study has advanced in developing dynamics DNA origami nanostructures with controlled motion and conformational changes including an approach for the magnetic actuation of DNA devices. This previous work demonstrated actuation of one or up to a few devices at a time with second timescale temporal resolution. Based on the foundation of the prior work, my research has focused on increasing the yield of the synthesized structures and the polymerized structures. With the same dynamic nanostructures, different assay conditions have been tested including choosing proper folding temperature, proper magnesium concentration, proper folding time duration and additional purification operations for the synthesized structures. Besides the optimization for the synthesized structures, the yield of the polymerized structures has also been optimized with the polymerization time duration, polymerization temperature, concentration of the polymerization strands and the concentration of the synthesized structures. This work achieves at least 10 to 20 objects in the same field of view, which represents an order of magnitude improvement compared with the prior results, and a key step for practical multiplexing. Moreover, the length of the polymers has been increased to micrometer scale which is vital for practical application.

Researcher: **Manqi Pan**
Major: **Biomedical Engineering**
Advisor: **Dr. Jun Liu**

Mechanical Deformation of Human Retina During Elevation of Intraocular Pressure

Glaucoma is considered as the second leading cause of blindness all over the world after cataract. The pathogenesis of glaucoma is not well understood, but the widely accepted primary cause is the damage of retinal ganglion cells resulting from chronic elevation of intraocular pressure (IOP). During elevation of IOP, increased stresses and strains occur within the posterior segment wall of the eyeball including the sclera, the choroid, and the retina. This study aims to explore the mechanical characteristics of the peripapillary retina (PPR) based on an in vitro experiment. To perform this study, an in vivo inflation test of ten human donor eyes by increasing IOP from 5 to 30 mmHg was analyzed and high-frequency ultrasound images at each pressure step along the nasal-temporal (NT) and superior-inferior (SI) axes were obtained. Reginal displacement of the posterior eye in the vertical and horizontal direction were calculated via the 2D ultrasound speckle tracking technique, and through-thickness, in-plane, and shear strains were calculated within the posterior eye region. Peripapillary tissue (PPT) and PPR were manually segmented and paired t tests were applied for PPT and PPR regional analysis. Based on the results, PPR experiences less radial compressions (-0.55 ± 0.25% vs. -2.32 ± 0.74%) and greater shear (1.49 ± 0.65% vs. 1.13 ± 0.32%) than PPT. PPR and PPT have similar tangential strain (0.29 ± 0.19% vs. 0.38 ± 0.19%). For quadrant difference, tangential strains were significantly greater in N than T for all tissues (p-value = 0.005). Colocalized tangential and shear strains were found close to the neuroretinal rim of the PPR and PPT. Our findings show although PPR experiences only little radial compression during IOP elevation, shear and stretch might be the main reason to cause the mechanical damage during IOP. Those results might provide more insights into the role of retina biomechanics in the study of glaucoma susceptibility.

Researcher: **Abhishek Vijaykumar**
Major: **Electrical & Computer Engineering**
Advisor: **Dr. Rizwan Ahmad**

Pilot Tone Signal Optimization for Cardiac Magnetic Resonance Imaging

For cardiac Magnetic Resonance Imaging (MRI), involuntary physiological motions pose a challenge because MRI acquisition is inherently slow. In particular, detection and compensation of these physiological motions are essential to acquire detailed images of the heart. Pilot Tone (PT) is an emerging technology where the transmitted signal from a dedicated transmitter undergoes modulations due to these physiological motions. The resulting modulated signal is picked up by the MRI receiver coils, thereby allowing PT to encode these physiological motions effectively. PT presents an efficient alternative that can circumvent the limitations associated with existing respiratory motion detection techniques, including respiratory bellows, navigator echoes, and breath-holding. Another challenge for cardiac MRI is that the electrocardiogram (ECG), at magnetic fields of 3T or higher, gets distorted and can result in an unreliable cardiac motion extraction. Robust and reliable extraction of respiratory and cardiac signals will enable PT to replace the existing paradigm for capturing physiological motions and benefit all cardiac MRI applications. In this work, we present a method to optimize the PT extraction process. The method first denoises the data using principal component analysis (PCA). Then, independent component analysis (ICA) and energy spectral analysis are applied to separate out the cardiac motion. For testing, the measured PT data from 15 volunteers were processed, and the resulting cardiac triggers were compared with those from the ECG reference. In 11 out of 15 datasets, the proposed method exhibited excellent agreement with ECG. In the other 4 datasets, where the signal quality was poor, the proposed method demonstrated only moderate agreement with ECG. Most importantly, for all the 15 datasets, the proposed method outperformed the existing PT processing methods.

Researcher: **Jack Sullivan**
Major: **Aeronautical & Astronautical Engineering**
Advisor: **Dr. Datta Gaitonde**

Application of modal decomposition techniques to the non-stationary condition of scramjet unstart

Scramjets are a class of high-speed aerospace propulsion devices that operate with no moving parts and perform combustion at supersonic speeds. They offer a viable option for reusable, efficient, air-breathing hypersonic propulsion and they will be of critical importance to powering the transportation and defense systems of the future. Due to the lack of turbomachinery in scramjet flow paths, sufficient compression and velocity reduction of the flow must be achieved using the Pre-Combustion Shock Train (PCST), which is a series of shocks in the isolator portion of a scramjet. Under certain conditions, the PCST is ejected out of the front of the engine, causing the engine to unstart. The consequences of unstart are severe, with the engine no longer producing thrust, and potentially causing complete vehicle loss. This work focuses on a high fidelity, computationally generated unstart simulation, in which a pressure induced unstart event is potentially controlled by an upstream cavity. Since such high-fidelity databases are large and difficult to analyze, modal decomposition techniques are often employed. The challenge in applying these techniques for the unstart problem is that it is not stationary i.e., it is unsteady but does not oscillate about a mean position. To address this, two data-driven modal decomposition techniques, Dynamic Mode Decomposition (DMD) and multi-resolution DMD (mrDMD) are examined by applying them to the streamwise component of the unstarting velocity field. Results from the DMD analysis are compared to those from a 3-level mrDMD analysis, which allows for hierarchical time-frequency analysis. It is shown that mrDMD better captures general PCST movements and associated separation regions during the unstart event than normal DMD does. However, mrDMD may require the snapshots to have finer spatiotemporal resolution, to allow for more than the current 3-level analysis, to truly reveal its benefits, such as detecting and controlling unstart.

Researcher: **Jon Nykiel**
Major: **Materials Science & Engineering**
Advisor: **Dr. Wolfgang Windl**

Identification of Materials with Axis-Dependent Conduction Polarity

Semiconductors offer two types of charge carriers, electrons and holes, which are referred to as n-type and p-type semiconductors, respectively. The combination of these two types into p-n junctions is a key component of transistors, solar cells, and is essential to modern electronic devices. Recent research at OSU has discovered materials which exhibit n-type and p-type behavior in different directions, creating a new class of materials described as goniopolar. The purpose of this investigation is to determine if PdS2, PdSe2, and delafossites like PdCoO2 and PtCoO2 but with different compositions exhibit this phenomenon. The band structures, Fermi surfaces, and band widths of these materials were calculated and analyzed to determine if they are candidates for goniopolarity. The methods used to evaluate the Fermi surfaces and band structures of these systems can be extended to widen the pool of available goniopolar materials, which has the potential to lead to drastic changes in solar cells, transistors, and quantum computing.

Researcher: **Andrew Haberlandt**
Major: **Computer Science & Engineering**
Advisor: **Dr. Zhiqiang Lin**

Template Code Discovery from Native Binaries

Security of modern software is increasingly dependent on the work of talented reverse engineers. Tasked with analyzing programs compiled to machine code, they rely on decompiler tools to recover a C-like approximation of control flow, statement, expression, and variable semantics. Existing tools are able to produce C code that is roughly equivalent to the original source on a per-function level but is substantially more verbose and lacks 'meaning' usually derived from variable names and comments. Using the 'angr' python-based program analysis framework, we implement a novel algorithm for identifying repeated expression or statement patterns in a compiled program. These patterns often correlate with the use of preprocessor macros or inlined function calls in the original source code. We identify template-like parameter substitutions and modify the 'angr' decompiler output to replace every occurrence of these patterns with a template identifier and the appropriate parameters. The result is decompiler output that is more concise and allows reverse engineers to avoid repeated analyses of similar chunks of code. Template code identification also paves the way for future automated analyses to recover meaning from frequently reused segments of code.

Researcher: **Yingjie Shi**
Major: **Chemical Engineering**
Advisor: **Dr. Umit Ozkan**

Electrocatalytic Oxidative Dehydrogenation of Propane in Solid Oxide Electrolysis Cells

Electrochemically-assisted oxidative dehydrogenation (ODH) of propane is a promising alternative method to steam cracking for propane production, due to its environmentally-friendly nature and lower operating temperature requirement. It also outperforms traditional catalytic dehydrogenation processes because the thermodynamic limitations are overcome, thereby enhancing propylene yield. In this study, the performance of dual phase composite perovskites consisting of electron and oxide ion-conducting strontium doped lanthanum manganite (LSM) and proton-conducting ytterbium doped strontium ceria (SCY) as the anode in a solid oxide electrolysis cell (SOEC) was investigated. The catalytic materials were characterized and analyzed via X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), diffuse reflectance infrared Fourier transform spectroscopy (DRIFT), X-ray absorption near edge fine structure (XANES), and temperature-programmed reduction (TPR). Propane ODH was carried out at 600°C in an SOEC with varied ratio of LSM and SCY in the anode. It was found that the selectivity towards proplyene was ~24% for any anode composition. However, the alkene/COx selectivity increased with increasing SCY composition, indicating the presence of SCY could reduce the propane deep oxidation. It was observed that although pure LSM without the addition of SCY exhibited the highest conversion, it produced the most COx, possibly attributable to the reactive nature of LSM with propane. This study certified the feasibility of using electrocatalytic propane ODH to resolve the propylene supply and demand mismatch, but further investigations and development are needed to meet the standards of industrial-scale applications.

Researcher: **Joey Carlson**
Major: **Engineering Physics**
Advisor: **Dr. Giorgio Rizzoni**

A Statistical Analysis of Frequency Regulation and Demand Response Signals for Energy Storage System Microgrid Applications

Electric vehicle charging stations are capable of forcing large loads onto the electric grid during uncontrollable hours, and this is only amplified by the recent rise in electric vehicle usage around the world. One solution set forth to mitigate these negative impacts of electric vehicle charging stations is the incorporation of energy storage systems, such as second-life batteries, to form a microgrid with the electric vehicle charging station and supply additional power to electric vehicles. Beyond electric vehicle charging, such systems are also able to find use in a multitude of additional applications, two of which are the grid services frequency regulation and demand response. These services were thoroughly investigated to better understand their use with an energy storage system and potential profitability, including an analysis of the service itself (power profiles, how to participate), and the specific application of an SLB system. The analysis indicated the stochastic nature of frequency regulation signals, compared to the known, constant output of power for a resource participating in demand response. Moreover, frequency regulation signals were found to contain a large amount of energy, especially for the signal type RegA under PJM's market, which yields the capability of free energy storage system charging, while the demand response signal would always cause a loss of energy.

Researcher: **Austin Hendrickson**
Major: **Aeronautical & Astronautical Engineering**
Advisor: **Dr. Randall Mathison**

The Efficacy of RANS Models for Turbulence Generating Grids

Turbulence generating grids are a widely used method for intentionally producing various amounts of turbulence in wind tunnels. The analysis of turbulent flow generated by these grids through experimental methods is well documented but has been computationally investigated primarily through computational fluid dynamics (CFD) using models such as large eddy simulation and direct numerical simulation. Because these models are time intensive, the incorporation of lower fidelity Reynolds' Averaged Navier Stokes (RANS) models in CFD can allow for quicker convergence times and greater relaxation of mesh requirements during evaluation of turbulence generating grids. In this work, an unstructured hexahedral mesh was incorporated with an SST k-Ω turbulence model to analyze how turbulence is generated by the grid at the boundary layer level of the plate hole walls as well as predict the effects of length scale change on turbulence intensity downstream of the grid. This analysis was verified experimentally with the collection of turbulence data produced using hotwire anemometry in a blowdown wind tunnel. It was found that the utilization of the SST k-Ω turbulence model produced results within 5% of experimental analysis. This study adds to existing literature a more detailed understanding of the efficacy of the SST k-Ω model for analysis of turbulence generating grids, and the results provide a framework for fast analysis of turbulence generating grids using RANS models in future study and industry application.

Researcher: **Gabriel Lee**
Major: **Biomedical Engineering**
Advisors: **Dr. Raghu Machiraju & Chaitanya Kulkarni**

The Wet Lab Annotation Project

Wet laboratory protocols (WLPs) are essential to convey reproducible procedures in biological research; however, reproducibility is a significant issue in research as 70% of researchers are unable to reproduce experiments. WLPs are instructions that are written in natural language depicting stepwise processing of materials by specific actions, but there is a current lack of resources for natural language instructions in laboratory protocols. Those that do exist focus solely on relations within sentences. The material synthesis as described in WLPs can be recorded by material state transfer graphs (MSTGs), which involves identifying temporal and causal relationships between actions. The WLP corpus is formatted so that non-experts in the research community can annotate protocols effectively. Through the Wet Lab Annotation Project, we manually annotated 622 wet lab protocols with such relations, thus curating large corpora of MSTGs to facilitate the training of machine learning and deep learning models. The annotation of 615 protocols derived from the WLP Corpus were split into two phases. The first phase yielded an inter-annotator agreement (IAA) score of 78.23%. The second phase focused on the previously-completed 128 protocols to implement adjusted annotation guidelines. Final annotations were sent to the annotation experts to be merged based on majority voting. The annotated dataset was later used to train a machine learning model, which achieved an F1 score of 54.53% for temporal and causal relations in protocols outperforming the baselines: Dy-GIE++:28.17%; spERT:27.81%. To conclude, we constructed a well-crafted dataset to facilitate modeling end-to-end workflows that will have a lasting impact in improving automation within life sciences and other domains.

Researcher: **Adam Buynak**
Major: **Mechanical Engineering**
Advisor: **Dr. Michael Groeber**

Development of a Path Planning Tool for Irregular Planar Paths Projected onto Contoured Surfaces

Industrial robotics are traditionally closed systems, inflexible to the factory integration efforts of the next industrial revolution. To ease standardization, collaborative academic and industry efforts have developed an open source, package-based framework for robotic systems known as the Robot Operating System (ROS). Developers assemble motion planning pipelines using path planners, kinematic motion planners, collision checkers, and robot-specific support packages. The goal of this study is to develop a path planning package that moves the robot tool along a machine vision determined path. Secondary goals include projecting the path to a curved surface. Existing path planners for curved, planar-like surfaces are designed to output a path of parallel lines. A method for creating complex, non-linear paths across a curved surface is needed to support applications such as surface finishing. To provide context to this study, a demonstrative application of navigating a robotic arm through a maze projected onto a curved surface was employed. Initial work configured the software environment, including the robot control, motion planning, and sensor packages necessary for testing. Code was developed to project the path onto a curved surface and each local orientation set perpendicular to the local slope. This new code for generating, visualizing, and executing these three-dimensional pathways was deployed onto a six-degree articulating arm. The projection technique proved functional, but was limited to planar-like regions where the local surface slope was small. Large changes in slope resulted in localized stretching of the original path and is inappropriate for highly curved applications. With many existing tools focusing on parallel paths, this tool offers greater flexibility to system designers in achieving a customizable complex motion.

Researcher: **Kamryn Russell**
Major: **Mechanical Engineering**
Advisor: **Dr. Shawn Midlam-Mohler**

The Role of Additive Manufacturing in Autonomous Vehicle Sensor Integration

Aptiv medium-range radar sensors, Delphi multimode electronically scanning radar sensors, and a Mobileye camera need to be placed and mounted onto the EcoCAR competition vehicle to be used for autonomous functions such as adaptive cruise control and driver alerts. The location and angles the radar sensors and camera are mounted onto the vehicle are critical to vehicle safety and autonomous vehicle functions. The objectives of this research project are to research sensor and camera placement, develop mounting solutions, test various potential sensor and camera placements, manufacture the final mounting solutions, and install the sensors and camera onto the competition vehicle. Research will be conducted on the two different radar sensors and the camera, their field of views, and what is important for the sensors and camera to capture in their field of view for autonomous applications. The potential uses of additive manufacturing for integrating advanced driver-assistance systems sensors onto autonomous vehicles will be investigated. Computer aided design and additive manufacturing will be used to explore various potential sensor and camera placement locations as well as design and manufacture the mounts.

Researcher: **Chance Carafice**
Major: **Engineering Physics**
Advisors: **Dr. Bryan Mark & Forrest Schoessow**

Characterizing glacial lake expansion in the Cordillera Blanca, Peru from 1984 to present using Landsat observations and Random Forest classification methods

70% of Earth’s tropical glaciers are found in the Peruvian Andes. Accelerating ice loss is predicted to increase geohazard risks, particularly those associated with growing meltwater lakes (such as outburst floods and debris flows) and slope destabilization (landslides and avalanches). The human toll of such events was demonstrated in 1941, when a glacial lake outburst flood caused 1,800 fatalities; and in 1970, when a glacier slope collapse triggered debris flows that claimed up to 18,000 lives. Now, as ice loss and lake growth accelerates, there is a pressing need for accurate, on-demand data to inform adaptive risk management strategies. However, the extent of these changes remains unquantified because complex terrain and dense cloud-cover limits observational capacities. To address these challenges, we leverage four decades of NASA Earth observation data alongside recent advances in cloud computing and machine learning to overcome cloud-cover limitations and characterize inter-annual lake changes. We introduce the 1,400 total images collected by NASA’s Landsat 5 and 8 satellites over the Cordillera Blanca since 1984 into the Google Earth Engine computing environment where they are subjected to temporal, spatial, and cloud-filtering algorithms. 431 total images survive. Annual composite images are derived from the median value of the surviving pixels from each year. The infrared bands are then used to calculate two water indexes that further isolate liquid and solid water pixels. Finally, our Random Forest classifier generates annual glacier and lake outlines validated by local measures. This research represents two separate achievements with broad basic and applied science applicability: 1) an efficient workflow for generating accurate, cloud-free satellite imagery time-series data products on demand; and 2) the first regional assessment to quantify spatial-temporal patterns of lake evolution from 1984 to present, describe hotspots of accelerating change, and identify the emergence of potentially hazardous glacial lakes.

Researcher: **Yue Sun**
Major: **Mechanical Engineering**
Advisor: **Dr. Ruike Zhao**

Magnetic Soft Robotics

Due to a greater variety of applications required for robotics, soft robotics have been studied because of its untethered control, fast transformation, and biocompatibility. The magnetic soft material has been developed by embedding hard magnets into the silicone-based soft matrix. Once programmed, the material provides magnetic torque remotely. However, with the simple geometry and structure design of the magnetic soft material, the system is always limited to simple deformations such as bending, folding, and twisting. To improve the system's capability, origami structure is therefore incorporated with the magnetic material in our current work. By putting magnetically programmed materials on the origami structures, the system's deformation can be controlled by three-dimensional magnetic fields. Therefore, the system can achieve multiple deformation modes such as elongation, bending, sequential folding, etc. Our results proved this idea experimentally. For Kesling origami structures, heights vary from the torque generated by magnetic fields. By switching materials used and the design of creases, the properties can be changed and under control. Different types of structures can be used for robotics in various applications, respectively. The study can be used in many applications, such as the composition of a soft robotic system.

Researcher: **Shubhank Gyawali**
Major: **Aeronautical & Astronautical Engineering**
Advisor: **Dr. Matthew McCrink**

Design of a framework for simulation and flight testing of UAVs

The project provides details on the complete framework to implement autonomous navigation of a custom-built quadrotor through an onboard computer using Robot Operating System (ROS). The project also focuses on the development of a custom flight controller and uses Software-in-the-loop (SITL) and Hardware-in-the-loop (HITL) simulations to validate the complete system. The development work presented herein uses MATLAB/SIMULINK for designing the flight controller, and it uses Gazebo as the simulation environment. QGroundControl is utilized as a Ground Control Station which is primarily used as a real time visualization tool. In terms of hardware, raspberry pi 3 Model B+ is used as an onboard computer which communicates to the quadrotor using Mavlink communication protocol. Pixhawk is the primary autopilot used in the system. To ensure a complete and accurate analysis, an exact replica of the quadrotor is designed using Computer-Aided Design (CAD) programs, which is utilized to simulate a more realistic flight dynamics in the simulator. Python is the primary programming language used to generate flight paths to perform any offboard control of the quadrotor. The combination of custom quadrotor design parameters, mission specific flight controller, and user-defined flight paths ensures that a more robust and optimized system is created. The specifications are altered based on the intended use and application of the UAV. To ensure the autonomous system travels the specified setpoints safely, SITL and HITL simulations helps to validate all the system components before performing any real flight tests.

Researcher: **Alexandra Ng**
Major: **Environmental Engineering**
Advisor: **Dr. Andrew May**

Numerical modeling of light absorption and radiative forcing impacts of biomass burning emission proxies undergoing aqueous chemistry and photolysis

Understanding climate change is essential to building knowledge for policymaking, engineering, and public health. Recent wildfires resulted in biomass burning (BB) emissions that impacted regional air quality and climate change. However, quantifications of BB radiative forcing are uncertain. BB emits black carbon (BC) and various organic compounds, ranging from particulate organic carbon to volatile organic compounds (VOC). Water soluble VOCs, including oxygenated aromatic compounds, can be oxidized by reactive hydroxyl radicals and undergo aqueous chemistry in cloudy atmospheres to form secondary organic aerosols (SOA). SOAs contribute to radiative forcing by reflecting light (cooling) or absorbing light (warming) when radiation is released as thermal energy.

The objective of this study is to model absorption and quantify the climate effects of BB chemistry. Two MATLAB scripts were developed for analysis of BB emission proxies using absorption values from another study. The first code fit experimental data to quantify the imaginary refractive indices (related to absorption and warming) of the compounds and identify the absorbing and warming effects of the colored compounds produced. The second code modeled absorbance changes as chemical processes occurred. The codes successfully modeled the imaginary refractive indices with experimental data and predicted absorbance chemistry. Absorbance experiments were deferred due to technical complications. A procedure to measure absorbance was created for future experimental work. A solar simulator will be used to irradiate oxygenated aromatic BB compounds (phenol, furfural, benzaldehyde). The solar simulator imitates natural sunlight and requires calibration using ferrioxalate, a chemical actinometer. A darkroom was constructed to prevent ferrioxalate degradation. Six cuvettes will be filled with solution and irradiated in the solar simulator for calibration and experiments. The cuvettes will be removed at specific times and spectral absorbances will be measured using a UV-vis spectrometer. Finally, the absorbance results will be implemented into the models to quantify radiative forcing.

Researcher: **Shanila Reza**
Major: **Electrical & Computer Engineering**
Advisor: **Dr. Asimina Kiourti**

Inductive Monitoring of Joint Kinematics: A Study of Canonical vs. Anatomical Tissue Models

The ElectroScience Lab has demonstrated the feasibility to monitor joint flexion and rotation using wearable electrically small loop antennas. Currently, the research uses canonical (cylindrical) tissue models. The objective of this research is to transition cylindrical to anatomical models which will be used to refine the sensors. The anatomical details will be varied for diverse individuals and then sensors will be optimized for each individual to aid in finding calibration techniques for real life operation. There will also be an experimental component to validate and improve upon numerical sensor operation in the real world. To meet the objectives mentioned, canonical tissue models will be replaced with anatomical ones, as readily available in libraries tied to electromagnetic solvers. Then the sensor design will be modified to fit the anatomical geometries and simulations will be run. The sensor design will be optimized for each geometry, and a methodology will be created to optimize sensor design for different body parts. The details on the anatomical model will be varied for simulations, and analysis of the results will help find ways to calibrate the sensor in real world conditions. The experimental aspect is the last part and includes fabricating and testing the sensor on a 3D printed anatomical limb.