SURF

SUMMER UNDERGRADUATE RESEARCH FELLOWSHIP

SURF 2022 SYMPOSIUM
JULY 28 – JULY 29

ABSTRACT BOOKLET

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Day 1 — Morning Presentations

July 28th, 10:00 AM – 12:00 PM EDT

Track A: Biomedical Sensing & Imaging 1 (WALC 3138)

Improving Under Agarose Gel Assay by 3D Printing for Investigating Neutrophil Migration

SURF ID: 178
10:00 AM - 10:15 AM

*Ting Hsuan Ku, Tianqi Wang, Qing Deng**
**PI: Department of Biological Science*

Neutrophils take up to 70 percent of white blood cells and function as the first defensive line in the human immune system using phagocytosis, cytokine release, NETosis, etc. To utilize the pro- and anti-inflammatory functions, neutrophils need rapidly transmigrate through the endothelial cells to the inflammatory sites by the delicate guidance from the chemoattractant gradient. The defect of neutrophil directional migration has been correlated to multiple severe human infectious and autoimmune diseases. Nevertheless, the mechanism of neutrophil directional migration remains elusive, and it has been a crucial topic in neutrophil studies. The under-agarose assay is a conventional method to study neutrophil chemotaxis due to its inexpensive simplicity, flexibility, and adaption for live-cell imaging. However, the current under-agarose assay has several imperfections to improve, especially when casting the agarose gel, including the inconsistency of well-well distance and the flaws of poking the agarose gel hole. To improve the assay, a mold that can produce consistent hole size and well-to-well length is the key; Using 3D printing, the mold can be made quickly and adjust to different parameters easily. Our Study suggested that 3D printing is a convenient way to improve current imperfections under agarose migration assay, reduce the possibilities of human errors, and keep the consistency of well size and length among different sets of the experiment.

Keywords: Neutrophil migration, under agarose gel migration assay, immune response

Hyaluronan Synthesis and Breakdown Response to Cell Stretch in Synoviocytes

SURF ID: 107
10:15 AM - 10:30 AM

*Maya Alborn, Clarisse Zigan, Aritra Chatterjee, Deva Chan**
**PI: Weldon School of Biomedical Engineering*

Osteoarthritis is a debilitating disease that affects millions of Americans. This ailment causes chronic pain stemming from the joints. The extracellular matrix is a network of proteins that gives structure to cells. Synoviocytes are the cells in the synovium, which is the tissue that produces surrounding fluid cartilage in the joint. They are responsible for producing hyaluronan, a macromolecule with wound-healing properties. Lack of loading or excessive loading can alter cells, affect the extracellular matrix, and change the synthesis and breakdown of hyaluronan. This study is aimed at constructing a mechanical loading system to stretch synoviocytes. I created an acrylonitrile butadiene styrene (plastic polymer) 3D printed holder for the FlexCell 6-well plate on which the synoviocytes will be seeded. I also constructed Delrin posts to push up on the membrane of the wells. I used the ElectroForce 5500 to push up on the posts to create strains of 0%, 5%, 10%, and 20%. The system was validated through strain quantification measurement to ensure the membrane was stretched at the specific strain values. Further analysis will quantify hyaluronan production between the different strain groups. Understanding the role in which mechanical stimulus plays on synoviocytes is important in paving therapeutic strategies to slow or stop the progression of osteoarthritis.

Keywords: Osteoarthritis, synoviocytes, cell stretch, hyaluronan, extracellular matrix

Rapid Diagnostic Auditory Testing and Correlation with Auditory Anatomy

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**PI: Department of Biological Sciences*

SURF ID: 153
10:30 AM - 10:45 AM

Keywords: Presbycusis, Metabolic Dysfunction, Oxidative Stress, D-galactose, Evoked Auditory Potential

Presbycusis is the phenomenon of hearing loss due to aging. The common progression of hearing loss begins with peripheral damage followed by central compensations. This study aims to discover how stimuli is encoded by peripheral and central structures when central damage is induced first. We predict that a normal functioning peripheral system will elicit signs of stress from resulting pathway compensation. To induce inflammation of the central auditory system while preserving the peripheral, a 28-day injection series of D-galactose at 150 mg/kg was used as a mimetic aging model. Similar D-galactose injections of this kind have been shown to induce metabolic dysfunction and oxidative stress in central structures. Subsequent auditory evoked potential recordings measured the neural activity of the auditory pathway in response to stimuli at various sound levels. The evoked potential amplitudes were then compared across days (0, 7, 14, 28, post 7, and post 28) at specific wave points to assess changes in the pathway. Each wave signifies collective synchronized neural activity to stimuli that is dominated by successive structures along the pathway. Wave 1 in the pathway indicates electrical potential from the auditory nerve, a peripheral structure in the system. The amplitude of wave 5 is expected to be affected first as it indicates central structures impacted by D-galactose. Wave 1 was maintained in both experimental and control groups, while wave 5 experienced decreased amplitudes at higher sound levels. Additionally, the wave 1: wave 5 ratio in the D-galactose group was elevated after the injection series.

Investigating Effects of Calcium-Dependent CaMKII Signaling on Dendritic Spine Morphology During Alzheimer's Disease

*Fiza Sikandar[1], Maria Rafiq, Agnes Doszpoly, Eugene Seo Kim, Tamara Kinzer Ursem**
*[1]University of the Punjab, Lahore, Pakistan *PI: Weldon School of Biomedical Engineering*

SURF ID: 281
10:45 AM - 11:00 AM

Keywords: Synaptic Plasticity, primary neuronal culture, Alzheimer's disease, CaMKII, Calcium dependent proteins, dendritic spines

As of 2022, almost 5.7 million people in US are affected by Alzheimer's Disease (AD). AD is a neurodegenerative disorder and one of the major causes of dementia that begins with minor memory loss and progresses to a loss of brain mass. AD damages the hippocampus, the part of the brain that regulates cognition, memory, and language. Multiple evidence suggests that weak synaptic plasticity (SP) may be associated with memory loss. Among the proteins that are involved in synaptic plasticity (SP), the most studied are the ones involved in regulating calcium signaling vital for basic cellular function and survival. Calcium-dependent protein kinase II (CaMKII) has been implicated in a variety of cellular signaling processes. Despite its significance, the connection between calcium dependent CaMKII signaling, AD and dendritic actin morphology is still to be discussed. Based on our hypothesis, we aim to investigate how CamKII influences F-actin morphology and the shapes of dendritic spines. For this, dissociated embryonic mouse neurons were used to observe and compare the development of neurons in two distinct media. The proximity and spatial organization of specific proteins (e.g., actin, $Ca2+$, CaMKII) were studied in neuronal cultures using antibodies for detection and labelling using Confocal microscopy imaging. Long-term objectives include;(1) determining how actin bundle formation affects the growth of new dendrites, (2) optimizing workflow for image analysis for high-resolution confocal images (of CaMKII beta and/or actin in primary neurons), and (3) quantifying the relative contribution of direct and indirect $Ca2+$-CaM regulation of actin polymerization dynamics.

Blood Sample Preparation for HIV Diagnostics in a Smartphone-based Microfluidic Device

SURF ID: 249
11:00 AM - 11:15 AM

*Jaylin Trice[1], Melinda A. Lake, Jacqueline C. Linnes**
*[1]Louisiana State University *PI: Weldon School of Biomedical Engineering*

Keywords: Blood sample, sample preparation, plasma separation, point-of-care diagnostics

Blood sample collection and preparation is an integral component in many diagnostic tests for blood-borne pathogens. For many tests, whole blood samples must be filtered to isolate plasma which is useful for blood analysis like HIV diagnostic tests. The most common method of blood filtration is centrifugation which requires expensive equipment and access to a reliable power source. Other issues with traditional filtration methods are that they require training and involve many user steps. Here, we demonstrate a sample preparation device designed to passively filter blood while minimizing the total user steps. The device was designed using 3D CAD software, SolidWorks, and manufactured using a FormLabs 3BL resin-based printer. The original concept for the device is comprised of five components: a blood-capturing inlet with a lid, a square base to hold the filter paper, and a micro-syringe body and plunger. To test the device's utility, we experimented with different gravitational sedimentation pressures and different sample concentrations. Instead of testing with real blood, we used fluorescent microspheres and water to represent red blood cells (7.5μm spheres) and HIV virus (0.11μm spheres). The fake blood was thickened with corn syrup to mimic the viscosity of blood. When testing with water, the water passed through the filter and microchannel of the device quicker with sedimentation pressure. The data shows that the sedimentation pressure is necessary for efficient filtration.

Clarifying Changes in Nerve Branching during Osteoarthritis Progression with Tissue Clearing

SURF ID: 114
11:15 AM - 11:30 AM

Youssef Beshay, Matthew Ward, Deva Chan*
**PI: Weldon School of Biomedical Engineering*

Keywords: Osteoarthritis, tissue clearing, optical clearing, pain, innervation, nerve branching

Osteoarthritis affects over 250 million patients worldwide with a greater prevalence among older demographics. Despite the efforts to alleviate the agony that impedes the quality of life of those affected by this disease, the fundamental mechanisms by which the disease induces pain are not fully understood. While it has been hypothesized that osteoarthritis results in increased innervation, there is a need to gauge the configuration that fibers adopt in 3D space to potentially understand the causes of increased sensitivity to pain in the afflicted state. To image the three-dimensional branching structures of nerves in the murine hindlimb, immunostaining labels the fibers of interest, and tissue clearing overcomes the inherent opacity of tissue. I developed code to quantify tortuosity, a parameter that could help distinguish the arrangement of nerves in normal mice and those resembling a specific model of post-traumatic osteoarthritis. After immersions in fructose-based solutions achieved unsatisfactory optical clearing, a well-defined method has been identified from literature to clear the hindlimb via decalcification, decolorization, delipidation, dehydration, and refractive index (RI) matching. The developed code can describe the geometric configuration of innervation patterns, and this has been validated by analyzing widely accessible images of lines and branches and finding that the computed values of tortuosity match intuition. Altogether, this research can enhance our understanding of osteoarthritis by providing a methodological approach for studying its progression. Future research can seek to modulate the organization of nerve branches and effectively manage symptoms of pain in patients with osteoarthritis.

Exploring Macrocracks and Microcracks in Cortical Bone using 3D imaging

*Roey Kuo, Glynn Ellen Gallaway, Thomas H. Siegmund**
**PI: School of Mechanical Engineering*

SURF ID: 179
11:30 AM - 11:45 AM

Under a mechanical load, bone can fracture. This process leads to the formation of a macrocrack as well as multiple microcracks surrounding the macrocrack. 3D x-ray imaging can be used to detect both types of cracks. For an accurate depiction of macrocracks, 3D image segmentation is used. This study investigated how machine learning algorithms, in the image analysis package ImageJ, can be utilized to aid in the creation of 3D images of macrocracks. To observe microcracks, a barium sulfate stain is used after fracture and prior to imaging. Samples, extracted from pig femur, were mechanically loaded and soaked in a barium chloride solution. Following, placed in a sodium sulfate solution, all under pressure. The combination of these two solutions would lead to a deposit of barium sulfate crystals within the microcracks. Following 3D x-ray imaging, the stained bone images are evaluated with the software ImageJ. CSBDeep, a machine learning algorithm, leads to a reduction in image noise and therefore facilitate a complete 3D segmentation model. Barium sulfate stain was successful in enhancing the crystals contrast within microcracks. This work is supported by NSF Award 1952993.

Keywords: Micro-CT, Barium sulfate, ImageJ, Bone, Microcracks, Fracture

Investigation of the Interactions of Neuronal Proteins in an Animal Model of Alzheimer's Disease

*Kenneth T. Jones[1], Eric Tan, Eugene Kim, Tamara Kinzer-Ursem**
*[1]North Carolina Agricultural and Technical State University *PI: Weldon School of Biomedical Engineering*

SURF ID: 167
11:45 AM - 12:00 PM

Alzheimer's disease (AD) is the number one cause of dementia. In the US, AD is estimated to impact as many as 5.5 million people and, it is estimated to impact as high as 24 million people worldwide. Recent studies have shed light on the relationship of proteins such as Calcium/calmodulin-dependent protein kinase II (CaMKII), F-Actin, and Tau, three proteins which play major roles in regulating neural plasticity and memory, as well as the assembly and maintenance of the structural stability of microtubules. These proteins are associated with many essential processes, including brain development as well as AD. This study aims to develop protein labeling techniques to study the protein-protein interactions in the brain of a rat model for AD. For this study, western blots were used to confirm appropriate binding of primary antibodies to their respective protein, and proximity ligation assay (PLA) was used to visualize neuronal protein-protein interactions. Primary neuronal cells were harvested from postnatal, day 0-1 rats and were imaged via laser scanning microscopy and were analyzed using ImageJ and DotCounter. We were able to validate our primary antibodies and show specific binding to our target proteins. However, we did not observe any significant variations when comparing the interactions of CaMKII and F-actin with and without the presence of Tau. Hence, additional optimization is needed to elucidate these findings and to further understand such AD-related neuronal protein-protein interactions.

Keywords: Proximity ligation assay, western blot, protein-protein interactions, tau, calcium/calmodulin-dependent protein kinase II, f-actin

Track B: Building Systems Engineering (WALC 2051)

Photocatalytic Air Purification for HVAC Systems

SURF ID: 270
10:00 AM - 10:15 AM

*Ziheng Zeng[1], Sudharshan Anandan, Xing Li, Andrew Freeman, Ernest Blatchley III†, William Horton†, David Warsinger**
*[1]Bucknell University *PI: School of Mechanical Engineering †Co-PIs: Lyles School of Civil Engineering*

The fast spread of the COVID-19 pandemic necessitates the need to ensure good indoor air quality and better controlling of the transmission of the SARS-CoV-2 virus. Air treatment technologies are essential to reduce the bioaerosol concentration in indoor air. Among all the purification methods, photocatalysis, light activated chemical reactions, is used as a treatment method in this study. The objective of this project is to develop a methodology helping design filter-based photocatalytic air purification for the HVAC systems to improve indoor air quality. A filter-based photocatalytic reactor with TiO_2 was installed in a wind duct along with UV lamps. MS2, a surrogate for SARS-CoV-2, will be used in the study with an initial concentration of 2×10^8 PFU/mL in the air. The air will be blown into the duct at a velocity of 0.5 m/s and 2 m/s. Air samples will be collected at 12.5 LPM both upstream and downstream. Lastly, the amount of virus will be analyzed using plaque assay analysis. The disinfection efficiency will be calculated based on the upstream and downstream virus plaques. The expected result is 3-log inactivation of MS2 virus, corresponding to 99.9 percentage of inactivation. If this design works as expected, it could be applied to HVAC systems in buildings to better purify the indoor air.

Keywords: Photocatalytic Disinfection, UVC, Air Treatment, MS2, SARS-CoV-2, HVAC

Development of A Simulation Model for Closed-Loop Apparatus for Load-Based Testing and Rating of Residential Heat Pumps

SURF ID: 184
10:15 AM - 10:30 AM

Alex Lee, Parveen Dhillon, Do-Hyeon Kim, Ashwin Kidambi, Travis Horton, James Braun*
**PI: School of Mechanical Engineering*

Load-based energy efficiency testing methodologies that utilize a virtual building model to capture the dynamic response of a split-system HVAC unit to the change in its environment have been under development as an alternative to the current methodology. The virtual building model continuously updates the indoor air conditions to emulate the response of a typical residential building based on the difference between an estimation of the building load and a test unit's real-time cooling/heating capacity measurement. However, the current load-based testing methodology can be expensive and time-consuming, considering the different test conditions outlined in CSA EXP07. Moreover, it may require an expensive psychrometric chamber controller update or at the least a significant software update. The motivation of this work was to develop and test the validity of a closed-loop apparatus with its own air reconditioning unit and integrated controls that work with the indoor unit while the outdoor unit remains in a psychrometric chamber kept under a constant condition. To validate the selection of air reconditioning components by providing a simplified depiction of the apparatus's performance, a simulation model of heat transfer within the apparatus has been developed. The simulation model employs inlet and outlet air data collected from previous load-based tests with a 3-ton fixed speed heat pump. Through a series of assumptions and idealizations, the amount of heat transfer from the apparatus to the atmosphere is calculated and the maximum required performance of the air reconditioning components are estimated accordingly.

Keywords: HVAC, Load-based testing, Closed-loop, residential split system, HVAC energy efficiency rating

Sustainable Air Conditioning by Combining Membrane Air Dehumidification and Dew Point Evaporative Cooling

SURF ID: 210
10:30 AM - 10:45 AM

*Maisha Mumtaz, Andrew J. Fix, David M. Warsinger, James E. Braun**
**PI: School of Mechanical Engineering*

Keywords: HVAC, membrane, dehumidification, evaporative cooling, sustainable

In the United States, approximately 46% of total building energy consumption is attributed to heating, ventilation, and air conditioning systems (HVAC), and 21% of electricity consumption in the commercial and residential sectors is due to space cooling. With the added issue of global warming, cooling and dehumidification loads are expected to further increase in the future. Current practices involve the use of a vapor compression cycle to cool and dehumidify air through condensation dehumidification using refrigerants which can be environmentally hazardous. This process is associated with large energy penalties relating to phase change of moisture, thus necessitating the exploration of alternative technologies. Combining membrane-based dehumidification with dewpoint evaporative cooling avoids this energy-intensive process of moisture condensation while efficiently cooling the air without the use of harmful refrigerants. This paper presents a thermodynamic model of an integrated system consisting of the dual membrane module dehumidifier combined with a dew point evaporative cooler. A parametric study is performed for different ambient conditions to investigate the system performance. Results show a system coefficient of performance (COP) value ranging from 2.1 to as high as 12.8 with a median value of 3.1. The system also displays potential for having its own self-sustaining water supply for cooling air at outdoor humidity ratios above 0.015 kg water/kg dry air. The modeling results show the technology to be promising and display potential scalability in the future to be used as commercial HVAC equipment.

Improving the Performance of Cyber-Physical Testing Employed in the Analysis of Deep Space Habitats

SURF ID: 252
10:45 AM - 11:00 AM

*Pirouz Vaziri[1], Jaewon Park, Herta Montoya, Seungho Rhee, Christian Silva, Davide Ziviani**
*[1]Rutgers, The State University of New Jersey *PI: School of Mechanical Engineering*

Keywords: Deep space habitats, cyber-physical testing, Kalman filtering, estimation, accuracy

Deep space habitats must be resilient to extreme environment hazards, such as micro-gravity effects, temperature variations, meteorite impacts among others, along with potential failures. The Resilient Extra-Terrestrial Habitat Institute (RETHi) developed a Modular Coupled Virtual Testbed (MCVT) to develop fundamental knowledge on designing resilient habitats. To validate the MCVT, it is not feasible to solely rely on all-physical experiments due to challenges associated with recreating deep space conditions in terrestrial laboratories. Therefore, a Cyber-Physical Testbed (CPT) is used to validate portions of the MCVT. Specifically, the CPT architecture features deep space environmental conditions being simulated in cyber space and the results of these conditions are imposed with a transfer system on a physical substructure, emulating a future habitat. The accuracy of the results of the CPT highly depends on the ability to accurately transfer information between the physical and cyber substructure in real time. A simplified experimental setup consisting of a pressure box (i.e., representation of a closed habitat environment) is used to prove the concept of CPT. The transfer system mainly consists of a thermal panel, where desired thermal conditions are imposed by a cryogenic chiller. Due to limitations on the possible number of temperature sensors on the panel, temperature across the panel is estimated with undesirable reliability. In this project, a linear Kalman filtering algorithm is utilized to estimate the temperature across the panel, using data from some of the sensors on the panel. The algorithm is validated using data from other sensors on the panel and will be used to model temperature of similar panels in future studies.

Resilience through Building Design with a Functional Recovery Focus

SURF ID: 259
11:00 AM - 11:15 AM

Federico Wiesner Urbina[1], Julio A. Ramírez, Shirley J. Dyke†*
*[1] Universidad de los Andes *Co-PI: Lyles School of Civil Engineering † Co-PI: School of Mechanical Engineering*

Buildings around the world are exposed to the risk of earthquakes and communities must be prepared for it. Currently, most structures are designed with life safety performance criteria. However, as earthquake events in New Zealand and Japan have shown, including Functional Recovery in the design is key for improving the resilience of communities. Functional Recovery is a performance state less than original functionality, but sufficient for re-occupancy and temporary provision of lifeline services. This focus arises from the fact that communities do not want their infrastructure to be down for a prolonged time, they want to resume their activities quickly. Through computational simulations, this project seeks to examine the performance of reinforced concrete buildings after an earthquake. The model will be used to evaluate drift demands and the impact of them on functional recovery by comparing against drift limits. Drifts are the relative displacement of one story with respect to the one beneath, divided by the distance between them. From there, health states will be established and the probability of transitioning from the original state to another one calculated, given a ground motion of some intensity. The final goal is to use drift as a performance criterion to identify needed areas of research leading to functional recovery after an event. That is, explore what changes in building design procedures could lead to a lower probability of exceeding drift limits after an event.

Keywords: Functional recovery, performance based engineering, earthquakes, drifts, markovian processes

Resilience as a measurable quantity for extra-terrestrial habitats

SURF ID: 229
11:15 AM - 11:30 AM

*Megan R. Rush, Megan R. Rush, Jacqueline M. Ulmer, Karen Marais**
**PI: School of Aeronautics and Astronautics*

The Resilient Extra-Terrestrial Habitat (RETH) Institute's goal is to research and develop technologies needed to establish extra-terrestrial habitats. These habitats must be equipped with advanced systems, such as sensor networks that actively learn, detect, and diagnose issues; autonomous robots that can collaborate with humans; and the ability to anticipate and adapt to possible threats. This ability to react to, survive, and recover from disruptions and threats is called resilience. To make sure that our habitats are resilient and can withstand the unknowns of space, we need to be able to measure and quantify the habitat's ability to "bounce back" from these disruptions. Using MATLAB, I developed a script that receives power generation data from the RETH Institute's testbed and calculates four different resilience metrics defined in literature. The script produces plots of the data with points at each increase or decrease in power generation. It then uses these points to calculate the four different resilience metrics which each range from either 0 to 1, 0 to infinity, or 1 to infinity. These metrics allow us to identify when power generation drops and how long it takes to get back to nominal. The MATLAB script allows us to see the plots and quantify resilience.

Keywords: Resilience, extra-terrestrial habitats, aerospace engineering, building systems engineering, space-technology.

Design of a Closed-Loop Apparatus for Automated Load-Based Testing of Residential Heat Pump Systems

SURF ID: 174
11:30 AM - 11:45 AM

*Ashwin R Kidambi, Alex Lee, Do Hyeon Kim, Parveen Dhillon, W. Travis Horton**
**PI: School of Mechanical Engineering, and Lyles School of Civil Engineering*

Keywords: HVAC, heat pump, load-based testing, closed-loop, 3-ton equipment, residential split system

A load-based testing methodology for residential split-type heat-pump systems is proposed to accurately measure equipment performance in the lab representative of the field application. Currently, for load-based testing, two psychrometric chambers are utilized to provide temperature and humidity test conditions for the indoor and outdoor units. Currently, only one unit can be tested at a time. To support multiple unit testing in parallel, this paper presents a closed-loop apparatus design for testing heat pumps up to 3-ton capacity. This enables the testing of multiple units using one psychrometric chamber for multiple outdoor units and multiple closed-loop apparatus for the indoor units. The apparatus is approximately 9' tall, 10' long, and 6' wide. It contains a nozzle box, inline fan, cooling coil, heating coil, humidifier, dampers, and mixers. The two coils and humidifier act as the air reconditioning system. The fan maintains the differential static pressure across the unit. The heating coil capacity was determined using the worst-case testing scenario based on previous load-based testing of a 3-ton split residential unit. ASHRAE Standard 41.2 was closely followed to design the nozzle box to measure the test unit airflow. All ducts are designed to be constructed from 18-gauge sheet metal with insulation. The closed-loop apparatus will be constructed, tested, and compared against test data results gathered from previous research conducted on load-based testing of a 3-ton split residential heat pump. Based on the findings, the closed-loop apparatus could be further developed to be made more compact and adaptable to larger HVAC equipment.

Track C: Composite Materials & Alloys (WALC 2088)

Identifying Candidate Oxidation Resistant Alloys via Validated End-to-End Simulation Workflows with Sim2L

SURF ID: 150
10:00 AM - 10:15 AM

*Noah B. Hallberg, Saswat Mishra, Michael S. Titus**
**PI: School of Materials Engineering*

Keywords: Oxidation, simulation, high-temperature, alloys, oxides

Energy generation systems use high-temperature structural Ni-based superalloys as internal rotating components, and these alloys require resistance to high-temperature oxidation. These state-of-the-art superalloys are utilized due to their excellent balance of materials properties, but their operating temperature is becoming limited by their melting temperature of about $1300°C$. Refractory alloys, on the other hand, exhibit melting temperatures hundreds of degrees greater than superalloys, but often lack high-temperature oxidation resistance. Traditional methods for experimental identification of oxidation-resistant refractory alloys are time-consuming and resource-intensive. We, therefore, seek to predict the oxidation behavior of roughly 1 million different alloys under extreme environments by developing a simulation using Sim2Ls and the Sim2L python library. By allowing a developer to create and share end-to-end computational workflows, Sim2Ls help to produce data that is Findable, Accessible, Interoperable, and Reusable (FAIR). High-throughput calculations are performed to predict oxide formation and thus oxidation resistance. The user begins by entering the input data which includes the composition of the alloy, temperature of the environment, phases to suspend, and the range of chemical potentials. Outputs of oxide layer property data and grand potential of oxygen for the possible phases are generated and configured into formats accepted by Sim2Ls. Relevant plots are printed out to the user and the inputs and outputs from a successful run are cached into a database. This workflow can be utilized to identify material systems in a high-throughput method thus accelerating the design of next-generation oxidation-resistant refractory alloys.

Corrosion of additively manufactured SS316L in a chloride environment

SURF ID: 237
10:15 AM - 10:30 AM

Morgan Smith, Yi Xie, William Appel*
**PI: School of Nuclear Engineering*

In nuclear reactors stainless steel is a commonly used metal for cladding and core materials due to its high chromium content. However, when exposed to the extreme reactor environment, stainless steels undergo corrosion which can be detrimental to the operation of the reactor. It is thought that additive manufacturing of stainless steel will create a more corrosion resistant microstructure however there is no clear consensus amongst publications. In this study, the corrosion rate of additively manufactured SS316L is compared to traditionally manufactured SS316L to determine whether additive manufacturing improves corrosion resistance. Open Circuit Potential, Electrochemical Impedance Spectroscopy, and Potentiodynamic testing is carried out in an electrochemical corrosion cell. 5mm diameter rods of AM SS316L and traditionally manufactured SS316L are exposed to .6M NaCl solution to simulate corrosion. Data is collected over 100 hours and analyzed using Gamry Instruments eChem software. This study compares the electrochemical results between the two tested samples and will allowed us to conclude and validate whether additive manufacturing improves the corrosion resistance of SS 316L.

Keywords: Additive manufacturing, SS316L, corrosion, electrochemical testing

Alloy Design for Low Temperature Solder

SURF ID: 294
10:30 AM - 10:45 AM

*Aleena Masaeng, Hannah N. Fowler, Carol Handwerker**
**PI: School of Materials Engineering*

Solder joints provide both a mechanical and electrical connection between components and printed circuit boards (PCBs) in electronics packaging. The difference in coefficient of thermal expansion between the board and the component during the reflow process results in the dynamic warpage of the board and solder joint defects. Eutectic Sn-Bi solder has a low reflow temperature of 180 C° which prevents warpage during reflow, and it performs well in thermal cycling at low strain-rates. However, Sn-Bi is highly strain-rate dependent, and this results in poor performance at the high strain-rates during drop-shock reliability testing. Improving ductility and strain-rate sensitivity with Ag and Sb additions can improve drop-shock reliability. This project will investigate how small additions of Sb and Ag impact the microstructure of eutectic Sn-Bi solders through microstructural analysis including measuring the area fraction of Bi and Sn. The microstructural analysis is used to study the possible mechanisms behind how Sb addition and Ag addition collaborate to improve the ductility of eutectic Sn-Bi solder. The result shows that the microstructure of the system is changed because of the dissolution of Cu from the OSP substrate, which form intermetallic compounds (IMCs) that strengthen the microstructure such as Cu_6Sn_5. In addition, the intermetallic compounds from the alloying additions, Ag_3Sn and SnSb, also contribute to the strength and ductility of the system and impact the microstructure. The small changes in Ag and Sb composition effect heterogeneous microstructures and may have impact on the mechanical properties of Sn-Bi solder joints.

Keywords: Eutectic Sn-Bi Solder, low reflow temperature, Ag and Sb addition, microstructure, mechanical properties

Microstructural Analysis of Laser Welds in RPV Steel Using Positron Annihilation Spectroscopy

SURF ID: 285
10:45- 11:00

*Nathan T. Gehmlich[1], Alejandro Figueroa Bengoa, Nicole Rodriguez, Maria A. Okuniewski**
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During nuclear reactor operation, neutrons constantly bombard reactor pressure vessels (RPVs), ultimately damaging the micro-structure. Reactor pressure vessels are expensive to produce, and the United States does not have the capability to forge them, therefore it is necessary to prolong their lifetime. To reduce production costs and to allow for the repair of older RPVs, laser welds are investigated to understand their micro-structures and mechanical properties after neutron irradiation. To characterize the micro-structure, positron annihilation lifetime spectroscopy was used as it can assess defect concentration and size. Lifetime spectra collected from a laser weld and the heat-affected zone were compared to pristine, bulk RPV steel to reveal changes in structure. The intensities of the lifetime spectra will be evaluated to determine the defect concentration; the average lifetime data will estimate the defect size. The data will help determine if laser welds are adequate and safe for RPV repairs.

Keywords: Reactor pressure vessels, positron annihilation spectroscopy, laser welds, positron lifetime, heat-affected zone, defect concentration

Finite Element Analysis of Corroded Steel Beams

*Julianna Horz, Deven Surya Chandan Kankamedala, Amit Varma**
PI: Lyles School of Civil Engineering

SURF ID: 158
11:00 AM - 11:15 AM

Corrosion is one of the most common forms of deterioration in aging bridges. Corrosion is caused by deicing salts used in winter and other accumulated sediment on the bottom flanges of beams, resulting in section loss. This eventually leads to structural deficiency. The effect of corrosion on the residual capacity of steel beams is studied both experimentally and numerically. Corrosion in beams is non-uniform with varying damage parameters such as thickness loss, damage heights and lengths. The effect of section loss on the residual shear and bearing capacity was evaluated by experimenting on beams with natural section loss and artificially induced section loss. Experimental results were used to validate the developed numerical models. Parametric studies were conducted to evaluate the effect of each damage parameter on the residual shear and bearing capacity. A finite element model was developed using shell elements and was validated using available experimental results. A Python script was created and utilized to develop models in Abaqus, a 3D finite element analysis software. Models include varying W-sections, material property, damage heights, damage length, thickness loses and imperfections. Models are developed through the script extracting inputs from a CSV file, allowing the user to develop 500 scenarios instantly, run the analysis and post-process the results automatically. Data from loading tests were compared to simulations of the replication of the beams and loading scenarios to ensure the Abaqus script and model were accurate. Simulations were then run and analyzed to make recommendations on bridge maintenance.

Keywords: Bridges, corrosion, I-Beam, W-Section, Abaqus, Python scripting, finite element analysis

Track D: Ecology and Sustainability 1 (WALC 2127)

Chemical Recycling of Novel Polymers Formed Through Free-Radical Polymerization

*Ian N. Burch, Qixuan Hu, Letian Dou**
**PI: School of Chemical Engineering*

SURF ID: 121
10:00 AM - 10:15 AM

Over the past century, plastics have become essential to everyday life. However, despite the drastic increase in plastic production in recent decades, plastic waste recycling has remained low. There are many obstacles to recycling polymers, such as difficulty separating different plastic types or impurities in waste. Thus, depolymerization has been a subject of increased study. Implemented on a larger scale, depolymerization would break post-consumer plastics down into their base monomers, allowing for repolymerization and reuse of the plastic. This project aimed to identify and synthesize novel polymers with the ability to efficiently undergo depolymerization and repolymerization while maintaining mechanical properties similar to current commodity polymers. After the synthesis of these monomers was complete, free-radical polymerization was performed to produce the desired polymer. These polymers were then melt processed to undergo tensile testing. The depolymerization process was then done by heating the polymers in diphenyl-ether to produce the monomer again. The yield of this recycled monomer from the originally synthesized monomer was found to determine the recyclability of the novel polymer. As this project is ongoing, specific results are not yet known. Still, the results of interest will be the recycled monomer yield and the mechanical properties, as it is desired to find a novel polymer with high recyclability and good mechanical properties.

Keywords: Free-radical polymerization, sustainable polymers, green chemistry

Impact of Flushing Plumbing Subsystems after Extended Water Stagnation

SURF ID: 157
10:15 AM - 10:30 AM

*Adelle H. Holder[1], Aliya Ehde, Caitlin R. Proctor**
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Keywords: COVID-19 shutdown, drinking water, water stagnation

During the COVID-19 pandemic, buildings across the nation were shut down or maintained low occupancy for extended periods of time. Researchers observed water quality degradation in plumbing systems that had remained unused. In response, government entities suggested that building owners flush their plumbing systems frequently (often weekly) before returning to regular use. However, there was little research to support these recommendations. Further research is needed in a controlled setting to determine if weekly flushing is effective for improving water quality after extended stagnation periods. A large-scale plumbing system model was constructed at Purdue University consisting of four identical subsystems supplied by municipal water. Each subsystem has a water heater storage tank and roughly 50-ft of copper pipe loops in triplicate. For 6 months prior to the sampling experiment, individual subsystems underwent various flushing regimes: extended, sporadic flushing (n=2), weekly flushing (n=1), and daily flushing (n=1). At the start of this experiment, the extended, sporadically flushed subsystems switched to weekly flushing for 4 weeks, with one subsystem undergoing an extended flush. After 4 weeks, all subsystems switched to daily flushing for 2 weeks. Samples were taken weekly from triplicate copper pipe loops, heaters, and municipal water inlet and were analyzed for chemical and microbiological parameters. No significant changes among water quality indicators were observed when enacting weekly and daily flushing. Results suggest weekly and daily flushing are not effective and further research is needed to find alternative ways to maintain or restore building plumbing water quality during and after stagnation events.

Impact of Spray Coating on the Performance of Hydrophobic Membranes

SURF ID: 196
10:30 AM - 10:45 AM

*Dominick Maiorano, Hamid Fattahijuybari, David Warsinger**
**PI: School of Mechanical Engineering*

Keywords: Wetting, Liquid entry pressure, Membrane distillation, Hydrophobicity, Gas permeability

Membrane distillation (MD) is a rapidly emerging water treatment technology used to combat the global water crisis. Membrane pore wetting is a primary barrier to the commercialization of MD. The primary causes of membrane wetting are membrane fouling and an exceedance of liquid entry pressure. The development of different types of polymer membranes and the use of pretreatment have led to significant movement towards the prevention of wetting in MD. We sought to take a new approach to combat membrane wetting that involves coating these membranes with hydrophilic chemical compounds, which consequently would decrease their air permeability. Pulling data from our HVAC group's latest papers, we used two different compounds for our coats: Graphene Oxide (GO) and Pebax 1657. After heating and mixing, these compounds were spray coated onto polypropylene membranes at 10 mL, 20 mL, and 30 mL worth of solution. 7 membranes with area 38 mm x 44 mm were created, including one uncoated for control, and placed into a porometer to measure the gas permeability. We discovered that 30 mL of Pebax and GO made an equal, strong difference in combating wettability. In the future, these membranes can be used in membrane distillation to measure the performance of their coats' ability to combat wetting. These experiments serve as a big step in the move toward the industrialization of membrane distillation with the goal of overcoming the freshwater shortages of the world.

Understanding Wildfire Impacts on Water Utilities: Roles and Responsibilities, Exhumed Asset Analysis, and Pipe Contamination Indicators

SURF ID: 180
10:45 AM - 11:00 AM

*Savannah Rose Kusnierz, Kristofer Issacson, Amisha Shah, Andrew Whelton**
**PI: Division of Environmental and Ecological Engineering*

As wildfires become more frequent, it is crucial for water utilities to understand the decisions they will need to make to protect their system and the populations they serve. Further, utilities are finding themselves needing to rapidly identify possible sources of drinking water contamination after fire damage. To address the needs of the water utilities to prepare for these events and make better decisions a Wildfire and Water Systems Workshop was conducted in July 2022. This event involved 9 water utilities from California, Colorado, and Oregon who convened to better understand the experiences and responses by others. Infrastructure exhumed from damaged utilities was also chemically analyzed and subjected to leaching experiments in the laboratory. This was designed to determine which chemicals may be present in drinking water systems after a wildfire. Hydrocarbon contaminated drinking water was also used to contaminate metal and plastic pipes to determine whether total organic carbon (TOC) concentration can be an accurate measure for volatile organic compound (VOC) and semi-VOC (SVOC) contamination. Results indicate that water utilities desire standardized response and recovery guidance pertaining to basic conditions and decisions. As expected, organic chemicals sorbed into and leached from pipes. TOC concentration did not serve as a reliable indicator that chemicals were present above health-based drinking water limits. As wildfires increasingly impact utilities and thus populations they serve, guidance and additional work is needed in this area.

Keywords: Wildfire, water utility, pipe, plastic

Biofouling Mitigation in Batch Reverse Osmosis

SURF ID: 120
11:00 AM - 11:15 AM

*Ethan T. Buck , Sultan Musaad, David Warsinger**
**PI: School of Mechanical Engineering*

Globally, clean water is a scarce resource, but recent advances in batch reverse osmosis systems have been used to make clean water more accessible. Batch reverse osmosis (BRO) involves pressurizing and purifying water sources by cycling brine (contaminated water) through a semi-permeable membrane. Oftentimes, BRO systems filter water sources which are rich in microbes. This causes a buildup of microbes and a layer of formation on the membrane, which decreases the functionality of the membrane. This buildup issue, called biofouling, is persistent and a simple solution to mitigation has yet to be achieved. A proposed method for biofouling mitigation is purposefully alternating high/low salt concentration of the feed water, dehydrating the cells, and inducing cell death/removal from membrane. If proved effective, this procedure will be cost-efficient and does not require stopping system operation, both of which are not accomplished by current mitigation methods. Finally, testing will be completed to investigate if alternating between high/low salt concentration of the feed water improves performance of the membrane. These tests will involve finding the optimal cycling time alternating between high/low, and the optimal high salt concentration, which will most effectively kill the cells. If the results are as expected, it will be a viable method for biofouling mitigation in reverse osmosis membranes.

Keywords: Batch reverse osmosis, biofouling, membrane life, salinity cycling

Track E: Machine Learning 1 (WALC B058)

A Step Towards Feasible Data-Free Model Extraction

SURF ID: 139
10:00 AM - 10:15 AM

*Eric Enouen[1], Jonathan Rosenthal, Hung Pham, Lin Tan**
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Model extraction is the task of replicating the capabilities of a machine learning model with only black-box access. Recent model extraction attacks on Machine Learning as a Service (MLaaS) systems have moved towards being completely data-free, enabling attacks on models trained with difficult-to-access data. However, these attacks are extremely inefficient in the number of queries required to steal a model and are not feasible in genuine MLaaS systems that charge per query. In this work we investigate two methods that could potentially improve the query-efficiency of these data-free model extraction techniques and can be readily applied to existing methods. This study reviews how these ideas impact the query-efficiency of model extraction algorithms. We apply our methods on top of previous model extraction techniques and measure the number of queries required to reach a given accuracy. We hope this will promote future work into the query efficiency of these algorithms, enabling feasible data-free model extraction on MLaaS systems.

Keywords: Model extraction, query efficiency, machine learning, MLaaS

Deep Particle Diffusometry Robustness Analysis

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SURF ID: 279
10:15 AM - 10:30 AM

Keywords: Deep particle diffusometry, deep learning, robustness, diffusion coefficient

Particle Diffusometry (PD) is crucial to the early detection of diseases like COVID-19, Malaria, and HIV. Particle Diffusometry, an extension of Particle Image Velocimetry (PIV), is an efficient yet easy way to study changes in viscosity. Conventional PIV and PD uses correlation-based techniques, which do not account for temporal stochasticity. Deep Particle Diffusometry (DPD) is a processing technique that accounts for temporal stochasticity. Therefore, DPD can be used as an alternate for correlation-based techniques. DPD uses temporally averaged images as inputs and convolutional neural networks to predict the diffusion coefficients. In DPD, robustness and generalization remain unevaluated. It makes it difficult to discern the performance of these algorithms with experimental images. A way to solve this problem is by adding noises and intensity fluctuations to the synthetically generated images(data). The purpose of adding noises is to recreate experimental (real-world) data. The performance of pre-trained deep learning algorithms were tested on newly generated simulated images from DPD and evaluate their robustness. The performance of the pre-trained algorithms showed a decline in performance.

Optimization of Molecular Image Clustering for Efficient Comparison of Biomolecule Spatial Distributions

*Rosemary Ajish, Emerson Hernly, Julia Laskin**
**PI: Department of Chemistry*

SURF ID: 106
10:30 AM - 10:45 AM

Keywords: Self-supervised image clustering, convolutional neural networks, contrastive learning, mass spectrometry imaging, biomolecule colocalization

Molecular images show the spatial distributions of biomolecules in tissue samples, which provide important insights into the effect of disease, genetic modifications, and medical treatments on biological systems. Comparing the biomolecule distribution in healthy and abnormally-conditioned tissues helps identify key metabolic pathways crucial for developing biomarkers, medical drugs, and other diagnostic tools. Chemical images are clustered according to spatial similarity through a convolutional neural network (CNN), a human brain-inspired computational model to compare the biomolecule distributions. This project aims to optimize the CNN to run autonomously, allowing us to handle more datasets and analyze a wider variety of tissue types effectively. First, a Python script was created to automatically download image datasets from an online database and filter out the low-quality images. Parallelism was implemented to execute this script on multiple datasets simultaneously, allowing faster data processing. The resulting data was automatically uploaded to Google Colab and entered into the CNN, which had its parameters optimized for more accurate clustering. We found that many biomolecules clustered differently when the tissue state changed. The biomolecules that cluster differently may belong to the metabolic pathways altered by the condition. In contrast, the biomolecules clustered similarly are likely to belong to pathways unaffected by the condition. These results suggest that the optimized CNN developed in this project can provide accurate and widely applicable clustering outputs, allowing us to conclude the effect of specific tissue states on biological systems.

Power generation forecasting of a hybrid renewable energy microgrid using machine learning algorithms

SURF ID: 200
10:45 AM - 11:00 AM

*Jose David Martinez Guerrero[1], Jhon J. Quinones, Abigayle Moser, Luciano Castillo**
*[1]Universidad de Los Andes *PI: School of Mechanical Engineering*

Keywords: Machine learning, renewable energy, power production, wind, solar, forecasting

One of the main challenges of a renewable hybrid microgrid is that power produced by these resources is directly proportional to weather conditions, such as wind speed and solar irradiance. This research aims to achieve accurate power production predictions based on weather conditions forecasting from public data for a specific microgrid location. Furthermore, this project sought to quantify the model's capacity to extrapolate power production estimations to surrounding areas. We collected historical hourly data of weather conditions from three stations around West Lafayette to train machine-learning algorithms, such as Random Forest, Ridge, LightGBM, XGBoost, and CatBoost, on the prediction of wind speed and solar radiation. The models were developed in Python, and metrics, such as mean-squared error (MSE), mean absolute error (MAE), root-mean-square error (RMSE), and R^2, were used to evaluate the accuracy of the predictions. For calculating the forecasting capacity of the model, we deployed two strategies. First, we used the historical weather data from two stations located far away from the target station to predict the wind speed and solar radiation. Then, we compared the extrapolated data with the actual measured data from the target station, where the hybrid microgrid is attempted to be installed. These models can then be ranked based on the metrics to obtain the best suitable model to predict power production. Moreover, we found that the data is inversely proportional when the accuracy of extrapolation is compared to the distance between the stations. This approach establishes an upper limit on the distances between the stations upon which the predictions are viable.

'Clearing the Cloud?' TinyML in Industrial Manufacturing

SURF ID: 244
11:00 AM - 11:15 AM

*Eugene O. Thompson Jr[1], Charilaos Mousoulis, Ali Shakouri**
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Keywords: Tinyml, predictive maintenance, machine learning, manufacturing, nicla vision, vibration

Predictive maintenance (PdM) is becoming more prevalent as it can predict future repairs before an actual failure or using resource-intensive scheduled maintenance. PdM uses machine learning and data collected from Internet of Things (IoT) devices. The data from the IoT devices are typically uploaded to the cloud for processing and inferencing. Sending the data externally poses security and privacy risks, high latency, creates a dependence on the network connection that may not always be available, and requires high amounts of energy for IoT communication. Tiny Machine Learning (TinyML) is a burgeoning field in machine learning where battery-powered; embedded devices can run machine learning models with real-time responses. TinyML can therefore be the solution to reducing the energy required, improving security, and lowering latency by removing the need to upload to the cloud. This research aims to bridge the gap between predictive maintenance and TinyML and apply TinyML in real manufacturing environments. To accomplish this, custom machine learning firmware was developed to utilize the onboard sensors of a TinyML-enabled edge device, the Arduino Nicla Vision, providing predictions based on vibration sensor inputs. The work consisted of collecting datasets from the sensors of the device, developing the TinyML models and adding them to compatible firmware. The process was performed using a testbed. The predictive machine-learning model was deployed, and its performance was examined and adjusted as needed. The model is designed for a TinyML setup at a Computer Numerical Controller (CNC) machine of a manufacturing collaborator.

Using Genetic Algorithm to Train Neural Network

SURF ID: 192
11:15 AM - 11:30 AM

*Binghang Lu, Christian Moya, Guang Lin**
**PI: Department of Mathematics*

Keywords: Genetic algorithm, neural network , gradient decent

The gradient decent (GD) algorithm that calculates the gradient of the error function at the weight's current value to modify each weight value in the neural network (NN) is prevalent in the NN training . However, it also has problems like it can't escape the local optima to find the global optima somehow. In our work, we use the genetic algorithm (GA) to train the NNs, which provide optimisation over large space state so it can find the global optima better. Specifically, the evolutionary loop of the GA is presented. Also, this work represents genetic operators like Crossover, Mutation, Selection. We also tested the relation between the mutation rate and the GA performance. Simulation results of using GA to train NN are compared with stochastic gradient decent (SGD), and the better performance of GA is observed.

Track F: Medical Science & Technology 1 (WALC B066)

A Nonlinear Optics Mathematical Framework on Chiral Naproxen Crystals Using Circular Dichroism Spectroscopy

SURF ID: 241
10:00 AM - 10:15 AM

*Camila Strachan[1], Gwendylan Turner, Yechan (Timothy) Hwang, Garth J Simpson**
*[1]New York University *PI: Department of Chemistry*

Medications are often given to patients in a crystallized form, where the body dissolves them. However, only some enantiomers can be safely dissolved. This is due to the chiral nature of our bodies: down to our DNA. Further understanding of chirality keeps pharmaceuticals safe. Chirality can be best explained by looking closely at one's hands. People's hands are chiral because they can not be superimposed onto each other. Chiral molecules have the same chemical compositions, but they are mirror images. In general, chirality is studied in an isotropic system, but little is known about the impact of chirality on assembly. Our framework assumes a uniaxial system through the use of crystal thin films. Using a mathematical framework developed for nonlinear optics, a theoretical framework was developed. The subsequent math predicted a sign of change when the uniaxial assembly flipped 180 degrees. Thin films of crystallized naproxen, a chiral molecule, and inflammatory drug, were used to gain further insight. Naproxen dissolved in Toluene was placed on silica slides that were chemically treated to create thin, small crystals once the solvent evaporated. Second Harmonic Generation images were taken to visualize the formation of crystals before being placed in a Circular Dichroism instrument, which detects the difference in right and left circularly polarized light. The thin film was flipped during experimentation, keeping the same field of view. Significant results were found using Toluene as a solvent. Further research will expand this framework to two-photon fluorescence.

Keywords: Circular dichroism spectroscopy, Nonlinear optics, Chirality, Naproxen

Dropwise Additive Manufacturing of Mini Tablets using Suspension and Melt-based Formulations

SURF ID: 256
10:15 AM - 10:30 AM

*Wanning Wang, Varun Sundarkumar, Gintaras V. Reklaitis**
**PI: Davidson School of Chemical Engineering*

Mini-tablet is an emerging product form for drug delivery that enables patient-personalized dosing in an easy-to-consume format. This can potentially address the needs of many patient groups (especially pediatric and geriatric populations) that suffer from drug-related adverse events due to over-medication and a lack of individualized dosing based on individual patient characteristics such as age, weight, gender, and other covariates. This technology's adoption is hampered by manufacturing difficulties – in particular, processing small amounts of active ingredient powders. To overcome this challenge, the current study investigates the use of a pharmaceutical 3D printing system called DAMPP (dropwise additive manufacturing of pharmaceutical products) to manufacture mini-tablets less than 4mm in diameter with consistent drug loadings. To accomplish this, the droplets printed by the DAMPP platform are proposed to be solidified using alternative types of baths as cooling mechanisms and isolated as single mini-tablets. This study aims to manufacture mini-tablets for the drug atorvastatin (used to treat high cholesterol) using a polyethylene glycol-containing formulation blend. Firstly, the appropriate formulation for printing and bath properties for drop solidification is determined. Then, mini-tablets with different diameters are printed and measured for consistency (size, weight, and concentration). The results demonstrate the feasibility of producing personalized mini tablets using the DAMPP method. However, further research is required to optimize processing conditions to enable efficient continuous production of these dosages. Thus, the study highlights the potential value of DAMPP technology in producing tailored, mini-dosage units for patients requiring personalized, easy-to-consume drug products.

Keywords: Additive manufacturing, mini-tablets, individualized dosages, drop-on-demand printing,3D printing, drug delivery

Drug Development and Structural Analysis of GRK5/6 in Complex with Inhibitors

*Natalie M. Galvan, Yueyi Chen, John Tesmer**
**PI: Department of Biological Sciences*

SURF ID: 145
10:30 AM - 10:45 AM

Keywords: G-protein Coupled Receptor, GRK5, Crystallography, Radiometric Assay, Therapeutics

G-protein coupled receptor kinase (GRK) 5 and 2 are overexpressed and contribute to the progression of cardiac hypertrophy and heart failure. GRK5 also contributes to various cancer types. Our project is to develop drugs that perturb the function of these proteins. We aim to develop effective non-toxic drugs that inhibit GRK5 and do not affect GRK2. Although both are cancer therapeutics this would be a tool to further understand the specific roles of GRK5. We will also determine the structure of GRK5 in complex with the best compounds. Obtaining this structure allows us to see how the inhibitors are interacting with GRK5. This knowledge will allow for the synthesis of better inhibitors. GRK5 inhibitors are synthesized in the Ghosh lab and tested for effectiveness in our lab using radiometric assays. In this assay, GRK5 transfer a radioactive phosphate from ATP to tubulin. If our inhibitor is effective, it should block this process at low concentrations. To obtain the structure of GRK5 in a complex with an inhibitor we will use X-ray crystallography and a soaking technique. This will allow us to have our protein-inhibitor complex in a solid and regular form, from which we can solve the 3D structure with X-ray diffraction imaging. We have identified 3 compounds to be good inhibitors for GRK5, which we are utilizing in our crystallography experiments. We are in the process of optimizing our crystallography experiments and taking results from diffraction imaging. We anticipate obtaining a detailed structure of the GRK5-inhibitor complex this year.

Low-Cost Esophageal Stent in Kenya

Chih-Kai Chang, Amber Carpenter, Aaron Lottes, Andrew Brightman*
**PI: Weldon School of Biomedical Engineering*

SURF ID: 125
10:45 AM - 11:00 AM

Keywords: Esophageal cancer, esophageal stents, Kenya, fishing line, mechanical testing, biocompatible testing.

Esophageal Cancer (EC) in Kenya is a significant healthcare concern. According to previous research, high rate of EC is positively correlated to risk factors including tobacco smoking, alcohol and acetaldehyde, and genetics. In Kenya, Esophageal cancer palliative care patients suffer from insufficient healthcare treatment, because of scarcity of the products and not being cost-efficient relative to their living standards. Hence, we aim to develop an esophageal stent, made of low-cost materials, that can be manufactured locally and sustainably in Kenya. By following this approach, we identified commercially available fishing lines as potential material and conducted material characteristic testing including mechanical and biocompatible tests to identify optimal material candidates. Secondly, we are developing a stent model, and basic manufacturing methods. Finally, we plan to perform thorough testing based on US FDA guidance for esophageal stents. As a result, we will develop a prototype esophageal stent that can be evaluated as a solution for palliative care in Kenya. Further testing will confirm that stent can withstand clinically relevant forces (e.g., longitudinally, and radially), and achieve acceptable biocompatibility results. Future work should consider optimizing manufacturability and validating the final product design in animal testing followed by human clinical trial. Successful development of this device will have a broad impact on patient care by providing an alternative low-cost solution for esophageal cancer palliative care treatment globally.

Tape Peel Adhesion to Soft Substrates

SURF ID: 163
11:00 AM - 11:15 AM

Rebecca M. Jennings, Jared A. Gohl, Chelsea S. Davis, Adrian P. Defante*
**PI: School of Materials Engineering*

Keywords: Peel mechanics, adhesion, tape peel, soft materials

Pressure sensitive adhesives (PSAs) play a critical role in medical supplies and systems from everyday bandages to more sensitive interfaces such as the skin surrounding a stoma to attach a colostomy bag. However, removal of such materials and devices can cause discomfort or trauma on the patient's skin. Therefore, we hope to understand the fundamental mechanisms that govern the peel mechanics and adhesion of PSAs upon removal from soft substrates to minimize or eliminate traumatic effects due to substrate deformation. For our skin analog, we create a bilayer substrate using a soft silicone with polyethylene (PE) thin film. The modulus of the silicone was varied from 6 kPa to 75 kPa. We conduct 90-degree peel adhesion tests for medical tapes and record the average peel force and work of debonding required for removal. For substrates with a very low modulus ($E = 6$ kPa), cohesive failure in the substrate occurred, prohibiting peel adhesion testing. For substrates with a relatively moderate to high modulus ($E \geq 35$ kPa), the surface of our skin surrogate deformed out of plane, reducing the initial peel angle before the tape reached a steady state peel force. This study highlights both qualitative and quantitative differences in the mechanical peel behavior of soft versus rigid substrates. By gaining an understanding of these mechanisms, we will be able to understand why trauma at an interface occurs between an adhesive and a soft surface and develop new strategies to mitigate this damage.

Design and Scalable Manufacturing of Point-of-care Nucleic Acid Diagnostics for Infectious Diseases

SURF ID: 204
11:15 AM - 11:30 AM

*Alberto Miranda[1], Marina Sala de Medeiros, Jacqueline Linnes**
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Keywords: Infectious diseases, sample-to-answer, scalable manufacturing, point-of-care diagnostics, lateral flow assay

Infectious diseases can spread exponentially among populations in a short period of time and current estimations are that over half of the world's population are at risk of infectious diseases. Early and accurate diagnostics are critical to providing informed prompt treatment and prevent transmission among populations. Conventional nucleic acid detection such as PCR (polymerase chain reaction) enables accurate and early detection of infectious diseases, but frequently require expensive laboratory infrastructure for cold-chain reagent storage and complex sample preparation performed by trained personnel. To overcome these limitations, researchers are exploring different methods of nucleic detection that could be translatable to point-of-care without requiring trained personal or cold-chain reagent storage. Despite advancements of sample-to-answer point-of-care nucleic acid tests, only a small percentage of developed technologies can be replicated and fabricated at scale. This work seeks to adapt a current working platform of a sample-to-answer nucleic acid detection device using design for manufacturing principles with the goals of making the device more affordable, accessible, and user friendly at point-of-care. The revised prototype consists of a single-axis design that's compromised of a vacuum-thermoformed well, laser-cut and 3-D printed parts, and thermally actuated wax valves for fluidic control. All methods and materials used during prototyping are commonly found in large-scale manufacturing setups. Preliminary tests on the prototype show successful flow of nucleic acid amplified sample to a lateral flow assay readout for point-of-care use. This integrated one-step sample-to-answer nucleic acid detection platform aims to enable automated and scalable detection of infectious diseases at point-of-care.

Track G: Nanotechnology 1 (WALC 3084)

Temperature-Dependent Infrared Reflectance of Hyperbolic Materials

*Ziyang Chen, Yikang Chen, Xianfan Xu**
**PI: School of Mechanical Engineering*

SURF ID: 129
10:00 AM - 10:15 AM

Keywords: Hyperbolic materials, molybdenum trioxide, Fourier-transform infrared spectroscopy, infrared reflectance, semiconductor

Hyperbolic materials have garnered heightened research interest with their anisotropic properties, properties that exhibit different values in different directions. This variation has led to many optical and thermal properties in hyperbolic materials that are unachievable with any other materials. One prominent example of such materials is molybdenum trioxide, for which prior research had discovered the infrared reflectance and dielectric function (a critical function as a semiconductor). This research project investigated the infrared reflectance and dielectric function of molybdenum trioxide at multiple temperature points spanning from -110 °C to 227 °C. molybdenum trioxide flakes were sampled and processed to a thickness of 1 to 5 micrometers, placed in a temperature control stage modulating sample temperature. An FTIR (Fourier-Transform Infrared Spectrometer) emitted and collected infrared radiation with wavelengths ranging from 2.5 to 15 microns, polarized in the longitudinal and transverse directions of the flake. With a preceding reflectance benchmark obtained with gold, the infrared reflectance of molybdenum trioxide was computed as a percentage and plotted as a spectrum against wavenumber. This spectrum was then loaded in MATLAB, and a Lorentz-Drude model approximation was applied to derive the dielectric functions at all temperature points. This research compared the infrared reflectance of molybdenum trioxide across a wide temperature range to search for changes and tendencies in properties with temperature variations and provided screening for future research in the anisotropy and temperature-dependence in hyperbolic materials.

High-Performance Radiative Cooling Paints

*Navdeep Vansal, Emily Barber, Xiulin Ruan**
**PI: School of Mechanical Engineering*

SURF ID: 251
10:15 AM - 10:30 AM

Keywords: Global warming, radiative cooling nanocomposites, ultra-white paint

Air conditioning (AC), a form of active or energy-consuming cooling, significantly contributes to global warming, primarily due to the carbon emitting processes it uses for energy such as the burning of coal and natural gas. Thus, complementary and/ or alternative cooling technologies which require no energy consumption to operate are being explored to alleviate this issue. One such promising technique known as radiative cooling (RC) is developing in the form of commercial-like paints which use particle-matrix nanocomposites to provide an efficient, low-cost, and scalable cooling option. Recent research suggests that a novel paint comprised of a pigment and binder theoretically outperforms the CaCO3-acrylic and BaSO4-acrylic paints which through field tests have demonstrated daytime sub-ambient cooling. Multiple samples of this novel paint are created, each with different pigment to binder ratios (55:45, 65:35, 75:25), and analyzed using a UV-Vis spectrometer to determine each sample's transmittance and reflectance within these spectral regions. In addition, the structural integrity of the samples is observed because the paint must maintain as a thick opaque film when applied to surfaces to ensure its' efficacy. This study uses these criteria in evaluating the samples and provides a recommendation as to the ideal ratio of pigment to binder. Furthermore, a comparison of the UV-Vis spectrometer results from the ideal ratio novel paint sample and the field-tested paints yields whether the novel paint should outperform them.

gdspy-autolayout: Automated GDS Layout for Large Scale Experiments

*Tin Tran, Samual Peana, Vladimir Shalaev**
**PI: Elmore Family School of Electrical and Computer Engineering*

SURF ID: 248
10:30 AM - 10:45 AM

Keywords: Gdspy, layout, autolayout, GDSII

In this work we present an easy to use python package for the popular GDSPY GDS generation package. The implemented python package is designed to handle the last stage of gds generation: the placement of designs. This task is often laborious, especially for layouts that involve many variations of designs. Placement of these layout can be time consuming and difficult. Furthermore, once a design is laid out identification and location of the fabricated design is generally non trivial. With the gdspy-autolayout package this process is automated. This is accomplished by taking in the codes for the generation of devices along with how many of these designs should be placed and then automatically adding identifier codes to each design and automatically laying out the designs specified on a chip with optimal packing density. Additionally, this package allows for the generation of experimental variables which allows for a full design of experiments (DOE) to be automatically laid out with high packing density. Finally, for each layout a CSV file is generated containing all the generation parameters, identifier code, and location on the chip allowing for easy reference and locating of fabricated devices. Such automation will be critical in an age of machine learning assisted design and optimization work where hundreds or thousands of variants of a particular device are needed.

Towards Utilization of DNA Nanotechnology for Targeted Drug Delivery

*Raey Hunde[1], Yancheng Du, Jong Hyun Choi**
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SURF ID: 159
10:45 AM - 11:00 AM

Keywords: DNA nanotechnology, nanostructures, nanomotors, selective cell uptake, drug delivery

DNA—the molecule that stores the genome, can be used outside of its biological context. The Watson and Crick base pairing of DNA makes it an excellent material candidate for engineering applications in DNA nanotechnology. DNA nanotechnology is an accelerating field that involves the design and construction of DNA nanostructures and nanomotors. The vast design possibility in sizes and geometries of DNA structures makes them potentially nanocarriers for targeted cell uptake. Compared to current methods with lipid nanoparticles, DNA nanotechnology takes the advantage of high programmability and biocompatibility. Therefore, developing novel methods with DNA nanostructures as nanocarriers can be applied in cell behavior studies and drug deliveries. The purpose of this research will involve researching DNA nanostructures and their interaction with cells. This experiment includes the preparation of arbitrary nanostructures via DNA self-assembly, which are explored in cellular uptake studies. Rectangular tile and tubular nanostructures were prepared and characterized with atomic force microscopy (AFM). Preliminary experiments suggest that the origami structures from DNA show stable geometries as designed and that they may be uptaken up by cells in a selective manner. The findings from the experiments show strong evidence suggesting that DNA origami may be used as a therapeutic mechanism for drug delivery to cancerous cells.

Assessing Thermal Conductivity of Doped GST Phase Change Films

SURF ID: 169
11:00 AM - 11:15 AM

*Arihant Kaul, Thomas Beechem**
**PI: School of Mechanical Engineering*

Keywords: GST, RAMAN, Spectroscopy, phase change materials, Thermal Conductivit

Germanium–antimony–telluride or GST has recently emerged as a nonvolatile phase change memory material mostly due to the large resistivity contrast between amorphous and crystalline states, allowing for storage of memory within its structural state. However, improving the thermal phase stability has necessitated further doping with additional elements such as Se and C. The effects of the doping process of GST are being investigated using frequency-domain thermoreflectance and with structural characterization derived from x-ray diffraction and Raman spectroscopy. Specifically, the room temperature thermal conductivity and heat capacity of variety of doped GST samples are reported as a function of carbon concentration from 0% to 12% and anneal temperature, from 350 C and down. These results are being assessed in reference to the measured phase, structure, and electronic resistivity. According to some of our results, at lower anneal temperature ($T < 140$), the addition of carbon is almost negligible resulting in similar thermal conductivity across the films. But as anneal temperature increases to over 250 C, we can see that the addition of carbon increases the structural stability of the bonds within the GST film. GST doped by carbon comes with relatively low thermal penalty as materials show similar levels of crystallinity and have comparable thermal conductivity despite the addition of carbon. The additional thermal stability provided by the carbon does, however, necessitate higher anneal temperatures to achieve similar levels of structural order.

Track H: Robotics 1 (WALC B093)

Characterizing Relationship between Air Pressure and Bending Deformation of a Cubic Soft Modular Robot

SURF ID: 272
10:00 AM - 10:15 AM

*Tianyi Zhang, Eshaan Agarwal, Joseph Chen, Patrick T. Mansour, Benjamin Hutchins, Adrian B. Tepole**
**PI: School of Mechanical Engineering*

Keywords: Robot, modular, soft robot, soft material, deformable, flexible, pneumatic, actuate, characterization

As modular robotics and soft material technologies mature, researchers are seeking to combine the merit of both fields by developing Soft Modular Robots (SMRs). SMRs intend to leverage the almost-infinite degrees of freedom offered by soft robots while adapting a versatile modular framework. However, previously researched SMRs generally have limited modularity: few SMRs have individually controllable modules, and most of them can only be cascaded in at most two dimensions. Therefore, to broaden SMRs' general modularity, this research project aims to develop and characterize an SMR that can be cascaded in three dimensions and individually controlled. First, cubic and pneumatically-driven SMR units that are capable of planar bending motion were designed, constructed, and tested. Experimentally, chamber pressures ranging from 0.00 to 0.60 psi resulted in bending angles ranging from 0.0 to 42.5 degrees with a cubic relationship. To improve designs and generate predictive models for SMR control, Finite Element (FE) simulations were conducted to generate theoretical pressure-bending relationships. The experiment and simulation results agreed that the SMR unit exhibits a cubic relationship between pressure and bending angle. However, noises in physical experiments and uncertainties in the simulation parameters caused a bias between experiment and simulation data. Additionally, the experiments and simulations were done on the shell of the SMR unit, without internal components. Thus, experiments need to be improved for noise elimination and characterization of the effects of internal components. FE model refinement is also needed to improve accuracy in order to guide the design of SMR assemblies.

ROS2/Gazebo Simulation for Autonomous Navigation of Robots in Agriculture

SURF ID: 156
10:15 AM - 10:30 AM

*Kenta Hirashima[1], Saron M. Bhoopathy, Varun Aggarwal, Aanis Ahmed, Dharmendra Saraswat**
*[1]University of Illinois at Urbana-Champaign *PI: Department of Agricultural and Biological Engineering*

Keywords: ROS2, Gazebo, Simulation, Agricultural robot, Unmanned ground vehicle, Autonomous navigation

Increasing the sustainability and productivity of agriculture is becoming crucial amidst a variety of challenges posed by rising population, climate change, and a lack of labor during critical crop production stages. Multiple studies suggest that agricultural robots could help offset these challenges by efficiently managing crop production. Despite advances in computer vision and internet of things (IoT) technologies, navigating agricultural robots in complex field continues to be challenging. This study aims to develop a simulation environment for evaluating navigation and control algorithms for robots in agricultural fields. The simulation environment was created using Robot Operating System (ROS), namely ROS2 Foxy, and Gazebo 11. A custom mesh model of the prototype unmanned ground vehicle (UGV) was developed with Ackermann steering and deployed on a virtual corn field. The virtual field was designed with rough terrain and corn row widths of 0.8 meters. Navigation2 package was used to avoid obstacles and calculate the shortest path between user-specified waypoints using two graph search algorithms, Dijkstra's algorithm and A* algorithm. The Ackermann steering robot, with a short wheelbase, was found to perform sharp turns without collision with plants. Addition of a detouring point at the end-of-row was found to smoothly transition UGV to the adjacent row. Both Dijkstra's algorithm and A* algorithm performed equally well in planning the optimal path, and the UGV was also able to follow the path without collision. These results provide insight into future experiments on deploying UGVs in cooperation with unmanned aerial system in a real-world setting.

The Characterization of a Soft Robotic Linear Actuator in a Physical Versus Simulated Environment

SURF ID: 103
10:30 AM - 10:45 AM

*Eshaan Agarwal, Tianyi Zhang, Ben Hutchins, Joseph Chen, Patrick Mansour, Adrian Buganza Tepole**
**PI: School of Mechanical Engineering*

Keywords: Soft robots, linear actuation, modular robots, bio-inspired robots

In recent years, soft robots have emerged as a viable bio-inspired alternative to traditional systems, especially in human-facing applications. One of their main advantages is that they leverage the strengths of soft materials—such as silicones and rubbers—to continuously deform. However, due to the unique properties of soft materials, the deformation of soft robots can be complex, resulting in large and unpredictable changes in shape. For this reason, soft robots have to be thoroughly characterized to determine precise actuation upon applied pressures. In this study, a soft robotic actuator design was created to combine continuous deformation with the unique versatility and repairability of an individually-controllable modular system. The unit was characterized using finite element simulations, as well as a physical test that measured deformation as a function of pressure. Across all six trials, there was a consistent non-linear relation, with the rate of deformation increasing at higher pressures. Finite-element simulations showed a linear relation that was consistent with the physical units at lower pressures but could not match the large deformations of higher pressures. Due to this disconnect, it is clear that refinement of both the physical characterization experiment and finite-element computational models is necessary. Nevertheless, this work has pushed forward the design and fabrication of individually controllable soft robots and advances towards precise pneumatic control of these actuators.

CLICK: Robotic Insertion for Cable Assembly Using Tactile Feedback

*Raghava Uppuluri, Harrison McCarty, Wenzhao Lian, Yu She**
**PI: School of Industrial Engineering*

Robotic insertion is a hallmark robotic skill due to numerous applications in industry from manufacturing to healthcare. End-to-end robotic insertion is characterized by the millimeter-precision needed to locate the pose of the connector and port throughout the task and the complex contact/friction mechanics involved in completing the "last-inch" of the insertion. Traditional approaches make assumptions about the initial pose of the connector and/or the port, hindering transfer to an inconsistent, real-world setting. By also relying largely on vision throughout the task, prior works face difficulty when facing full-occlusions, which commonly occur in real-world manufacturing tasks such as car harness assembly. In this work, the insertion task is studied through an electrical cable assembly task. By introducing a visuo-tactile sensor known as GelSight placed in the robot fingers, the connector and port is robustly localized, augmenting previous perception approaches for insertion to better generalize to real-world manufacturing scenarios. Experimentally, the proposed method along with baselines are evaluated on a standardized task board, measuring the success rate of the connector grasp, connector handoff, and connector insertion primitives.

SURF ID: 250
10:45 AM - 11:00 AM

Keywords: Robot manipulation, perception, robotic insertion, cable assembly, tactile feedback

Day 1 — Afternoon Presentations

July 28th, 2:00 PM – 4:00 PM EDT

Track A: Genetics and Cellular Biology 1 (WALC 3138)

The Effect of Ca+2 Signal Dependence on Actin Morphology of Dendritic Spines in Alzheimer's Mouse Model

SURF ID: 283
2:00 PM - 2:15 PM

*Maria Rafiq[1], Fiza Sikandar, Agnes Doszpoly, Eugene Seo Kim, Tamara Kinzer-Ursem**
*[1]National University of Sciences and Technology, Islamabad, Pakistan *PI: Weldon School of Biomedical Engineering*

Keywords: CaMK-II, Ca+2 signal dependence, Dendritic spines, Actin bundling, Long-term potentiation

Neurodegenerative diseases like Alzheimer's disease are thought to be associated with calcium dysregulation as hypothesized by the calcium/calmodulin hypothesis. CaMK-II (Calcium/calmodulin-dependent protein kinase) is an essential signaling molecule that induces calcium signaling pathways and regulates multiple cellular processes in neurons. It acts as a structural and functional protein in excitatory postsynaptic terminals and is involved in learning and memory formation by maintaining synaptic plasticity. Dendritic spines give rise to new connections between synapses that underlie the mechanisms of memory formation regulated by actin filaments. However, the exact mechanism of how calcium-dependent CaMK-II regulates the actin morphology in budding dendritic spines remains indistinct. To investigate this, the attainment of a viable neuronal culture is critical to growing stable mouse hippocampal dendrites. The project's overall goal is to obtain an optimal mouse hippocampal neuronal cell culture technique that will be best suited for confocal and super-resolution microscopic imaging to investigate the relative proximity and spatial organization of actin and CaMK-II in dendritic spines. The results from the confocal imaging show the presence or absence of CaMK-II in relation to F-actin indicating its involvement in dendritic spine morphology. Further investigation into protocol optimization will be needed to generate a stable dendrite culture line for quantitative imaging analysis. In summary, the project goal is to develop an optimized neuronal culture protocol for clear imaging of dendritic spines in neurons to understand the calcium-dependent processes that lead to impairment of synaptic plasticity during memory formation in neurodegenerative diseases.

The Effect of Fibronectin on Breast Cancer Dormancy

SURF ID: 201
2:15 PM - 2:30 PM

*Grace B. May, Jordanna Payne, Alexandra Plummer, Luis Solorio**
**PI: Weldon School of Biomedical Engineering*

Keywords: Breast Cancer, fibronectin, dormancy, cellular microenvironment, extracellular matrix

Approximately 12% of women will be diagnosed with breast cancer during their lifetime. One of the greatest risks to these patients is the development of metastases where the five-year survival rate for metastatic breast cancer is only 29%. Metastases can develop years after the treatment of the primary tumour due to a period of cancer dormancy. Previous research suggests that this state of dormancy can be regulated by the cellular microenvironment. Specifically, the protein fibronectin has been shown to reactivate cells from a dormant phenotype into a proliferative one. Therefore, the correlation between fibronectin and breast cancer dormancy needs to be further investigated. Two cell lines from mouse mammary tumours, one dormant and one proliferative, were cultured in a control and experimental environment. The control environment contained the proteins commonly found in tumours while the experimental environment was fibronectin rich. Over a course of ten days the cell growth was documented through growth assays, and after ten days the proliferation status of the cells was assessed via immunofluorescence imaging. The growth assays revealed that the cells responded as expected in the control environment, but the fibronectin rich environment allowed for the typically dormant cell line to proliferate. The immunofluorescence images further supported these results since the dormant cell line lacked the proliferative marker in the control environment but contained this marker in the experimental environment. These results suggest that fibronectin plays a role in the switch from dormancy to proliferation making it a possible target for future breast cancer therapeutics.

Designing a Human Protein for Bacterial Secretion

SURF ID: 226
2:30 PM - 2:45 PM

*Shravan K Ranganathan, Leopold Green**
**PI: Weldon School of Biomedical Engineering*

Cytokines and chemokines are secreted, small cell-signaling protein molecules, whose receptors are expressed on immune cells. These factors play a critical role in immune cell differentiation, migration, and polarization into functional subtypes and in directing their biological functions. Interleukin-10 is an anti-inflammatory cytokine, and Interleukin-22 is a pro and anti-inflammatory cytokine. Because of their properties, it is essential to be able to express and secrete them. The purpose of this study was to design a human protein that can be used to express and secrete various cytokines and chemokines in E. coli to analyze genetic regulation via the host. Novel genetic sequences were extrapolated from the original cytokine genetic sequence removing introns, that do not code for proteins, with the purpose of identifying the receptor sequence that would enable secretion. An existing logic gate for HIL-22 was used. The genes for IL-22 were cut out and 40 base pairs of the remaining backbone and the HIL-4 gene were also cut out in order to PCR the parts together. A Hyla tag was also attached using this method as the receptor region. Using this procedure, it was understood that a gene block of this design would withstand the conditions needed to come together and produce a part that would allow for secretion. The designed construct was then sent out for sequencing. This construct will be used for future tests to express and secrete the interleukins in E. coli.

Keywords: Cytokines, 3G Assembly, PCR, Chemokines, Receptors, ompF

Computational Investigation of Cell Polarization in Extracellular Matrix

SURF ID: 134
2:45 PM - 3:00 PM

*Nhat Hong Doan[1], Donghuyn Yim, Taeyoon Kim**
*[1]Grinnell College *PI: Weldon School of Biomedical Engineering*

Mechanical interactions between the cell and its extracellular matrix (ECM) are fundamental for different physiological processes such as wound healing or cancer metastasis. The cell responses to cues from the ECM by generating forces that lead to the remodeling of the ECM. In recent years, there has been an increasing number of computational investigations on this interaction; however, most of them assumed that the ECM is elastic. As the viscoelasticity of the ECM has been proven to be crucial in the cell-ECM interaction, this research implements a discrete model to study the response of the cells with protrusive behaviors in a viscoelastic ECM. Using a model with cross-linkers of varied unbinding kinetics to investigate, time-dependent characteristics of the cell and the ECM are visualized and studied quantitatively. In particular, the cell shapes and tensile force development are analyzed. The simulations showed that as the connections between the actin filaments and membrane exhibit more catch-bond nature and higher unbinding rate, there is more tensile force developed with more adhesion points. Future work involves studying how other factors such as protrusion forces or bond stiffness affect membrane shapes and force development patterns over time. These results would provide more insights into how the cell responds to mechanical forces in a viscoelastic ECM.

Keywords: Cell polarization, extracellular matrix, cell membrane, fiber network, computational simulation

Identifying the Mechanism of KMT5C in Driving EGFRi Resistance in Non-Small Cell Lung Cancer

SURF ID: 154
3:00 PM - 3:15 PM

*Maximillian Hellrung, Alejandra M. Agredo, Andrea L. Kasinski**
**PI: Department of Biological Sciences*

KMT5C is a known catalyst of histone H4 lysine 20 (H4K20) trimethylation, which is required for canonical gene repression. Loss of KMT5C in non-small cell lung cancer (NSCLC) patients results in increased resistance to epidermal growth factors receptor inhibitors (EGFRi). EGFRis are the primary treatment for cancers with EGFR mutations, and resistance to these inhibitors can lead to additional or recurring disease. The mechanism by how this resistance is conferred is not fully understood and further investigation into how, mechanistically, KMT5C loss drives resistance is needed. To evaluate KMT5C protein expression and understand its mechanism, a tool is needed to visualize KMT5C due to lack of available antibodies. Therefore, we developed an inducible, tagged version of KMT5C that can be detected following transfection into NSCLC cells using an antibody specific for the tag. Tagged KMT5C will allow us to identify the half-life of KMT5C using an optimized dynamics assay and Western Blot. We expect to develop a viable vector that allows us to express KMT5C in our cell line. We also expect to determine the half-life of KMT5C and identify a timepoint in which future research on the dynamics of KMT5C can benefit. These results will further advance the knowledge of the mechanisms behind EGFRi resistance and the role of KMT5C role in conferring resistance. Additional research on KMT5C can strongly benefit therapeutic treatment of EGFR mutants in lung cancer.

Keywords: EGFR inhibitor resistance, Non-small cell lung cancer, KMT5C, H4K20, histone trimethylation

Enhancer RNAs Effects on T-cells

SURF ID: 214
3:15 PM - 3:30 PM

*My Nguyen, Yuxin Zhuang, Majid Kazemian**
**PI: Departments of Biochemistry and Computer Science*

Enhancers are cis-regulatory elements that help establish the gene transcription program by increasing transcription of their target genes. Sometime enhancer regions themselves are transcribed producing novel regulatory RNAs termed as enhancer RNAs (eRNA). Several studies have analyzed the relationship between expression level of eRNAs and target genes and found strong positive correlation. However, the function of these eRNAs in immune cells are less understood. T cells are lymphocytes produced mostly in the thymus and play an important role in the adaptive immune system. There are two major T cell types: the CD8+ T cells that are known as cytotoxic T cells, and the CD4 T cells that are known as helper T cells. Cytotoxic T cells can attack infected cells and/or cancerous cells. Helper T cells, as the name suggested, help the activation of cytotoxic T cells, macrophages, and B cells. This research focuses on the function of eRNA in T cells. In order to investigate this, we were trying to knock down eRNAs in the CD4 T cells. The first approach is to use the small interference RNA (siRNA). However, we have not been able to successfully knockdown our candidate eRNA. Therefore, we are now aiming to manipulate the expression of eRNAs by CRISPR activation/inhibition systems in T cells regulations and analyze the effect.

Keywords: T cells, enhancer RNA, small interference RNA, CRISPR activation/inhibition

Track B: Human Factors Engineering 1 (WALC 2051)

Understanding Team Cognition in the Context of Software Development Teams

*Mariana Zamora Bula[1], Aparajita Jaiswal, Theodora Amuah, Alejandra J. Magana**
*[1]Universidad de los Andes *PI: Computer and Information Technology, and School of Engineering Education*

SURF ID: 268
2:00 PM - 2:15 PM

The advancement of technology in the last years has increased the need for competent professionals in software development, who are required to work in teams to solve problems and develop complex projects. The growing need for teamwork culture in the industry has urged higher-education institutions to incorporate group-based learning in their instruction to prepare students for their professional careers. Therefore, understanding teamwork in an educational context becomes relevant, as it can improve the way in which these abilities are taught and learned. This study focuses on characterizing team cognition and team effectiveness in a software development course. To explore this, students' teamwork sessions right before the first milestone of the semester-long project were recorded. The recordings were qualitatively coded to (1) characterize the team's level of cognitive engagement by using the Interactive, Constructive, Active, Passive (ICAP) model; and (2) characterize the team's coordination processes by using the Dickinson McIntyre model. The coding from these two frameworks was qualitatively analyzed to calculate an overall engagement score and an overall coordination score respectively. These scores were then used as input for a clustering algorithm which grouped the teams in three clusters based on their engagement and coordination characteristics. The clusters provide a comprehensive description of productive and unproductive teamwork. The implications of this work will create new knowledge about team cognition in educational settings and will derive pedagogical implications to better support teamwork skills development at the undergraduate level.

Keywords: Teamwork, team cognition, ICAP model, Dickinson McIntyre model, software development

Endothelial-based Blood Vessel Formation Inside Tumor Organoids

*Monique N. Watson, Yun Chang, Xiaoping Bao**
**PI: Davidson School of Chemical Engineering*

SURF ID: 258
2:15 PM - 2:30 PM

Cancer is one of the leading causes of mortality around the world. Understanding tumor biology is essential to finding cures for the many types of this disease. *In vitro* tumor organoids, or tumors created outside the body, could provide more knowledge to investigate tumor development and screen anti-tumor drugs. Endothelial cells or blood vessels containing tumor organoids will be better to restore or mimic the tumor microenvironment *in vivo* or inside the body. In this study, tumor organoids with or without endothelial cells were prepared through the hanging drop method or by placing the cells in a droplet to form together. After optimizing, 10% endothelial cells were identified as the maximum percentage inside tumor organoids and are thus used for subsequent studies. To promote endothelial cell growth and vessel formation, tumor organoids were placed in hypoxic conditions or conditions with limited oxygen. The blood vessel-contained tumor organoids were further employed for several anti-tumor drugs screening. Compared with normal oxygen conditions, hypoxia prompted more blood vessel formation inside the tumor organoids. In summary, functional and vascularized tumor organoids were successfully constructed in this study. This may pave the way for further pre-clinical or clinical applications in interrogating tumor development and screening anti-tumor drugs.

Keywords: Tumor organoids, endothelial progenitor cells, blood vessels, anti-tumor drug selection

Computer Vision System for Ergonomic Risk Evaluation in Veterinary Practice: A Pilot Study

SURF ID: 168
2:30 PM - 2:45 PM

*Jessica T. Joslyn, Jing Yang, Sun Young Kim, Denny Yu**
**PI: School of Industrial Engineering*

Occupational health and safety is a prevalent issue for those working in veterinary medicine. Specifically, veterinary surgeons are often exposed to physical loads and postures during operative tasks that are risk factors for musculoskeletal disorder and injury. Accurate ergonomic assessment is necessary to identify fatigue, reduce ergonomic risk, and increase productivity and safety in the workplace. Computer vision is an objective method of ergonomic assessment which employs an algorithm to make postural measurements from video data captured by cameras. Measurements are made based on ergonomic scales designed to assess workload, such as the rapid upper limb assessment (RULA). However, challenges such as joint occlusion and multiple-camera calibration make accurate computer-based assessment difficult. We seek to develop a refined computer vision algorithm for application in the veterinary operating room which allows for more accurate real time assessment of surgeons' ergonomic risk. Video data is captured in the Purdue University Small Animal Hospital operating room from multiple camera angles per surgical case. For each case, the computer algorithm is applied, and manual video analysis is conducted by an expert to obtain RULA scoring over evenly spaced time intervals. This study compares expert RULA scoring to that of the algorithm using nonparametric statistical analysis, providing insight into the algorithm's accuracy and ability to minimize effects of occlusion and missing data as a human grader would. Improving real time ergonomic assessment offers the ability to pinpoint veterinary surgeon fatigue for the implementation of measures to improve surgeon and patient safety in the operating room.

Keywords: Computer vision, ergonomic risk assessment, posture analysis, work related musculoskeletal disorders

Utilizing Eye Metrics to Verify the Impact a Self-Confidence based Automation Control Strategy has on Learning

SURF ID: 238
2:45 PM - 3:00 PM

*Kylie S. Sommer-Kohrt, Madeleine S. Yuh, Neera Jain**
**PI: School of Mechanical Engineering*

The increasing integration of automation in multiple fields has led to questions about how much and what form of automated assistance is ideal for different sectors (e.g. healthcare, manufacturing, education.). Using automation to aid in teaching people tasks is especially challenging since numerous cognitive factors, including trust and self-confidence, impact a person's ability to learn effectively. In prior work, participants in a human subject study learned how to land a quadrotor in a simulator module. Analysis of the data showed that accounting for each participant's self-confidence explicitly in an automated assistance allocation algorithm may have accelerated learning outcomes. To further validate this hypothesis, this project integrated eye tracking, using a VT3-mini eye tracker, into the study. Heat maps were created to display focal points, fixation points were analyzed, and methods of error correction for eye-tracking were examined. The eye metrics collected include screen gaze coordinates and pupil diameter. Screen gaze coordinates indicate where the user is looking on the screen throughout each trial. Pupil diameter metrics may be used to infer the participants' cognitive states of self-confidence or workload. These data were compared against previous results to better gain insight into how the designed algorithm impacts what people focus on as they learn and demonstrate whether or not there is a physiological link between pupil diameter and self-confidence.

Keywords: Automation, learning, self-confidence, eye metrics, heuristic

Mixed-Reality Testbed for Human-Robot Interaction

SURF ID: 110
3:00 PM - 3:15 PM

*Fahad S. Aloufi, Mahsa Ghasemi**
**PI: Elmore Family School of Electrical and Computer Engineering*

Keywords: Augmented reality, robotic controls, human-robot interaction

Augmented reality (AR) has been growing in popularity over the past few years with several companies creating purpose-built hardware for augmented reality applications while others have developed the needed software to build and create AR applications. However, very few have explored using augmented reality as a testbed for simulating virtual robots and their control algorithms. This research surveys the available tools for creating AR applications and aims to apply them to AR authoring of virtual robots that can interact with the physical environment. The goal of this research is to incorporate AR as a tool in testing robots and their control algorithms. The primary sets of tools we use to create the AR testbed come from Unity's suite of products. The Unity editor 2022.x, Unity's AR Foundation 5.0 (prelease version), and Unity's AR simulation environment are the main tools we use in this research project. The results of this research will be demos of robotic simulation in AR along with the framework used to build them. These demos will serve as a proof of concept. These AR robotic testbed demos will be used to answer questions about how suitable current AR testbeds are in robotics to evaluate robotic control algorithms. Based on our results, we will also describe the components of AR that are needed to make it a suitable robotics testbed.

Physiological Impacts of Emergency Patient Care

SURF ID: 234
3:15 PM - 3:30 PM

*Arizona R. Shreck[1], Nicholas E. Anton, Denny Yu**
*[1]The Pennsylvania State University *PI: School of Industrial Engineering*

Keywords: Cognitive workload, heart rate variability, human factors

Healthcare workers are educated, trained, and expected to provide quality care in a variety of circumstances. Despite extensive preparation, errors can occur in the field, and a large portion of these errors are caused by human factors. Cognitive workload (mental effort) is an area of human factors that has been historically studied through subjective measures of surveys and reports and objective, physiological measures. This study aims to use objective measures (heart rate variability, pupillometry) to identify points of heightened cognitive workload for experienced nurses during clinical simulation. A convenience sample of experienced, in practice nurses was utilized. Nurses participated in a patient care simulation, which involved monitoring a patient admitted into the emergency department for a traumatic fracture of the tibia and fibula during a motor vehicle crash whose vital signs then changed with the onset of a stroke. HRV data was collected during resting and simulation periods using the Polar H10 chest strap and the Elite HRV application. Recordings of the nurses' visual input were taken through the Tobii Eye Tracker Glasses. Kubios software was utilized to separate the data collected from the Polar H10 chest strap into 10 second intervals and measure the HRV features within them. Specific timestamps of HRV values indicating moments of high cognitive workload were extracted using MATLAB and were then compared to Tobii pupil diameter measurements to narrow the timestamps of cognitive load. Synced video files from the Eye Tracker were then used to determine the stimulus that caused cognitive workload to increase.

Track C: Composites & Structural Materials (WALC 2088)

Measuring the Effect of Cerium Oxide Nanoparticles (CeO NPs) in 3D Printed Hydrogels

*Ambrose Haskin[1], Aritra Chatterjee, Juana Mendenhall, Deva Chan**
*[1]Morehouse College *PI: Weldon School of Biomedical Engineering*

SURF ID: 292
2:00 PM - 2:15 PM

Keywords: Cell-Laden Hydrogel Scaffolds, Tissue Engineering, Osteoarthritis, AFM, Cerium Oxide, Young's Modulus

Osteoarthritis (OA), the most common form of arthritis, affecting more than 22% of adults worldwide, occurs when the protective cartilage that cushions the ends of the bones wears down over time. Currently, applications of hydrogels, crosslinked natural and synthetic hydrophilic polymers, in the form of 3-D structures (scaffolds), organize cells and present stimuli to ensure the development of a specific tissue. Exhibiting the same characteristics of the extracellular matrix and mimicking cell behavior, these injectable hydrogel scaffolds could serve as a viable alternative to surgery in the cure for Osteoarthritis. Mechanical properties of such hydrogel-based constructs are key considerations that can promote cell behavior, such as viability, proliferation, differentiation, and spreading. This project aims to quantify the bulk and microscale mechanical properties of hydrogel scaffolds used for cell culture. An Electroforce 3200 series load frame will be used to conduct compressions tests to analyze the bulk mechanical properties of the hydrogels and an atomic force microscope (AFM) will be used to study the microscale mechanical properties of the hydrogels. Bulk mechanical testing will provide the overall modulus of the scaffolds while AFM will provide insights into the local properties on the surface at a micro-scale of where cells interact with their environment. The mechanical properties of each test will be compared to the mechanical properties of our control group, articular cartilage/ meniscus which will help determine the viability of cell-laden hydrogel scaffolds with protective oxidative properties for tissue engineering applications in regenerative medicine, specifically for articular cartilage and meniscal regeneration. Our results provide useful findings to investigate the changes in mechanical properties of the cerium oxide nanoparticle hydrogels as compared to regular hydrogels.

Splice Connections for Concrete Filled Composite Plate Shear Walls

*Wyatt Alexander, Soheil Shafaei, Shivam Sharma, Amit Varma**
**PI: Lyles School of Civil Engineering*

SURF ID: 109
2:15 PM - 2:30 PM

Keywords: Composite plate shear wall, Wall to wall connection, Splice connection

Composite plate shear walls / concrete-filled (C-PSW/CFs) consist of steel plates connected by tie bars, which are filled with self-consolidating concrete (SCC). C-PSW/CFs are being used as a replacement for traditional reinforced concrete walls in high rise buildings. For construction purposes, steel modules of C-PSW/CFs are prefabricated in a shop and then transported to the site for erection. The steel modules are then connected to form a tall wall. Extensive research on the mechanical behavior of these composite walls under lateral loading (wind or seismic loading) has been conducted. However, research on splice connections needed to connect wall sections to each other are limited. The project team has been conducting research to develop, design, and test innovative bolted splice connection for C-PSW/CFs. As part of this project, small-scaled specimens of steel modules were designed, connecting steel plates with either blind bolts or threaded rods, fixed together with tie bars. A tensile load was then applied to a beam welded to the specimen, applying a shear force onto the connection between the plates. The load was increased until connection failure, and data from displacement transducers (DTs), string potentiometers (SPs), and strain gages (SGs) was gathered. The shear capacity of different connections and connection patterns was assessed. The ultimate strength of the specimens was calculated and compared with the experimental results. This paper will focus on the overall methodology, and summarize the results of a couple of the tests conducted at Bowen Laboratory.

Raloxifene's Effects on Bone Hydration and Microstructure

SURF ID: 254
2:30 PM - 2:45 PM

*Lucy Wagner, Elizabeth Montagnino, John Howarter**
**PI: School of Materials Engineering*

Keywords: Osteoporosis, Raloxifene, bone hydration, thermogravimetric analysis, Fourier transform infrared spectroscopy

Osteoporosis, a disease that results in weak and brittle bone, affects approximately 44 million Americans. A common pharmaceutical treatment for osteoporosis, Raloxifene HCl, is a selective estrogen receptor modulator (SERM), predominantly prescribed to postmenopausal women, to increase bone mineral density (BMD). Earlier studies have found that Raloxifene may have mechanisms, in addition to its role as a SERM, that influences the current hydration state of the bone and therefore mechanical properties. The microstructure of bone can be altered with hydration by modifying free or bound water, which is either bound to the collagen, between the collagen-mineral interface or structurally bound within the hydroxyapatite mineral. Fourier-transform infrared spectroscopy (FTIR) and thermogravimetric analysis (TGA) were used to investigate the ex vivo effects of raloxifene on bone hydration and microstructure. FTIR gave insight into the ability of bone to take in the raloxifene treatment. TGA assessed the decomposition of the bone in response to exposure of high temperatures (25-800°C), as a function of mass. Free water was released at temperatures between 150-300°C and the organic matrix decomposed between 300-700°C, while the final mass at 800°C is representative of the mineral content. Water content was shown to be between 10 to 15 weight percent, the organic matrix between 20 to 25 weight percent and the mineral composition is around 60 to 70 weight percent. These results reveal the possibility of Raloxifene to have effect on bone hydration and microstructure, thus providing a foundation for future experimentation.

Contamination and Decontamination of Plastic Components in Plumbing Systems: Lessons on Addressing Hydrocarbon Contamination in Plumbing

SURF ID: 183
2:45 PM - 3:00 PM

*Halley Le[1], Kristofer Isaacson, Andrew Whelton**
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Keywords: Drinking water, contamination, decontamination, petroleum, plastic, plumbing

Chemical spill accidents and wildfires can prompt hydrocarbon contaminants to enter community water supplies and infrastructure and reach customer buildings, where plastic plumbing components are likely vulnerable to contamination. Drinking water contaminants can be found inside buildings for over 9 months after contamination occurred; however, little data exist regarding the presence of volatile and semi-volatile organic compounds (VOCs and SVOCs) in plumbing. Using petroleum as a source of contamination, this study aimed to characterize the fate of VOC and SVOC contaminants in plumbing systems involving multiple plastic materials. To conduct this project, plastic plumbing components were inventoried, and petroleum-contamination and decontamination practices were applied on selected materials. Following an initial 24-hour contamination period, water samples were taken at three consecutive periods of 72 hours. Water samples were characterized for VOC, SVOC, and total organic carbon (TOC) concentrations. Results will (1) quantify contaminants that leached from plastic components after contaminated water has been removed, (2) indicate which materials were most susceptible to contamination, and (3) provide insight into whether VOC, SVOC, and TOC concentration could act as indicators of contamination. Study results can help inform guidelines for responding to potential plumbing contamination incidents.

Floor-to-SpeedCore Wall Connections Under Fire Loading

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**PI: Lyles School of Civil Engineering*

SURF ID: 223
3:00 PM - 3:15 PM

A SpeedCore wall is a concrete filled composite plate shear wall that is made by connecting prefabricated steel modules. These modules consist of two steel plates connected by steel tie rods that are spaced in a square grid pattern. After the modules are assembled, they are filled with concrete. The structural integrity of the sections prior to being filled with concrete allows for faster construction in building applications such as mixed-use skyscrapers. However, there exists a gap in knowledge regarding the strength of simple connections to these SpeedCore walls in the event of a fire. This simple connection refers to a steel plate welded to the wall for the purpose of attaching an I-beam floor girder/beam. The authors designed a set of test specimens that have different variations of simple connections. A series of test scenarios were developed. The test scenarios apply tensile and/or compressive forces on a simply connected I-beam under fire loading. Fire loading is applied using ceramic heating components. These tests will lead to the collection of data which will enable safer calculations of load capacities and fire ratings for connections within structures that employ SpeedCore wall technologies. In preparation for this research, preliminary tests were conducted on an SpeedCore specimen to validate the test setup for future tests regarding connections to SpeedCore walls.

Keywords: SpeedCore wall, Shear tab connections, Simple connections, Concrete, Steel, Tie rods, Fire loading

Track D: Human Factors Engineering 2 (WALC 2127)

Autonomous Vehicles for People with Disabilities: A Survey Study to Assess Future Transportation Needs and Preferences

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**PI: School of Industrial Engineering*

SURF ID: 147
2:00 PM - 2:15 PM

People with travel-limiting disabilities often experience significant difficulties using personal and private models of transportation. Autonomous vehicles (AVs) promise to make travel more accessible and seamless for people with disabilities (PwDs). But this vision can only be realized if PwDs are part of the AV design process. The Efficient, Accessible, and Safe Interaction in a Real Integrated Design Environment for Riders with disabilities (EASI RIDER) project has proposed a practical AV solution. To aid in the design of particular EASI RIDER features, we developed and administered a nationwide survey to assess the needs and preferences of individuals with mobility impairments regarding AVs. In total, 144 responses were received. Responses were divided based on age, the current mode of transportation, and travel frequency and were used to determine differences among groups. Preliminary analysis suggests that, for vehicle safety, individuals who travel less frequently feel more unsafe about using AVs compared to those who travel more often. In addition, older PwDs, and those who use private vehicles, report feeling safe using AVs.

Keywords: Autonomous Vehicles, People with Disabilities, Driverless Vehicles, Accessibility, Inclusive Design

Immersive Augmented Reality (AR) Toy System with Multi-User Capability

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SURF ID: 164
2:15 PM - 2:30 PM

Augmented reality (AR), which has the opportunity to connect the physical and virtual worlds presents the possibility of enhancing traditional toy design. A handful of AR-enhanced toys have recently emerged exploiting the symbiosis relationship between virtual-physical interactions. However, these toys bring engagement at the individual level while the development of multi-player capability remains exploited. To fill this gap, we contribute to the design of collaborative toy games enhanced by augmented reality. Our focus is to synchronize and align the real-time position of virtual content across multiple AR devices. We further validate our design with the demonstration of several use cases. Finally, we present insights around the future design of collaborative toy game experience empowered by AR technology.

Keywords: Augmented reality, IoT toolkit, Multi-user capabilities, Real-time synchronization

Interactive Synthesis of VR Fire Evacuation Training Scenarios

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SURF ID: 165
2:30 PM - 2:45 PM

Keywords: Training, Firefighters, environments, modifications, adaptability, UI, Human-Computer Interaction, VR/AR.

Training is a process that is necessary but also hard to set up as it is expensive and time-consuming, so there is a latent need to create virtual environments that facilitate and improve training scenarios. For that reason, virtual reality is an opportunity to reduce costs for companies in terms of money, time, and preparation. There are multiple scenarios where virtual training has covered the development of various sets of skills. Training firefighters are among the most common ones, where virtual environments prepare firefighters with essential skills such as environmental awareness, context analysis, fast response, and fire containment. Therefore, the diversity of environments became important as firefighters learned through various situations. This creates an opportunity where only technology can provide such variety at an affordable price. This project uses a user interface (UI) that fulfills this need of diverse environments. It allows modification in an accessible way without requiring high-end computer hardware. So, any trainer can create different training scenarios regarding the skills necessary. The project aims to create a UI that allows modifications of environments intuitively, so coaches can use it to improve training for the firefighters. As a result, trainees for firefighters will be trained in different scenarios and sharpened in fast response skills.

An Empirical Study of Trust & Safety Risk Management in Social Media Platforms

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SURF ID: 188
2:45 PM - 3:00 PM

Keywords: Social media platforms (SMPs), Trust & Safety (T&S), open-source software (OSS) SMPs.

Social media platforms (SMPs) have been widely used in recent years. Along with the ubiquity of SMPs, there are increasing Trust & Safety (T&S) risks that expose users to fraud, spams, abuses, and other harmful contents online. However, the lack of T&S risk management studies leads to an inefficient approach managing T&S issues. The goal of our study is to gain more insights into how software engineers are currently managing T&S risks in SMPs. To evaluate T&S risks, we examined two distinct sources of data: Trust & Safety Professional Association (TSPA) case studies and open-source software (OSS) SMP issue discussion analysis. First, we read through TSPA case studies and analyzed each T&S failure in SMPs to see how T&S issues were handled in practice. Second, to find more about engineers' decisions, we went through GitHub discussions on two OSS SMPs, filtered out non-T&S issues, and used closed coding with existing argumentation models and frameworks. We defined the types, results, risk effects for each issue to get a more detailed analysis. Through these two studies, we found from TSPA case studies that moderation failure happened most frequently, followed by policy failure and design & implementation failure. The GitHub discussions showed that the arguments in the decision-making process were mostly hypothetical. Although the final decisions are not factual-based, users have no choices but bear with its impacts. A preliminary conclusion from the analysis indicates that the process of managing T&S risks is difficult and still rudimentary.

Workflows Within Robotic-Assisted Surgeries Operating Rooms

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**PI: School of Industrial Engineering*

SURF ID: 239
3:00 PM - 3:15 PM

Keywords: Robotic-assisted surgery, workflow, surgical practice

Due to the growing advancements in robotic technologies for surgical procedures, surgical teams in operating rooms (OR) are rapidly evolving. The arrangement of these robotic technologies within the OR adds an extra layer of complexity to their successful integration into surgical procedures. Additionally, in robotic-assisted surgery (RAS), the surgeon sits behind a console and teleoperates the robot away from the surgical field and members of the surgical team. Consequently, these have implications for workflows within the OR. Hence, there is a need to analyze the current OR layout and personnel workflows during RAS. Position and motion data of key OR personnel and objects were collected in five live RAS procedures using Pozyx© sensors. The data was analyzed to calculate metrics such as distance traveled per personnel, areas of concentration, and surgeon's proximity to key OR equipment and personnel. The surgeon's proximity metric was binned based on separation distances, and statistical values were calculated per bin. Findings show that congested zones in the OR include the sterile zone where the patient bed, surgical table, supply tray, robot tower, and robot are situated. In addition, the surgeon and scrub nurse spend approximately 32% and 89% of the procedure in the sterile zone. Finally, on average, the surgeon spends at least 5% of the surgical procedure teleoperating the robot in the console zone. Based on these findings, we recommend prioritizing the decongestion of zones with higher traffic and leveraging Human Factors principles to improve communication and teamwork between the surgeon and surgical team.

Track E: Machine Learning 2 (WALC B058)

Physics-informed Machine Learning to Predict Extreme Weather Events

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SURF ID: 215
2:00 PM - 2:15 PM

Keywords: Extreme weather events, convolutional neural network, atmospheric sciences

Extreme weather events refer to abnormal, non-seasonal, and large-scale climate phenomena that lead to severe consequences. Although large-scale extreme weather events, such as extreme heatwaves and cold spells, may not seem as exotic as smaller-scale events like thunderstorms or tornadoes, they pose serious threats to people's lives. Despite the prominent threats that extreme weather events pose to society, it is challenging to reliably forecast these events due to the chaotic nature of the atmospheric physical dynamics. Therefore, it is imperative to develop a better understanding of the atmospheric patterns and physical causes of large-scale extreme events to improve the predictability of such events. We propose an interdisciplinary approach between Machine Learning and Atmospheric Sciences. Specifically, we first train the convolutional neural network on a big dataset of two-layer quasi-geostrophic model, a fundamental atmospheric model, to predict atmospheric blocking events up to 10 days ahead. Next, we apply feature tracking algorithms to interpret the neural network's decisions and highlight spatial patterns that are highly correlated with blocking events. We show the high prediction accuracy of the neural network in predicting extreme events with different lead time periods (from 1 to 10 days) and show the most remarkable regions outputted by the feature tracking algorithm. Based on the experimental results, we conclude that convolutional neural networks are very efficient in capturing complex spatial atmospheric patterns and can effectively highlight those patterns for future study of the physical properties of extreme weather events, which is vital for improving the predictability of such events.

A State-Based Approach to Model General Aviation Accidents Using Narratives

SURF ID: 271
2:15 PM - 2:30 PM

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Inflight loss of control (LOC-I) is a significant cause of General Aviation (GA) fixed-wing aircraft accidents. The National Transportation Safety Board (NTSB) records all aviation accidents in its database. Previous studies focused on investigating relative frequencies of accident causes and the top causes, but did not provide much insight into how LOC-I accidents happen. The state-based approach found more insights into LOC-I causation by modeling accidents as sets of states and triggers based on the findings recorded in the NTSB reports. However, not all information mentioned in the accident narratives is translated as findings. We expand the state-based approach by using accident narratives and findings in the accident reports. We use a natural language processing (NLP) model to identify additional states and triggers from accident narratives. Preliminary analysis with the DistilBERT, NLP model shows potential for discovering states and triggers from narratives. However, fine-tuning the model with 90 manually labeled accidents with 307 states and triggers suggests that more high-quality data and model configuration are needed to achieve an accuracy of over 90%. The findings from this study may provide a more complete understanding of LOC-I accident causation as compared to previous analyses.

Keywords: General aviation, accident modeling, loss of control, machine learning, natural language processing

Automatic Program Repair for Java Security Bugs

SURF ID: 133
2:30 PM - 2:45 PM

*Jordan Davis, Yi Wu, Lin Tan**
**PI: Department of Computer Science*

One of the most difficult and time-consuming tasks a programmer performs is fixing bugs, among which security bugs, a bug that causes a vulnerability that can be exploited, are particularly dangerous and often hard to fix. This project seeks to answer the question of if and how existing large language models as well as current learning-based models can fix java security bugs. In this project a variety of java security bugs were taken from real world projects and databases before being compiled into a dataset. Afterwards the dataset had static analysis tools applied to each bug. Then, the dataset as well as the information gathered by the static analysis tools is used as input to large language models and current learning-based models. Additionally, the models will be fine-tuned with specific training data as well as prompt engineering. The results of both the large language model and current automatic program repair models will then be analyzed and compared. If there is a significant improvement to both the accuracy and quantity of bugs successfully fixed this could lead to a change in how these models and techniques are engineered, trained, and used.

Keywords: Program repair, java, security, bugs, language models, prompt engineering, vulnerability

Secured and Protected: Designing a TinyML Device Enclosure

SURF ID: 171
2:45 PM - 3:00 PM

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With the rise of TinyML implementation in manufacturing settings, these embedded systems will need to be secured and protected within a proper and durable enclosure. The search for proper enclosures for TinyML devices is vast as the concept of Tiny Machine Learning is relatively new. With these devices incorporating onboard sensors such as a camera, a microphone, an accelerometer, etc., the enclosure must include a way for those features to be accessible. In this work, an enclosure for the Nicla Vision was made by 3D printing using polyethylene terephthalate glycol which allowed the design to be more robust. The Nicla Vision enclosure with the device inside is tested to acquire an image dataset of printed carbon electrodes. These carbon electrodes have an active and unactive region. The Nicla Vision captured roughly 200 images of both regions separately. With the data collected and labeled, the training process and then the testing process for the machine learning model began. The model used 80% of the images captured to train itself and 20% of the images captured to test itself. With the model's testing process completed, the trained model was deployed back to the Nicla Vision device. The results gathered show how the enclosure created benefits the device and how the trained TinyML device can detect the different regions of the carbon electrode accurately. This study will elaborate on the details and design of the 3D printed enclosure and clarify the process of machine learning.

Keywords: TinyML, enclosure, 3D printing, image dataset, Nicla Vision

Conditional Synthetic Food Image Generation

SURF ID: 144
3:00 PM - 3:15 PM

*Wenjin Fu[1], Yue Han, Sriram Baireddy, Jiangpeng He, Mridul Gupta, Fengqing Zhu**
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Keywords: Deep learning, Generative Adversarial Networks, Conditional Image Synthesis, Food Image Generation

Generative Adversarial Networks (GAN) have been widely studied thanks to their powerful representation learning in image synthesis. In this work, we explore different GAN architectures for the application of synthetic food image generation. Despite the impressive performance of GAN for natural image generation, synthesized food images contain severe visual artifacts, and quality tends to be very poor. Therefore, we aim to explore the capability of state-of-the-art image generation methods and improve their performance in synthetic food image generation. We first analyze the experimental process and results of the off-the-shelf synthetic image generation technique (e.g., StyleGAN) as the baseline. Then, we identify two problems during training: inter-class feature entanglement during training of multiple food classes and loss of high-resolution details while downsampling the original image to meet the required image resolution. To address these issues, we train one food category at a time to resolve the feature entanglement problem and train on image patches cropped from original high-resolution datasets to retain discarded fine details during data preprocessing. With improved methods, the food images we generated are more realistic and detailed than the results from the baseline. We implement conditional image generation on the baseline, analyze its advantages and drawbacks, and evaluate the results with our improved method. Our proposed conditional image generation may contribute directly to the food image analysis because such generative data augmentation method could be used to expand training samples and improve the performance of the food classification.

Automatic Program Repair Method Coverage and Comparing Language Models

SURF ID: 277
3:15 PM - 3:30 PM

*James Zhu, Nan Jiang, Lin Tan**
**PI: Department of Computer Science*

Keywords: Automatic program repair, language models, deep learning

The ability to write correct programs is more important than ever. However, as any programmer should understand, programming can be difficult. More significantly, the debugging part of writing a program is time consuming, especially for less experienced programmers. We sought to investigate ways to help programmers in debugging and writing better code by having deep learning assist our software development. Our team has developed Automatic Program Repair (APR) tools and projects in the area of deep learning for software. One of our previous works is an Abstract Syntax Tree (AST) based APR tool. We are also interested in evaluating other language models pre-trained on code and compare them with APR. It would be meaningful to evaluate the performance of these different models and approaches. We created and optimized a grammar dictionary parsing Python AST file by the AST tokens and nodes, in which case model training could begin. We also tested different language models on a range of tests, and we evaluate the performances of these language models versus our APR. This evaluation extends our previously developed APR tool to see its comprehensiveness, while also getting a comparison of how effective our APR tool stand against many language models in fixing bugs.

Track F: Biological Signaling, Simulation & Technology 1 (WALC B066)

Evaluation of Cytotoxicity Sources for a Novel Tendon to Bone Healing Model for Tendon Tissue Engineered Approaches

SURF ID: 141
2:00 PM - 2:15 PM

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Keywords: Tendon tissue engineering, enthesis, demineralized porcine bone matrix, electrospun scaffolds

300,000 rotator cuff repair surgeries are performed per year, with a high overall retear rate. The connection between tendon and bone, the enthesis, is the most common area where tears occur in the rotator cuff. The enthesis is a challenge to heal due to its complex composition and lack of regeneration. Therefore, tendon tissue engineering has been used to try and improve outcomes for this tendon to bone connection. Previous in-vitro pilot studies to model regeneration of the enthesis region using electrospun synthetic scaffolds and demineralized porcine bone matrix to simulate tendon and bone respectively showed promising results. However, in more recent studies after 28 days of seeding stem cells in tenogenic conditions, the cells were not able to survive. This study tested separately the different parts of the model to determine sources of cytotoxicity. Collagen alignment, collagen and sulfated glycosaminoglycan (sGAG) deposition, hydroxyapatite content, and DNA content were analyzed 14 days after cell seeding to determine the differences between sections of the construct. pH of media was evaluated over the cell culture period to analyze possible residues from construct preparation leading to non-physiologic pH and culture. Collagen alignment, collagen and sGAG deposition, and hydroxyapatite content were used to quantify tendon and bone-like extracellular matrix deposition expected from cell differentiation. DNA content was measured to determine cell proliferation. These results will allow for the identification of the cytotoxic source, and how this model can be improved for future studies.

Making Simulated Patterns Look Real: Image Processing for Zebrafish

SURF ID: 155
2:15 PM - 2:30 PM

*Caroline Henson, Alexandria Volkening**
**PI: Department of Mathematics*

Keywords: Zebrafish, simulated images, post-processing software, patterns, pattern formation

Zebrafish (*Danio rerio*), named after the striped patterns that form along their body, are small fish with important biomedical applications. Zebrafish patterns are comprised of pigment cells. One type of pigment cell, melanophores, is closely related to skin cancer cells in humans. Due to the small size of these fish (less than 3cm in length), understanding how cells interact and develop to form patterns is a challenging endeavor. While there are mathematical models that describe pattern development, images of these simulations do not achieve the variety in cell size or color seen in real fish. The goal of my research is to develop post-processing software to make simulated zebrafish patterns look akin to live fish. By viewing a large number of zebrafish images, I am analyzing their cell colors and shapes. Based on the mathematical model data, I build realistic simulated fish patterns by reconstructing small portions of cells in real zebrafish. Additional filters are then overlaid onto the simulated image to replicate the glossiness and form of live fish. Our software produces more convincing images of zebrafish and has potential applications in future zebrafish study.

Modeling of Cell Membrane Pore Dynamics for Nonideal Electric Pulse Waveforms

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SURF ID: 263
2:30 PM - 2:45 PM

Electroporation occurs in cells when an applied electric pulse (EP) induces a transmembrane potential above a threshold to cause an increase in the plasma membrane conductivity. Many experiments, mathematical models based on the Smoluchowski equation (SME), and molecular dynamics simulations have examined the phenomena responsible for this behavior for idealized rectangular, trapezoidal waveforms, sinusoidal, and exponential waveforms. In practical experiments, the applied waveforms differ from these idealized shapes, as increases in cellular conductivity create an electrical mismatch between the impedance of the cell suspension and the pulse generator. For the Blumlein generators often used for nanosecond EP delivery, these mismatches can create a train of degenerate pulses following the initial pulse. The effect of these degenerate pulse trains on overall electroporation efficiency is poorly understood. This study examines this behavior by applying an asymptotic Smoluchowski equation (SME) to model membrane pore dynamics for a cell exposed to pulse trains characteristic of a mismatched Blumlein transmission line. We have shown that in general, the intensity of the initial square pulse has the greatest effect on the degree of electroporation. Our simulations also show that the residual pulse train for longer-duration, lower intensity (300ns, 20kV/cm) nanosecond EPs (NSEPs) do not induce additional poration, while shorter duration, more intense NSEPs (10ns, 80kV/cm) induce secondary pulses that can enhance electroporation.

Keywords:
Electroporation, pulsed power, bioelectrics, numerical methods

Towards the Development of Novel Catheter-integrated Thin-film Microelectrodes for Deep Brain Stimulation

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**PI: Weldon School of Biomedical Engineering*

SURF ID: 127
2:45 PM - 3:00 PM

Deep brain stimulation (DBS) is an electrical procedure commonly used to treat movement disorders including Parkinson's disease (PD), dystonia, and tremor. In recent years, DBS technologies have also shown potential to be effective in the treatment of various neuropsychiatric disorders such as treatment-resistant depression (TRD), obsessive-compulsive disorder (OCD), and Alzheimer's dementia (AD). Implanted in the brain, DBS electrodes deliver electric impulses from the implantable pulse generator (IPG) to target neural substrates via stimulating electrodes. However, only a few commercially available DBS devices exist with limited functionalities. Those available are often bulky, inflexible, and provide insufficient data for closed-loop stimulation. These limitations can result in inefficient stimulation and poor selectivity which ultimately leads to an off-target effect. In this work, we seek to develop novel highly compliant DBS leads by integrating ultra-flexible thin-film microelectrodes onto existing ventricular silicone catheters used for the treatment of other neurological disorders. Integrating these thin-film electrodes on existing catheters provides easy and more compliant access to different parts of the brain. Moreover, it can provide additional flexibility in deploying different therapy and diagnosis tools via the catheter. The new integrated DBS lead will be better localized and immobilized to prevent migration during and after implantation using a bio-adhesive. We plan to construct and package a model DBS device with a surface coating procedure and characterize device performance in vitro via cyclic voltammetry, electrochemical impedance spectroscopy, accelerated aging, and voltage transient response. These experiments will demonstrate in vitro device performance for future refinement.

Keywords: Deep brain stimulation, hydrogel bioadhesive, thin-film electrodes, implantable devices

On-field Detection Method for Bovine Respiratory Disease

SURF ID: 170
3:00 PM - 3:15 PM

*Ashley D. Kayabasi, Ishaan Rath, Ilan Y. Benschikovski, Abdullah Bayram, Jiangshan Wang, Simerdeep Kaur, Naseem Abbas, Mohit S. Verma**
**PI: Department of Agricultural and Biological Engineering*

Keywords: Bovine respiratory disease, colorimetric loop-mediated isothermal amplification, paper-based biosensor, cattle nasal microbiome

Bovine respiratory disease (BRD) is a complex of respiratory illnesses in North American beef cattle feedlots that leads to a decline in meat quality and economic loss to the US beef industry. Currently, there are multiple detection methods utilized to diagnose BRD pathogens, but many lack in on-field feasibility, accuracy, and time. Therefore, we sought to fabricate an accurate, quick, and easily reproducible method of BRD pathogen detection for on-farm applications. A heating and imaging water bath device was prototyped to implement for a low-cost, user-friendly, paper-based biosensor based on the principles of uniform heating and temperature regulation at 65 degrees Celsius. This device is compact, generates measurable heat in real time, is efficiently powered, and reaches the temperature requirement in under 20 minutes. Samples were prepped for a colorimetric loop-mediated isothermal amplification (LAMP) assay to ultimately amplify the DNA of the BRD pathogens in the cattle nasal microbiome. The samples were then placed inside the device for 60 minutes and imaged for a pH color change from red to yellow, indicating that the bacterial DNA for the BRD pathogen was present. This study demonstrates the ability to swab the nasal cavity of cattle suspected of having BRD and to utilize this sample in the device to create the optimal environment for DNA amplification while remaining on the farm. Using these on-field results, an effective plan can be made, specifically in choosing the antibiotic of best-fit that will better impact the cattle, the farmer, and the US beef industry.

Molecular Dynamics Simulations for Paclitaxel-2E' Filament Assembly

SURF ID: 230
3:15 PM - 3:30 PM

*Trevor Sargent, Jianping Wang, Yoon Yeo**
**PI: Department of Industrial and Physical Pharmacy*

Keywords: Molecular dynamics, filamentous assembly, nanoparticle, VMD, NAMD

Nanoparticles, defined as a particle of matter that is between 1 and 100 nanometers (nm) in diameter, have been widely explored in many diseases such as cancer. Paclitaxel (PTX) is an anti-cancer chemotherapeutic drug. 2E' is a newly engineered polymer that can help deliver hydrophobic drugs. PTX can be encapsulated in 2E' and initially form 2E'/PTX spherical micelles. After aging, the spherical micelles will transform into filamentous assembly nanoparticles. Molecular dynamics (MD) simulation is used to study the theoretical interaction between particles over a set timeframe. In this case, its application is to understand the possible mechanism of the filamentous assembly of 2E'/PTX at the atomic scale. MD packages such as NAMD and GROMACS have been used in MD simulation. VMD is a package which will be used for the result analysis, both as a motion capture of the simulation, and how the energy is optimized as the simulation progresses. The aim of this study is to use MD to provide a theoretical mechanism for 2E'/PTX filamentous assembly, and increase their effectiveness against a number of diseases. To date, the project has not been completed yet. The necessary input files for NAMD simulation, including .pdb and .psf files for both PTX and 2E', as well as a solvation box, have been created using psfgen in VMD and the Packmol package. Further simulation will be performed in NAMD in Cluster in the future.

Track G: Nanotechnology 2 (WALC 3084)

Tri-phase Photonic Crystal Emitter for Thermophotovoltaics

*Vidisha Singhal, Jie Zhu, Peter Bermel**
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SURF ID: 235
2:00 PM - 2:15 PM

Keywords:
Thermophotovoltaic, Selective Emitter, Photonic Crystal, Tri-phase

Nearly half of the energy released by fossil fuel plants is dissipated as waste heat. Thermophotovoltaics (TPVs) are devices that can potentially convert such waste heat into useful electricity. The key components of a thermophotovoltaic system include a heat source, a selective emitter, and a low-bandgap photovoltaic cell. Designing a selective emitter that is spectrally matched with the PV cell's bandgap and is stable at high temperatures is critical for achieving high-efficiency systems. Photonic crystal (PhC) emitters can provide excellent spectral control, but prior experimental designs lack the thermal stability required for use with TPVs. In this study, a novel tri-phase PhC emitter design is proposed and optimized. The tri-phase design introduces an additional material in one of the alternating layers of an existing PhC structure, potentially stabilizing it at high temperatures. $BaZrO_3$ is introduced in the CeO_2 layers of a CeO_2/MgO PhC emitter. S4sim (a tool used to solve periodic multilayered structures) is used to model the emittance of 100 tri-phase PhC variations. The parameter for optimization is the spectral efficiency of the emitter which is calculated using a Python code. This study provides contour plots that inform the design of a tri-phase emitter with the optimal emission spectrum. The design with the highest spectral efficiency is only 0.02% less efficient than the original design. The design with the lowest spectral efficiency is only 0.28% less efficient. Therefore, the tri-phase design is a promising alternative to existing designs that may improve thermal stability without affecting the spectral efficiency.

Composite Electrodes from Carbon Nanotubes, Zeolitic Imidazolate Frameworks, and Molybdenum Disulfide for High-Performance Supercapacitor

*Yuhe Yuan, Jaehoon Ji, Jong Hyun Choi**
**PI: School of Mechanical Engineering*

SURF ID: 267
2:15 PM - 2:30 PM

Keywords:
Supercapacitor, energy storage, carbon nanotube

With the high demand for storing energy and the serious environmental problems brought by the rapid development of the world, the design of renewable energy storage device has become an important topic. The supercapacitor, one of the electrochemical capacitors charging or discharging ions has demonstrated high capacitance and high-power density to meet such requirements. However, despite the promising characteristics, its energy has not reached that of batteries yet. In this research, we aim to enhance the energy density by introducing a novel supercapacitor based on hybrid composites for exploiting the distinct benefits of the component materials. The supercapacitor electrode is made of carbon nanotubes (CNTs), zeolitic imidazolate frameworks (ZIFs), and molybdenum disulfide (MoS_2). Here, CNTs function as conductive networks for the electrode. These were prepared by using a solution-based sonication process. ZIFs with many pores were constructed on top of the CNT structure to boost the ion diffusion rate across the electrode. Subsequently, we deposited MoS_2 layers on the CNT-ZIF composites with a solvothermal process. The MoS_2 layer providing a large surface area may offer a large ion capacity to accumulate abundant ions. Given the excellent properties of the components, the CNT-ZIF-MoS_2 electrodes demonstrate an energy density to be about 100 Wh/kg, competing to that of ion batteries. This result suggests that our approach will be beneficial to design a high-performance supercapacitor for energy-storing applications in the future.

Simulating the Total Optomechnic Phenomena Between a Laser Source and SiN Membrane

SURF ID: 221
2:30 PM - 2:45 PM

*William D. Pavlick, Adam W. Behnke, Thomas J. Pollei, Kevin J. Webb**
**PI: Elmore Family School of Electrical and Computer Engineering*

Research and experimentation within optomechanics focus on variations of electromagnetic force density derivations and nanoscopic measurements of mechanical motion. Existing optomechanic models only consist of individual components of optical systems – electromagnetic field descriptions, electromagnetic force density descriptions, and differential equation modeling of mechanical systems – absent a unifying infrastructure for modeling optical phenomena from source to the ultimate mechanical response of the system. The presented model combines known techniques for decomposing electromagnetic fields in space due to generic sources such as lasers, developed theories of force densities due to electromagnetics, and ultimately the spatial responses of a solid, thin membrane due to a forcing function. To mimic existing experimental components, the system incorporated a laser source, free space propagation of electromagnetic waves, interactions between media, the generation of electromagnetic force, and the response of a forcing function to a mechanical system. Planewave decomposition techniques were used to simulate the existing electromagnetic fields within various media due to a Gaussian beam. Electromagnetic force density models, developed by Einstein, Laub, and Lorentz, were used were used as a basis for modeling electromagnetic forces. Three-dimensional differential equation solutions were used to determine the mechanical response of a membrane system due to a two-dimensional forcing function. The developed combination of all of the individual components has yet to be directly compared to experimental results. Results of the performance of individual components showcase appropriate adherence to electromagnetic and mechanical phenomena.

Keywords: Optomechanics, electromagnetics, force density, Gaussian beams, waves, thin membrane

Automatic Data Collection of Projection Two-Photon Lithography for Machine Learning

SURF ID: 216
2:45 PM - 3:00 PM

*Gavin Noel, Jason E. Johnson, Paul Somers, Xianfan Xu**
**PI: School of Mechanical Engineering*

Two-photon lithography is an additive manufacturing technique capable of producing structures with nanoscale resolution. The accuracy of two-photon polymerization can be limited by shrinkage as well as a loss of features due to optical limitations of the set-up. Previous studies have proven the viability of machine learning in additive manufacturing. Large data sets are needed to properly train neural networks, which can limit the effectiveness of machine learning techniques. In this study a novel additive manufacturing process, projection two-photon lithography, is automated to collect large data sets for estimating inaccuracies which will be used to develop machine learning techniques. A transmission illumination system allows for high resolution imaging of the printed structures. Randomly distributed data is generated through random variations of patterns based on simple geometric shapes printed at various exposure times. The automation of the printing process reduced time spent on prints by up to 94% and allowed for 683 data points to be collected per hour.

Keywords: Two-photon polymerization, additive manufacturing, machine learning

Clean and Controllable Site-Specific Transfer of Monolayer Graphene

*Chih-Yi "Jane" Chen, Thomas E. Beechem**
**PI: School of Mechanical Engineering*

SURF ID: 128
3:00 PM - 3:15 PM

Keywords: Graphene, transfer, site-specific, controllable

Graphene has been studied with great interest for its potential applications in next-generation electronic and optical devices. Despite this, no method currently exists to reliably transfer graphene from its conductive growth substrate to a desired substrate in a repeatable, precise, and clean way. Site-specific methods of transferring graphene must be further investigated. In this study we report a dry transfer approach—that is, one without the use of toxic chemicals—with high coverage comparable to traditional wet transfer techniques, and yet have the cleanliness and scalability characteristic of dry transfer methods. The approach employs three key components: controlled transfer to enable optimization of contact mechanics, thermal release tape to adjust adhesion forces, and oxidation of copper samples to promote graphene release. Varying thermal tape adhesion and contact mechanics resulted in clean transfer with up to 90% coverage, as verified by Raman spectroscopy. However, these parameters had no systematic effect on graphene's undesirable yet consistent presentation in the form of flakes. For this reason, oxidation effects were investigated: copper samples were oxidized at durations ranging between 0 and 48 hours. Scanning electron microscopy imaging demonstrated that oxidation of copper yielded systematic effects on the morphology—and likely the transfer behavior—of graphene. The link between oxidation and transfer has important implications for future developments in effective graphene transfer and informs future work on graphene-based next-generation devices.

Track H: Material Processing and Characterization (WALC B093)

Soft Dielectrics with Microgels for 3D Printing of Electrically Driven Artificial Muscles

*V. Khoi Pham Khac , Michael M. Sotzing, Alex Chortos**
**PI: School of Mechanical Engineering*

SURF ID: 222
2:00 PM - 2:15 PM

Keywords: Dielectric elastomers, microgel, 3D printing, soft actuators

Dielectric elastomers actuators (DEAs) are strong candidates for soft actuators due to their fast quick reactions, lightweight, and long lifetimes. To use DEAs for applications such as human-scale arrays of actuators, we pursue scalable and versatile fabrication in the form of 3D printing. Therefore, this project focused on the use of microgel material, which provides a higher rheological characteristic while maintaining its dielectric ability. The dielectric elastomer layers were manufactured using a microgel combination of a silicone base (DMS-V31), a crosslinker (HMS-053), and silicone powder (KMP-579), cured through platinum-catalyzed hydrosilylation. This material exhibits a higher viscosity, which is more suitable for 3D printing while maintaining a high electric field breakdown and a minimized Young's modulus resulting in a high actuation strain limit. Electrodes are composed of a silicone base, crosslinker, and conductive filler. Throughout various tests, the microgel was determined to have a suitable electric breakdown field with a high strain actuation limit compared to commercially available products such as the Sylgard® 184 or Ecoflex. From the results found in this project, the microgel elastomer has proven to be a great candidate for the DEAs' dielectric layer, which would be suitable for the 3D printed soft actuator.

Linking Flow Behavior to 3D Printability in Highly Loaded Polymer-Ceramic Suspensions

*Yuan-Jung (Vineeta) Chen, Ria D. Corder, Kendra A. Erk**
**PI: School of Materials Engineering*

SURF ID: 126
2:15 PM - 2:30 PM

Keywords: Rheology, direct-ink-writing, polymer-ceramic suspensions, shear-thinning

With broad applications in fields from electronics to orthopedics, ceramic materials are valued for their high thermal conductivity and mechanical strength. The addition of polymers to suspensions of ceramic particles (thus forming polymer-ceramic suspensions), enables adjustment of flow properties such as viscosity and yield stress. The 3D printing of these suspensions has potential to reduce material waste and produce complex designs, but print defects often result. These defects can be caused by a suboptimal choice of suspension—one with too high or low viscosity—thus printing objects that cannot hold their ideal shape. This study aims to inform and improve the 3D printing of ceramic suspensions by addressing suspension composition to streamline the printing process and minimize waste. To characterize flow behavior, we ran tests on a rheometer for water-based suspensions containing varied polymer (polyvinylpyrrolidone) volume fractions and molecular weights while keeping the volume fraction of ceramic (alumina) particles constant. The same suspensions were then printed with direct-ink-writing (DIW), a type of 3D printing, to observe the final print quality. We compared data gathered from rheometer tests with respective prints to identify predictive flow parameters and determined optimal suspension composition(s) for direct-ink-writing. We also identified compositions that were printable despite observed shear-thickening behavior—a dramatic jump in viscosity with increasing shear rate—due to this occurring at shear rates above that of extrusion. These results suggest that improvements in DIW can improve printing accuracy, and future research can apply lessons from this combination of materials to other printable polymer-ceramic suspensions.

Modular Extrusion System Design for Additive Manufacturing

*Alonso J. Manzueta, Fabian B. Rodriguez, Yu Wang, Jan Olek**
**PI: Lyles School of Civil Engineering*

SURF ID: 199
2:30 PM - 2:45 PM

Keywords: Additive manufacturing, concrete construction, mechanical engineering, extrusion, pumping

Additive manufacturing, also known as three-dimensional printing of concrete (3DPC) is a promising technology with the potential to become the future of the construction of civil infrastructure. It is a technique with high efficiency, low labor cost, and lower waste generation compared to more traditional methods of building concrete structures. However, most of the current academic research has been focused on material and process development, while little attention is put to show the development of the appropriate equipment for 3D-printing systems. For this reason, there are little to no publications regarding the design of extruder and pump systems for a reliable 3D printing process. Using computer-aided design (CAD) software like Solidworks and various manufacturing techniques, we take a closer look into the widely accepted extruder and pumping systems. After dozens of prints and tests, the drawbacks and advantages of the systems were analyzed and documented. It was found that with the current extrusion and printing system we could not maintain structural rigidity for many complex prints. Also, we are constrained by the viscosity of the concrete that the extrusion system is able to process and deposit. With prior research and this data from printing sessions, we propose a modular design that is adaptable to different materials and structures that could be used when printing. With this design of an extruder and pumping system, we will be able to print structures that are applicable for a wide range of applications. The 3DPC has the potential to revolutionize the construction industry by drastically lowering the cost of various projects and applications.

Layer-to-Layer Interaction during Dehydration in Drop-on-Demand Inkjet Printed Hydrogels

SURF ID: 108
2:45 PM - 3:00 PM

*Karla Maureen Alemán Alicea[1], Cih Cheng, Bumsoo Han, George Chiu**
*[1]Universidad de Puerto Rico *PI: School of Mechanical Engineering*

Keywords: Particle distribution, 3D printing, hydrogel

The use of hydrogels has increased in recent years in biomedical applications, such as tissue engineering, drug delivery, and cell culture. These water-swollen materials often are embedded with small molecules or particles to add functionality. Recently, studies of various additive manufacturing approaches have demonstrated their potential to customize hydrogel structures and geometries. Among them, drop-on-demand (DOD) inkjet printing has been shown to be capable of creating hydrogel structures with spatially controlled functional properties and compositions by controlling the deposition geometry, timing, and the associated dehydration rate. Previous studies have investigated the particle distribution of printed polymer drops, but these are limited by observing the interstitial flow and interactions of nanoparticles in a single layer of hydrogel during dehydration. However, as more complex structures require printing of multiple layers, understanding functional particle distribution at the layer-to-layer intersection is needed to determine the appropriate printing process parameters and the associated dehydration profiles, ensuring desired spatial distribution of nanoparticles to achieve functionality. The objective of this project is to investigate and validate an experimental method to study layer-to-layer interaction during dehydration of nanoparticles in DOD inkjet printed hydrogels. A single layer of hydrogels is first printed and dehydrated. A single drop of nanoparticle-embedded hydrogel is then deposited onto the dehydrated layer. The movements of the nanoparticles before and after dehydration will be measured from images and data captured by an optical profilometer. The 3D distribution of the nanoparticles should be able to validate the working hypothesis. Experimental data will be presented to demonstrate the validity of the proposed method.

An Investigation of Microstructure-Property-Processing Relationships in Concentrated Surfactant Solutions

SURF ID: 137
3:00 PM - 3:15 PM

*Katherine G. Eisenman[1], Parth Kelkar, Kendra Erk**
*[1]Carnegie Mellon University *PI: School of Materials Engineering*

Keywords: Anionic surfactants, concentrated surfactants, rheology, evaporation, microstructure, sodium laureth sulfate

Sodium laureth sulfate (SLES) is a widely used surfactant in soaps, shampoos, and household products. Companies wish to produce more concentrated products for environmental benefits, but there is a lack of knowledge of the structure-properties-processing relationship in concentrated solutions of SLES. This study investigated the rheological profile and microstructural evolution of concentrated SLES solutions (70 wt% in water) with varying concentrations of common manufacturing additives like monovalent salt (NaCl) and propylene glycol (PG). Six samples were prepared, containing SLES and equal weight percentages of NaCl and PG ranging from 0-10%. Rheological behavior was examined through shear rotational and oscillatory experiments performed on a rheometer, using both concentric cylinder and parallel plate fixtures. Microstructure changes during evaporation were investigated using an optical microscope with cross polarizers. It was observed that adding NaCl and PG in equal weight percentages to SLES solutions counteracted the previously discovered effects of adding them individually and made the solutions behave like raw SLES. Evaporation induced microstructural changes were observed over the course of a week in samples of different concentrations of NaCl and PG. These changes were compared to rheological measurements of one sample also left to evaporate for a week. Temperature ramps through processing and end-use relevant temperatures were found to induce an unexpected increase in the complex viscosity of all solutions at lower temperatures. This study provided insights about SLES' behavior and performance with different additives under varying shear rates, temperatures, frequencies, and evaporation times.

Anomaly Detection of Extrusion-Based Additive Manufacturing

SURF ID: 152
3:15 PM - 3:30 PM

*Blake G. Harris[1], Mitchell R. Donoughue, Monique S. McClain**
*[1]Lee University *PI: School of Mechanical Engineering*

Additive Manufacturing is a rapidly growing field of research that enables cheap and easy manufacturing of geometrically complex parts. However, if a printer is operating unwatched and an error occurs, the print will continue uncorrected which causes the formation of defects that negatively impact part quality and performance. Such defects can make a part unusable, wasting time, materials, and money. The goal of this research is to collect position and image data from a fused deposition modeling (FDM) printer to identify when a defect occurs without operator supervision. Three linear encoders were used to track the nozzle position, a rotary encoder was used to track the feed and retraction rates of polylactic acid (PLA) print filament, and a webcamera was used to observe the print quality. Multiple 10mm-by-10mm cubes were printed at various speeds and bed temperatures to produce samples with and without induced defects. The position and image data from these prints were collected via a python script. To improve the data collection speed, image labels were appended to the corresponding position data located in a .csv file. Then, calibration data from a baseline print were used to train a principal component analysis (PCA) to create a model for anomaly detection. The model was used to implement statistical process control (SPC), which was then used to determine which prints exhibited normal (good print) or abnormal (bad print) quality. The methodology developed in this study can be used to detect errors in 3D-printed parts to improve part qualification.

Keywords: Additive manufacturing (AM), Fused deposition modeling (FDM), Anomaly detection, Principal component analysis (PCA), Statistical process control (SPC)

Evaluation of Limewater and Sodium Silicate Treatment to Innovate Composite SAP Containing Cement Hydration Product Nucleation Seeds

SURF ID: 185
3:30 PM - 3:45 PM

*Haotang Li, Caitlin J. Adams, Kendra A. Erk**
**PI: School of Materials Engineering*

Superabsorbent polymer (SAP) as an internal curing agent has been proven to be a promising method for decreasing cement shrinkage and cracking risk. This study aims to develop and evaluate composite SAPs which combine internal curing and nucleation seeding functionality. SAP was treated in calcium hydroxide and sodium silicate solutions to synthesize a crystalized composite SAP to mix with cement paste. Composite SAP and SAP-cement pastes were characterized with microscopy, compositional analysis, and mechanical testing. A 1:9 ratio of commercial sodium silicate solution and DI water was selected for SAP treatment to maximize sodium silicate loading of SAP while minimizing total material use. In 7 days cement paste samples, both limewater and sodium silicate solution treated SAP formed calcium hydroxide plates. Cement matrix capillary porosity decreased in the vicinity of SAP-induced voids across samples, with the lowest porosity observed in the limewater-treated SAP samples, followed by the sodium silicate-treated sample and the pure SAP samples. Mechanical testing showed that the addition of any of the SAP used in the study did not lower the compressive strength. Calcium hydroxide and sodium silicate composite SAPs displayed internal curing and nucleation seeding behavior that could improve cement paste properties.

Keywords: Internal curing, superabsorbent polymer, nucleation seeding, limewater, sodium silicate

Compatibility of Admixtures and Non-traditional and Natural Pozzolans in Cementitious system

SURF ID: 186
3:45 PM - 4:00 PM

*Junjie Li, Bibigul Zhaksybay, Alberto Castill, Raikhan Tokpatayeva, Jan Olek**
**PI: Lyles School of Civil Engineering*

So-called traditional supplementary cementitious materials(SCMs), such as fly ash, silica fume and slag, have been widely used as partial replacement for Portland cement to increase the durability and sustainability of concrete. However, growing demand for these materials combined with continued closures of coal-powered power plants and other industrial facilities result in rising prices and supply shortages. It is therefore critical to explore feasibility for substituting these traditional SCMs with potentially cheaper and more abundant materials, such as calcined clays, fluidized bed combustion ashes, and volcanic glasses. Since the chemical and physical properties of non-traditional and natural pozzolans (NNPs) are often different from those traditional SCMs, they may not be fully compatible with some chemical admixtures used in concretes, such as water reducers (WRAs) and air-entraining agents (AEAs). This project investigated the potential incompatibility issues in cementitious systems containing NNPs and various combinations of AEAs and WRAs. NNPs included one calcined clay (CC) and one fluidized bed combustion (FBC)ash. Mini-slump and spread tests were performed on mortar samples with addition of various combinations of admixtures to evaluate workability and air-content of the mixtures made with three different types of cements partially (25% and 35% by weight)replaced by these two NNPs. Isothermal calorimetry test was performed on paste samples (at 23 °C) to evaluate the effect of different combination of admixtures on hydration kinetics and the total heat of hydration of mixtures. Outcome of this project can be used to develop recommendations related to the practice of production of concrete mixes with partial replacement of cement by NNPs studied in this project.

Keywords: Concrete, Supplementary Cementitious Materials, Chemical Admixtures, Incompatibility

Day 2 — Morning Presentations

July 29th, 10:00 AM – 12:00 PM EDT

Track A: Chemical Catalysis & Synthesis (WALC 3138)

Development of Siloxane-Based Surfactant Formulation for Fire Extinguishing Foams

SURF ID: 173
10:00 AM - 10:15 AM

*Jadyn Kennedy[1], Yue Zheng, Jeffrey P. Youngblood, Carlos J. Martinez**
*[1]Marist College *PI: School of Materials Engineering*

Keywords: TRIS, AFFFs, Sustainability, Silane Surfactant

Current environmental concerns demand a reassessment of the chemicals allowed to accumulate in oceans. Presently, aqueous film-forming foams (AFFFs) are used on government ships to contain and rapidly put out fires spreading over liquid near stored explosives. These AFFFs are developed from fluorosurfactants (FS) due to their high surface activities that allow for high spreading parameters, though their byproducts are unable to naturally degrade in the environment. There is potential for surfactants developed from the tris(trimethylsiloxy) - moiety (TRIS) to behave similarly to FS AFFFS with more considerations for environmental sustainability. Synthesis experiments were run to simulate the effectiveness of the chemical workup for products that analogue the desired TRIS-based surfactants. This synthesis substituted 3-(chloropropyl)trimethoxy-silane for the desired chlorinated propyl-trimethylsiloxy reagent and ran it with hydrated sodium hydrosulfide and Oxone which proved hard to clean but did report the expected sulfonate peak when analyzed through Fourier transform infrared spectroscopy (FTIR). Tris(trimethylsiloxy)vinyl-silane was then treated with hydrobromic acid and benzoyl peroxide such that a radical addition of bromine onto the less substituted carbon position could occur. Although the product has not been appropriately cleaned, FTIR analysis proved the successful addition of bromine to the TRIS-based molecule. Work must still be done to determine their effectiveness in use as surfactants.

Biofunctionalization of PEDOT: PSS by Thiol-Ene Click Chemistry for Biological Applications

SURF ID: 142
10:15 AM - 10:30 AM

*Dylan Forbes, Wenting Wu, Jianguo Mei**
**PI: Department of Chemistry*

Keywords: PSS: PEDOT, disulfide, thiol-active reaction, biofunctionalization, organic bioelectronics

Biofunctionalization of highly conductive PEDOT: PSS is a crucial goal but remains a formidable challenge for organic materials chemistry. PEDOT: PSS has demonstrated limited success in the integration into the biological world and lacks long-term stability and truly integrated covalent bonds between polymer and biological material. Herein we have demonstrated that the biofunctionalization of disulfide-containing PEDOT: PSS through thiol-ene click chemistry is a robust strategy that renders the high-performance conductive polymers. The synthesized P(DS-ProDOT/EDOT): PSS is covalently bio-functionable at biologically relevant pH values and temperatures. The key to successful biofunctionalization is the design of the disulfide-containing monomer and the efficient post-modification via thiol-active reaction upon reduction. It is expected convenient attachments of various functional biomolecules onto disulfide containing P(DS-ProDOT/EDOT): PSS provides a simple, covalent, and biocompatible platform for the functionalization of conductive polymers. In the future, biotin-binding P(DS-ProDOT/EDOT): PSS might exhibit highly selective detection of metabolites in OECT devices, generally inaccessible by non-covalent attachments. This biofunctionalization strategy will promote the potential application of PEDOT: PSS in organic bioelectronics.

Exploring the Underwater Adhesion Strength of a Soybean-based Adhesive

*Sebastian Gomez Combellas, Bradley C. McGill, Clayton R. Westerman, Jonathan J. Wilker**
**PI: Department of Chemistry*

SURF ID: 148
10:30 AM - 10:45 AM

Keywords: Adhesive, bio-inspired, solvent-based, underwater, polymer

Many industrial adhesives struggle to maintain strong adhesion while underwater. However, in nature, several examples of adhesion occur in conjunction with water. Recent research has shown a concerted effort to mimic biological adhesive systems. For instance, marine mussels can adhere to surfaces underwater to resist the ocean's currents and avoid the dangers of predators. The Wilker lab has developed a new adhesive combining the mussel-inspired adhesive with epoxy chemistry through epoxidized soybean oil. This adhesive has had substantial success while dry. Still, as with many underwater adhesives, it quickly oxidizes while underwater, turning from an amber-like hue to a milky-white color and losing most of its adhesive strength. This paper explored the viability of this adhesive when underwater and saw success in improving the application process using an organic solvent. The crosslinker iron nitrate was also proposed to improve the adhesive strength. Instead, it weakened the cohesive forces at play and decreased the underwater adhesion. This indicated that improving the adhesive's underwater strength may be better pursued by modifying the components and their ratios rather than adding additives after the glue has polymerized.

Induction Based Reactor for Ethylene Production

*Ali D. Alshubbar, John R. Ueding, Keylin Boyd, Edwin A. Rodriguez, Rakesh Agrawal**
**PI: Davidson School of Chemical Engineering*

SURF ID: 111
10:45 AM - 11:00 AM

Keywords: Thermo-fluid simulations, induction heating, reactor design, ethylene production

Ethylene production, mainly done through Steam Cracking, accounts for a global emission of more than 300 tons of CO2 annually. Steam Cracking implements the combustion of hydrocarbons to get the energy required for the endothermic reaction to run. Consequently, more than a ton of CO2 is emitted for every ton of ethylene produced. To address the carbon emissions problem within ethylene production, this work analyses the implementation of a heat induction coil surrounding the tubular reactor as its required energy source, ultimately eliminating the need for combustion reactions. To do so, the reactor was designed and examined using Ansys Products. Ansys Maxwell 3D is used to design the coil system and simulate the induction mechanism, Ansys Transient Thermal Analysis is used to analyze the thermal energy induced via induction, and Ansys Fluent is used to analyze the heat and momentum transport phenomenon of the fluid flowing in the reactor. Results show that required temperature profiles for reaction along the tubular reactor could be potentially achieved through induction heating technology; a proof of concept has been simulated. Inductive-based reactors can be implemented not only for ethylene production but also for any other endothermic reaction undergoing in a tubular reactor. Further work in developing this technology could potentially result in more environment-friendly and energy-efficient production of petrochemicals.

Employing Surfactants Alongside Chelating Agents to Increase Production Efficiency

*Ching(Winson) Chang[1], Thomas A Everett, Jeremy Holtsclaw, Nathan C Schultheiss**
*[1]The University of Texas at Austin *PI: Davidson School of Chemical Engineering*

SURF ID: 124
11:00 AM - 11:15 AM

Keywords: Chelating agents, surfactants, emulsion and microemulsion phases, interfacial tension

Conventional oil drilling methods can only extract a minor percentage of oil from the reservoir. Enhanced oil recovery methods that utilize polymers and surfactants to change the viscosity and flow efficiency of the oil are capable of maximizing production. The utilization of surfactants, however, is cost-ineffective due to divalent ions in the formation water that cause anionic surfactants to attach to them. With that, it is important to reduce divalent ions in water formation. Chelating agents are inexpensive substances that can remove Ca2+ and Mg2+ in water. In this work, brines with different hardness will be mixed with oil and chelators, including acetate, malonate, citrate, ethylenediamine tetraacetic acid, and polyacrylic acid, to observe the behavior of the emulsion and microemulsion phases formed. Spinning Drop Tensiometry is then used to measure the interfacial tension of the selected trials to quantify the effect of adding a chelating agent to the reservoir. This experiment aims to determine the optimum ratio of the specific chelating agent and brine that will give the best microemulsion phase and lowest interfacial tension. The results show that utilizing a lower concentrated chelating agent to hard brine gives a more fluid and distinctive microemulsion phase. The interfacial tension is higher in trials that solely add surfactants than trials that add both chelating agents and surfactants. In conclusion, chelating agents may effectively lower the interfacial tension of formation water but couldn't be confirmed since only less than ten measurements are made.

Mussel-Mimetic Bioadhesives for Biomedical Applications in the Oral Environment

*Kaniese I. Mack, Aishwarya V. Menon, Jonathan J. Wilker**
**PI: Department of Chemistry, and School of Materials Engineering*

SURF ID: 194
11:15 AM - 11:30 AM

Innovations inspired by nature are known as biomimicry. One such example of biomimicry is the development of adhesives inspired by sea creatures like mussels, barnacles, and oysters that sticks to rocks even as the ocean waves crash against them. Herein, we have designed mussel-mimetic bioadhesives for biomedical applications in the oral environment, such as clinical practice in dentistry and drug delivery. Our bioadhesives are formulated using zein (a corn protein) and tannic acid (source of mussel-inspired chemistry), both of which are plant-derived, non-toxic, degradable, and low-cost. We tested the ability of two of our bioadhesive formulations to withstand the harsh conditions of the oral environment and stay adhered to dentin and buccal mucosa for the desired duration. The bioadhesives were allowed to cure on the surface of dentin and buccal mucosa for 5 minutes, 2 hours, and 24 hours. To test adhesive stability, a commercial water flosser was used to determine the amount of bioadhesive removed from the surface of dentin and buccal mucosa after exposure to various water pressures for 1 minute. Following the test, a protein assay quantifies the concentration of zein protein remaining. To measure the adhesion strengths of the bioadhesives, lap shear testing was used after cure times of 30 minutes, 2 hours, and 24 hours. The results of this research project were evaluated to determine the most efficient bioadhesive composition and provide inferences on the performance for biomedical applications in the oral environment.

Keywords:
Mussel-mimetic bioadhesives, wet-adhesion, dental adhesion, mucoadhesion

Investigating Effects of Cations in Bicarbonate Electrolytes on Interfacial pH during Electrocatalytic CO_2 Reduction Reaction

*Yoonsun Park, Michael J. Ricci, Hwiyoon Noh, Brian M. Tackett**
**PI: Davidson School of Chemical Engineering*

SURF ID: 219
11:30 AM - 11:45 AM

The electrochemical CO_2 reduction reaction (CO_2RR) is one potentially effective and sustainable way to recycle CO_2 into useful chemicals and fuels. Beyond electrocatalyst design, the reaction environment can be engineered to optimize the activity and selectivity of CO_2RR. "It is well known that electrolyte cation identity impacts local pH and consequent CO_2RR selectivity, but quantifying this near-surface pH change has proven difficult. In this work, a rotating ring disk electrode (RRDE) equipped with a pH sensing IrOx ring enables measurement of the interfacial pH change during CO_2RR in bicarbonate electrolytes with varying cation identity (Li^+, Na^+, K^+, Cs^+). With the pH sensing RRDE, the open circuit potential of the ring is measured during simultaneous CO_2 reduction at the disk, allowing for the subsequent calculation of interfacial pH under CO_2RR conditions. Simultaneously, the strongly buffered electrolytes show the pH change trends according to varying cations with different atomic sizes. Within the small changes in pH, the cation with the longest atomic radius, Cs^+, shows the largest pH changes, while Li^+, the cation with the shortest atomic radius, has the smallest pH changes. In comparison, 0.1 M bicarbonate electrolytes show different trends with 0.5 M bicarbonates, having more significant pH changes. The difference in cation trends in different concentrations of bicarbonate highlight the dynamic nature of the CO_2RR electrochemical environment and the importance of developing accurate measurement techniques.

Keywords:
Electrocatalysis, interfacial pH, cations, electrolytes, sustainability

Carbon Dioxide Recycling with Catalytic Biochar Gasification

SURF ID: 218
11:45 AM - 12:00 PM

*Adolfo Luis Palma Vergara[1], Adity Bora, Jay P. Gore**
*[1]Universidad de los Andes *PI: School of Mechanical Engineering*

Carbon dioxide is a greenhouse gas whose emissions have been increasing because of industrialization and, as a result, the global temperatures have been rising. Biomass gasification with CO_2 can convert it into CO for energy generation, permitting CO_2 recycling. Gasification involves thermochemical conversion of carbonaceous materials first into char and then into syngas, whose primary constituents are CO and H_2. Thus, gasification has the potential to restrict carbon dioxide emissions and provide energy. However, gasification efficiency can vary depending on the type of biomass and catalyst. Potassium carbonate is an alkali metal catalyst that is loaded to biomass for gasification. The effectiveness of the potassium catalyst varies depending on the pre-loading of the biomass prior to charification. Bamboo is an easy-to-grow and non-edible biomass grown in many countries, including Colombia and India. In this study, bamboo samples from India were gasified with the addition of K_2CO_3 catalyst following charification. The charification temperature of 973 K was reached by heating the sample at a rate of 30 K/min and at a fixed charification pressure of 1 atm. The fixed bed gasification experiments involved three gasification temperatures (1023 K, 1123 K, and 1173 K) and two gasification pressures (1 atm and 3 atm). The CO mole fractions in the mixture exiting the gasifier were measured using a Horiba gas analyzer. Both pre-loading and post-loading of the K_2CO_3 catalyst led to significant increases in the efficiencies of biomass conversion especially at the 3 atm pressure.

Keywords: Bamboo, catalyst, char, gasification, potassium carbonate

Track B: Ecology and Sustainability 2 (WALC 2051)

Challenges for Sustainable and Cost-effective Plastic Waste Disposal in the Muzaffarabad Region of Pakistan

SURF ID: 280
10:00 AM - 10:15 AM

*Zoya Bashir[1], George T. C. Chiu**
*[1]National University of Science and Technology (NUST), Islamabad, Pakistan *PI: School of Mechanical Engineering*

Plastics are widely-used materials with several attractive properties, such as easy manufacturing, low cost, and relatively high specific strength. Their popularity in the 20th century has created a significant environmental challenge due to their durability. Plastic takes hundreds of years to decompose in nature. Without proper handling and treatment, the accumulation of plastic waste causes a lasting negative impact on the health of all living things as well as the environment. In many cases, specifically in developed countries, plastic waste disposal is done responsibly through different methods. However, this is not the case for many developing countries for a variety of cultural, social, technical, and economic reasons. The objective of this work is to identify specific challenges for sustainable and cost-effective plastic waste disposal in the Muzaffarabad region of Pakistan. First, we will identify the unique social, economic, cultural, and infrastructure characteristics of the region. Then, we will consider the unique challenges imposed by these characteristics on existing plastic waste disposal methods. This work will identify specific challenges associated with the region for existing plastic waste disposal approaches. The results will serve as a basis for future research and efforts to identify eco-friendly and sustainable plastic waste disposal methods in Muzaffarabad.

Keywords: Plastic waste, photodegradation, incineration, landfills, recycle

Socioeconomic and Land Use Factors as Drivers of Chicago Canopy Equity

*Jackson D. Lyall, Lindsay E. Darling, Brady S. Hardiman**
**PI: Department of Forestry and Natural Resources, and Division of Environmental and Ecological Engineering*

SURF ID: 193
10:15 AM - 10:30 AM

Keywords: Chicago, Urban Canopy, Environmental Justice, Urban Forestry, Urban Ecology

Not everyone has equal access to nature. For cities, variability in urban forest distribution can partially be attributed to historic racism. In the 1930's, the Home Owners' Loan Corporation (HOLC) ranked neighborhoods based on housing characteristics, ethnicity, and immigration status. Today, this practice is known as "redlining". The lowest ranked communities were often Black majority neighborhoods, which consequently experienced significant community disinvestment, even after HOLC's dissolution. This disinvestment has resulted in disproportionately less urban canopy. Fewer trees cause higher temperatures, more pollution, and excess storm water. Greening and targeted tree planting programs attempt to reconcile with this reality. This study sought to evaluate canopy change in the Chicago Metropolitan Area using high-resolution canopy data from 2010 and 2017. The magnitude of canopy change was aggregated to census tracts and compared to socioeconomic and land use variables using GIS. In highly urbanized areas, Pearson and Spearman correlations displayed canopy growth having a positive correlation with higher proportions of non-white, high-poverty, and unemployed populations. Negative correlations were found with higher proportions of white, higher income, higher rent populations and in residential areas. These findings indicate that historic inequities in the urban forest may be improving. The results of this study could be used to inform policy and spending to further improve the equity of the urban forest.

Human Induced Emissions and Energy Correlation

*Eric A. Cobos, Jinglin Jiang, Nusrat Jung**
**PI: Lyles School of Civil Engineering*

SURF ID: 131
10:30 AM - 10:45 AM

Keywords: Volatile organic compounds, zEDGE (Zero Energy/Emissions Design Guide for Engineers), Particulate matter

With microwaves, stovetops, ovens, fragrant foods, high heat, and relative humidity, kitchens serve as a primary source of particulate matter and gas-phase emissions of volatile organic compounds (VOCs), whose concentrations go unregulated in residential environments. Particular VOCs of concern include volatile methyl siloxanes (VMSs), also referred to as siloxanes, which are man-made via synthesis, are found in various personal care products (PCPs), and be potentially dangerous to consumers. With people spending most of their time indoors, the indoor atmosphere is of particular concern, which is easier to pollute and harder to dilute than the outdoor one. Our lab seeks to quantify and analyze particulate and gaseous emissions in the indoor atmosphere from everyday human activities. This study will analyze emissions from an electric oven while baking cupcakes in a silicone mold. To achieve this, a protocol will be developed for standardizing baking cupcakes in the oven. A TVOC sensor and a device to measure the particulate matter will be located in the zEDGE laboratory, where the experimentation will occur. Energy consumption data will be collected by the energy monitoring system installed within the zEDGE laboratory and superimposed upon the emission results. The particulate matter (PM) will be measured in size and distribution and will be correlated with the oven's energy consumption at the power level/s utilized during the experiment. These results will depict the relationship between energy consumption and particle emission while baking.

Geospatially Resolved Model of Heat Pump Operating Costs and Emissions

SURF ID: 227
10:45 AM - 11:00 AM

*Mohammad Rezqalla, Kelsey Biscocho, Rebecca Ciez**
**PI: School of Mechanical Engineering*

The electrification of space heating is a major area that must be addressed to meet decarbonization goals. Heat pumps are often considered a primary solution to this problem. However, heat pump adoption exhibits both technical and social challenges. This study aims to generate heat pump performance models of existing and upcoming technologies to study the effect of their use on the overall energy consumption, cost, and greenhouse gas emissions across the contiguous United States, starting with a single case study state. In addition, this study looks at three kinds of heat pump technologies: R410a refrigerant heat pumps, R32 refrigerant heat pumps, and dual fuel systems that use natural gas as back-up heating. For each of the technologies, linear regression models were developed using manufacturer data and laboratory test data when available. These models compared the efficiency of each heat pump (referred to as COP, or coefficient of performance) with respect to ambient temperature. Once generated, each technology's models were validated and combined to create an average model. The output of an energy demand model will be used as input for the heat pump models, quantifying the costs and emissions of operating heat pumps across real weather conditions. This will allow for a better understanding of the potential use of the different heat pump technologies as a replacement to fossil-fuel driven technologies.

Keywords: Decarbonization, electrification, heat pump, regression, model, refrigerant

Solar-Powered Batch Reverse Osmosis for High Efficiency Desalination

SURF ID: 151
11:00 AM - 11:15 AM

*Aaron Harp, Antonio Esquivel-Puentes, David M. Warsinger**
**PI: School of Mechanical Engineering*

By 2050, the United Nations predicts that over 6 billion people will be affected by water scarcity. Over 70% of the earth's surface is covered by oceans yet its water remains unusable due to the high salinity of seawater. Reverse Osmosis (RO) is the most common method of desalinating water but is dependent on non-renewable generated electricity to meet its high energy requirements. In response to this issue, this paper aims to evaluate a batch reverse osmosis system driven solely on solar-thermal energy. Bach reverse osmosis (BRO) is a state-of-the-art reverse osmosis configuration which utilizes a transient pressure distribution to save energy. The system aims to drive the most efficient solar-powered desalination process to date, utilizing the BRO configuration in combination with pressure-driven desalination. By utilizing the collection of solar power via the cyclical compression and expansion of a working fluid to drive a Stirling engine, work generated by the solar powered engine can be used to drive the proposed piston-batch RO configuration. Currently a model has been developed proving efficient solar-thermal to mechanical power conversion and the ability to run a single BRO cycle with a constant flow rate and load. The BRO model with a constant flow rate has achieved a specific energy consumption of 1.88 kWh/m^3 of permeate produced and a permeate flux of 15 L/m^2/h during membrane separation. Current results have proof of concept in the ability to run a BRO cycle utilizing solar-thermal as the primary source of energy.

Keywords: Desalination, reverse osmosis, batch reverse osmosis, solar-thermal power

Track C: Machine Learning 3 (WALC 2088)

Aiding Farm Operations With Artificial Intelligence Chatbot

*Samia Sohail Azim[1], Varun Aggrawal, Dharmendra Saraswat**
*[1]Institute of Business Administration *PI: Department of Agricultural and Biological Engineering*

SURF ID: 282
10:00 AM - 10:15 AM

Adoption of advanced technologies in US farms is increasing as per a 2019 survey of agricultural retailers. Though the use of Chatbots, an intelligent conversational computer system, is gaining acceptability among many industries to provide virtual assistance to customers, limited use cases exist in agriculture. This study aims to implement an Artificial Intelligence (AI)-based Chatbot (AI Chatbot) that promotes conversation with the farmer in a near-human context and converts the conversation into actionable farm operations. The AI Chatbot was trained using Machine Learning (ML) algorithms on a custom dataset that simulates human conversation using Natural Language Generation (NLG) tools. The AI Chatbot helped fetch real-time weather data for a farmer's current location, allowed digitization of paper-based receipts/invoices stored on smartphones or laptops/desktops using Optical Character Recognition (OCR), and sent reminders of daily schedule based on past operational data. The AI Chatbot showed the potential to increase the efficiency of the work done by farmers on a day-to-day basis and help digitize ledger and record keeping. This study is a step towards realizing the full potential of advanced AI technologies in agriculture.

Keywords: Artificial intelligence, natural language processing, machine learning, chat bots, natural language generation, virtual assistants, optical character recognition, smart agriculture

Multi-label Classification of CNC Machine Status Using CNN

*Daihun Kim, Eunseob Kim, Martin Byung-Guk Jun**
**PI: School of Mechanical Engineering*

SURF ID: 175
10:15 AM - 10:30 AM

Development in machine monitoring and Internet of Things (IoT) has led its way to flood of data in manufacturing. However, not all data is utilized to its furthest extent of potentials. One of many, raw sound data of a machine may be easily collected, yet, due to internal and external noise, remains intrinsically hard to be utilized. This paper proposes a method based on Convolutional Neural Network, using raw sound data collected from sensors, to classify the binary operational status of 3 auxiliary components of CNC machine: coolant, chip-conveyor, and spindle. As for the sound feature for the model, Mel-spectrogram is generated. The 3-layer CNN model successfully performed the 'multi-label' classification, and the results are presented in a form of confusion matrix.

Keywords: Smart manufacturing, mel spectrogram, CNN, machine learning, multi label classification

Ensemble Approaches for Automatic Program Repair

*Kevin Zhang, Nan Jiang, Lin Tan**
**PI: Department of Computer Science*

SURF ID: 273
10:30 AM - 10:45 AM

Fixing bugs in code is a time-consuming endeavor. Automatic Program Repair (APR) represents a category of software designed to autonomously offer fixes to errors or bugs present in source code by generating patches- adjustments to the existing code. The extension of neural networks and deep learning techniques to generate patches from buggy code has recently made great headway in this field. Ensemble techniques also find great benefit in improving the effectiveness of these deep learning models, training multiple separate copies of a model to capture the benefit of "the wisdom of the crowd." However, APR techniques have yet to achieve the accuracy and speed of patch generation which developers desire. The use of better ensemble methods offers a relatively simple way to improve performance of learning methods. Clustering of the buggy type via human programmer heuristics about the bug type and clustering via the encoder hidden state output of a pre-trained model were compared with random ensembles. These different clustering techniques were assessed for division of the training data, with different models within the ensemble being trained on different clusters. Each method was then tested on the Quixbugs APR benchmark of 39 bugs in Java to determine their relative effectiveness. The ensemble models trained with randomly clustered data outperformed the models trained on both human and machine clustering, achieving 26 fixes compared to 20 fixes produced by both other methods. These results suggest that balanced training and general knowledge are more important than specific intuitions for automatic program repair.

Keywords: Automatic program repair, deep learning, ensemble techniques

Tweets Modeling: A Machine Learning Approach to Analyze the Sentiment of Airline Passengers

SURF ID: 261
10:45 AM - 11:00 AM

*Shengyang Wu, Yi Gao**
**PI: School of Aviation and Transportation Technology*

Keywords: Twitter, machine learning, natural language processing (NLP)

With the widespread of technology and the access to mobile devices at ease, social media platforms have exponentially grown their popularities over the past years. Twitter, being one of the largest social networking services, has more than 300 million active users at the moment. For air travelers, especially, Twitter has become increasingly popular as a platform to share their traveling experiences. This study investigated modeling customer satisfactions, and airline management operations, by analyzing Tweets' sentiments through machine learning. The Tweets were retrieved from Twitter's database and preprocessed with natural language processing algorithms. After that, these processed Tweets will be passed into a pre-trained machine learning classifier to predict the sentiments. In additional to sentiment analysis, we also performed lexical analysis on the Tweets to model keywords' frequencies. The study compared common keywords and average Tweet's sentiment per day in time series plots, and provided conclusions that anomalies in the airline industry could be detected through monitoring Tweets.

"Sounds of Nuclear Radiation" – Identifying Fundamental Nuclear Particle Interacted Acoustic Shock Spectra via TMFD Coupled-Machine Learning

SURF ID: 205
11:00 AM - 11:15 AM

*Ankita Mishra, Bailey Christensen, Nathan Boyle, Rusi Taleyarkhan**
**PI: School of Nuclear Engineering*

Keywords: Neutron, alpha, metastable fluids, acoustics, machine learning

Neutron and alpha nuclear particle detection and characterization is of fundamental importance to science and engineering – impacting fields as varied from astrophysics to nuclear energy/security, radiation dosimetry and nuclear medicine. Distinguishing one particle from the other has to date required specialized detectors and complex electronic trains. The Metastable Fluid Advanced Research Laboratory (MFARL) at Purdue University has developed the novel tensioned metastable fluid detector (TMFD) sensor technology, which can spectroscopically detect alpha and neutron radiation while being entirely blind to common background (beta and gamma) radiation. Alpha and neutron radiation interacting with the tensioned metastable state fluid atoms of the detector at the nanoscale can lead to acoustic shock signals – via audible and visible fast-growing bubbles on the microsecond time scale. For this study, the acoustic shock waves were led through a wave guide and interact with tiny piezoelectric transducers leading to electric pulse shock spectra - and used to generate particle specific spectrograms which describe how the acoustic power is uniquely distributed across both frequency and time. We attempted to discriminate between these spectra by training a neural network to analyze the spectrograms of the acoustic signatures generated from neutron and alpha particle interactions. Rn-222 isotope dissolved in the TMFD sensing fluid provided alpha particles, whereas an external Pu-Be/Am-Be source provided neutrons. Over 2,367 particle interaction event shock spectra were recorded. The spectrograms from these events were then used to train a Keras classifier and then used to train a convolutional neural network (CNN) algorithm. After a 5-fold cross validation, the CNN algorithm was able to accurately identify the incident particle as being either alpha or neutron, with a success rate of $89.39\% \pm 9.6\%$.

Track D: Genetics and Cellular Biology 2 (WALC 2127)

ARP 2/3 Complex Mediated Actin Filament Response in Presence of MAMP Treatment

SURF ID: 286
10:00 AM - 10:15 AM

*Chiana Barski[1], Weiwei Zhang, Christopher J. Staiger**
*[1]University of Puerto Rico-Mayaguez *PI: Department of Biological Sciences, and Department of Botany and Plant Pathology*

Plants possess innate immunity against microbial attack which differs from animal immune systems. Plants don't have specialized immune cells, but they do have many layers of defense. Therefore, when a pathogen encounters living plant tissue, this can potentially initiate an immune response. One of the early plant defense responses involves the rearrangement and accumulation of the actin cytoskeleton around the site of pathogen infection. However, the signaling events and molecular mechanisms underlying the remodeling of the actin cytoskeleton during plant defense are not well understood. It is unknown whether the actin-related protein 2/3 complex (ARP 2/3) or other filament nucleators are responsible for generating new filaments in response to chemical signals from pathogen attacks. Collected data will contribute toward determining which stimulus has a greater impact on cytoskeletal rearrangement at the site of infection. A microbial-associated molecular pattern (MAMP) treatment will be applied to plant tissue as the chemical stimulus. Subsequent MAMP treatment of ARP 2/3 inhibitor pre-treated cells, or genetic mutants of APR2/3, will be used to determine the function of ARP 2/3 in defense-related actin remodeling. The cortical actin array dynamics will be imaged by Total Internal Reflection Fluorescence (TIRF) Microscopy and the single actin filament behavior will be quantified to determine actin nucleation frequency by the ARP 2/3 complex. This study will provide a detailed understanding on how the ARP 2/3 complex may differently respond to various types of stimuli during plant-pathogen

Keywords: Innate immunity, actin, pathogen, ARP 2/3 complex, MAMP, chemical stimuli

The Impact of Oncogene PLK-1 on Angiosarcoma

SURF ID: 102
10:15 AM - 10:30 AM

*Elise Abney, Nimod Janson, Jason Hanna**
**PI: Department of Biological Sciences*

Angiosarcoma is a rare cancer that develops in the inner endothelial linings of lymph and blood vessels of the body. Angiosarcoma is associated with a severe mortality rate due to its aggressive metastatic nature and lack of effective treatments. Common treatment options often consist of a combination of chemotherapy, radiation, or surgery. Unfortunately, these methods have proven relatively unsuccessful at inhibiting the metastasis of angiosarcoma. In order to improve the prognosis for angiosarcoma patients, targeted therapies are being explored to understand the genetic basis of metastasis so that it can be effectively prevented. Previous studies have indicated that increased levels of the oncogene PLK-1 are associated with many cancers including angiosarcoma. In this study, we investigated how PLK1 expression is impacted by microRNAs in human and mouse cell lines to better understand the biological regulators of angiosarcoma. We have found that miR-497 regulates PLK-1 expression through the use of qRT-PCR and luciferase assays. Future studies will focus on determining if this regulation is direct or through intermediate cell cycle mediators. Identifying the biological regulators of angiosarcoma allows us to identify viable targets for treatment development. In the future, the results of this study could aid in the development of more successful therapeutic treatments for angiosarcoma patients in order to improve the prognosis of the condition.

Keywords: Angiosarcoma, PLK-1, gene therapy

Genetic Investigation of a Geleophysic-like Connective Tissue Disorder in Goats

SURF ID: 232
10:30 AM - 10:45 AM

*Maeve Sheehy, Shawna Cook, Jeanna Blake, Kari Ekenstedt**
**PI: Department of Basic Medical Sciences*

Keywords: Goat, FBN1, ADAMTSL2, LTBP3, connective tissue disorder, Geleophysic Dysplasia, Musladin-Lueke Syndrome

Rare connective tissue disorders characterized by extensive fibrosis of the skin and joints, such as Musladin-Lueke syndrome (MLS) and Geleophysic Dysplasia (GD), have been previously described in dogs and humans, respectively. In early 2022, a goat presented to the Purdue University Veterinary Hospital with a stiff gait and preference to ambulate backward. Neurological conditions were ruled out, leaving a suspicion of a connective tissue disorder similar to MLS/GD. The objective of this study was to investigate *ADAMTSL2*, *LTBP3*, and *FBN1* in the affected goat via Sanger sequencing of all exons; variants in these genes are associated with MLS and GD. DNA was extracted from whole blood from the affected goat and two control (unaffected) goats. Primers were designed in Primer3Plus, using the 2016 USDA goat reference sequence. Template DNA was prepared from the affected goat and one control for each primer pair. Samples were submitted to a service laboratory for Sanger sequencing. Resulting sequence electropherograms were manually examined for any discrepancies between the affected goat and the reference/control sequence. All identified variants were evaluated for their predicted effect on gene expression, quantified using Ensembl Variant Effect Predictor (VEP). Those of moderate or high effect were explored further. Results thus far have shown one missense mutation present in *ADAMTSL2* that was ruled out via its frequency in the population and low VEP score. Determining the genetic basis for rare disorders that are shared across species provides novel translational biological knowledge and supports the development of treatment modalities for all affected species.

Investigation and Quantification of the pSmad Profile in Early Embryonic Development of Bambia Mutant Zebrafish

SURF ID: 293
10:45 AM - 11:00 AM

*Nathan B. French, Linlin Li, Nissa J. Larson, David Umulis**
**PI: Weldon School of Biomedical Engineering*

Keywords: Bone Morphogenic Protein, Morphogen Gradient, pSmad, Zebrafish, Bambia, Dorsal-Ventral Patterning

Bone Morphogenic Proteins (BMPs) are a class of molecules that pattern the dorsal-ventral (DV) body axis during early zebrafish embryonic development. BMPs specify cell fate in a concentration-dependent manner by interacting with the surface cell receptors leading to the phosphorylation of Smad proteins which are transcription factors able to enter the nucleus and regulate target gene expression. BMP and Activin Membrane Bound Inhibitor (BAMBI) is a gene encoding for a pseudoreceptor that lacks an intracellular Receptor Serine/Threonine Kinase (RSTK) domain therefore the pseudoreceptor can not transduce extracellular signaling caused by BMP ligand binding. The interplay between the BAMBI gene and other genes encoding for functional surface receptors is important for modulating BMP signaling during embryonic development. The BAMBI gene has been implicated in some human cancers making its characterization valuable in human oncology. This study sought to characterize the pSmad profile in BAMBI ortholog ‘A’ (Bambia) mutant zebrafish for Homozygous and Heterozygous mutants compared to Wild-Type (WT) zebrafish embryos. Confocal imaging was performed on pSmad stained embryos which were later genotyped. Image analysis was performed through Matlab to semi-quantitatively assess and characterize the pSmad profile. The results of image analysis will be used to draw conclusions regarding the effect of the Bambia gene on BMP gradient formation in zebrafish embryonic development. Furthermore, the results will be incorporated into a Partial Differential Equation (PDE) Model studying the BMP signaling network in 3D distribution to increase the fidelity of the model to be capable of describing both WT and mutant scenarios.

Investigation of Cell Culture Technology and Cell Metabolism

SURF ID: 160
11:00 AM - 11:15 AM

*Yalan Huo, Tae Hong Kim, Arezoo Ardekani**
**PI: School of Mechanical Engineering*

Keywords: MIN6 cells, NIH/3T3 cells, metabolism

Cell lines are one of the most significant components for in vitro research, however, they are limited due to donor shortages. Even if researchers obtain donor cells, the diversity of donors will alter the data comparability in the experiment, which is another issue that in vitro research faces. As a result, a variety of cell lines, including MIN6 cells and NIH/3T3 cells, have been developed. MIN6 cells are derived from an insulin-promoter/t-antigen-expressing transgenic C57Bl/6 mouse insulinoma. NIH/3T3 is a fibroblast cell line isolated from mouse NIH/Swiss embryos. This cell line has shown to be helpful in DNA transfection investigations and is extremely sensitive to the development of sarcoma virus foci and the spread of leukemia virus. This study aims to (1) investigate the optimized methods for culturing various cell lines (MIN6 cells and NIH/3T3 cells) and (2) evaluate the activity of the metabolism of the cell by using different glucose concentrations.

A Zebrafish Drug Screen for the Discovery of Compounds to Treat Spinal Cord Injury

SURF ID: 265
11:15 AM - 11:30 AM

*Kaitlyn R. Ying, Gentry Andrews, Alexandria Warren, Marguerite Whiteside, Elise O'Herron, Nina Fujii, Beichen Wang, Daniel Suter**
**PI: Department of Biological Sciences*

Keywords: Spinal cord injury, drug screen, zebrafish, regeneration, visual motor response assay

Spinal cord injury is a complex condition that affects between 250,000 and 500,000 new people around the world every year. Available therapeutic options have limited abilities to fully restore lost motor function. In humans, regeneration in the central nervous system following spinal cord injury is inhibited by a poor intrinsic growth capacity of neurons, the formation of a glial scar, and the lack of proper remyelination. Unlike mammals, fish possess an extensive capacity for regeneration and functional restoration. This project uses zebrafish as a model system to conduct a drug screen of an FDA-approved library with the aim of identifying novel compounds to promote axonal regeneration and functional recovery following injury. Spinal cord transections were performed on zebrafish larvae, followed by drug treatment and a visual motor response assay to measure functional recovery of swimming behavior. In an initial toxicity screen, we identified 97 out of 400 compounds as toxic. The remaining drugs are subjected to the primary screen for functional recovery. Among 77 screened drugs so far, we identified 9 compounds as strong hits, which will need to be confirmed with a secondary screen. Several of the hits are potentially new drugs for enhanced axonal regeneration and functional recovery. These results are promising since we have identified potential new candidates for pharmacological therapies to treat spinal cord injury in humans.

Effect of CDK Inhibition on HBV Genotypes B and C

SURF ID: 240
11:30 AM - 11:45 AM

*Ella G. Stone, Aryamav Pattnaik, Majid Kazemian**
**PI: Department of Biochemistry*

Keywords: Hepatitis B virus (HBV), HBV genotype B, HBV genotype C, CDK inhibitor (CDKi), HBV surface antigen (HBsAg)

Hepatitis B Virus (HBV) is a DNA virus that affects human liver cells. It can be either acute or chronic, with chronic patients at higher risk for developing issues such as liver damage and liver cancer. There are at least ten different HBV genotypes, each with slightly different characteristics that can affect treatment. This project aims to identify several cyclin-dependent kinase inhibitors (CDKi) that reduce the replication of HBV and then compare the response in HBV genotypes B and C. The Huh-7 cells were transfected with HBV genotype B and C respectively and then treated with CDK inhibitors Thz1, CCT068127, Seliciclib, and GW8510. The cell viability, HBV surface antigen (HBsAg) production, and pgRNA expression were analyzed to compare the two genotype's responses to the CDKi's. Interestingly, our preliminary results show that most of the tested CDKi's caused increased expression of the HBsAg. Thz1 showed some promise of decreasing HBsAg expression; however, it was toxic at the 1µM concentration. These results have indicated that CCT068127, Seliciclib, and GW8510 are ineffective at inhibiting HBV growth. Further testing of Thz1 at lower concentrations will be necessary to determine its effects at non-toxic levels, and more in vitro replicates are needed to confirm any findings.

Living Medicine: An Engineered Probiotic Approach for the Localization of Celiac Disease Therapeutics

SURF ID: 242
11:45 AM - 12:00 PM

*Nathan J. Tank, Rachel Zheng, Leopold Green**
**PI: Weldon School of Biomedical Engineering*

Keywords: Celiac, Synthetic Biology, Fur operon, Probiotic, Therapeutic, Molecular Biology

Celiac disease (CD) is an autoimmune disorder affecting approximately 1% of healthy, average Americans with symptoms caused by gluten peptides present in the small intestine. Though many promising treatment options have been discovered, localization of therapeutics has proven difficult, and engineered probiotic approaches are scarce. In this work, we designed and transformed novel genetic constructs into *E. coli*. which aim to secrete larazotide, an intestinal tight junction therapeutic, in response to ferrous influx which is present during consumption of gluten-containing foods. Sensing design was achieved by taking advantage of the fur protein natively expressed in *E. coli* and a signaling cascade for larazotide and peptidase expression utilizing the rpaI/R induction system. We used fluorescent reporter proteins to quantify the transcriptional activity of the iron-repressible promoter, Pfhua1, in response to iron chelation. Our results show that although transformed colonies grew on selective antibiotic plates, the effect of iron chelator on transcription remains unclear. The findings of this study will assist in future efforts in engineering a sensitive probiotic capable of localized therapeutic delivery.

Track E: Quantum Technology (WALC B058)

Verification of Single Photon Sources Through Latent Variables of Spectral Broadening

SURF ID: 161
10:00 AM - 10:15 AM

*Vaishnavi Iyer, Blake Wilson, Alexandra Boltasseva**
**PI: Elmore Family School of Electrical and Computer Engineering*

Keywords: Nanophotonics, quantum technology, nitrogen vacancy centers, spectroscopy, interferometry

In the past decade, advanced methods in solid state nanophotonics created a plethora of single photon sources using color centers such as nitrogen vacancy (NV) centers within nanodiamonds. However, current fabrication methods cannot enforce indistinguishability in spectral diffusion and other random properties of single photon sources, making them unfit for quantum computation. In this study, we take advantage of the difficulty in enforcing indistinguishability as a physical unclonable function, specifically with spectral diffusion, and use these properties as a form of authentication. Using simulated Landau-Zener-Stueckelberg (LZS) and Hanbury-Brown-Twiss (HBT) interferometry, we construct a generative model to learn the latent variables that parameterize the spectral diffusion of a single photon source and use these parameters as a source of verification. The experiments produce anti-bunched, squeezed and exponential photon packets with sub-Poissonian statistics to determine the probability of differentiating between single photon sources. This method can also be extended to other sources of physical randomness like photon shot noise.

Field Engineering in Quantum Storage

SURF ID: 181
10:15 AM - 10:30 AM

*Humbert Lai, YiSheng Lei, Mahdi Hosseini**
**PI: Elmore Family School of Electrical and Computer Engineering*

Keywords: Quantum storage, laser mode locking, high-voltage pulse

In a quantum storage lab, we require high-precision lasers in the wavelengths of photons they emit and high-voltage pulses with sharp edges and low noise to produce the most significant results. Due to the nature of lasers, their frequency is known to drift over time and causes a problem when trying to implement into experiments, reducing the laser intensity at required frequencies. Also, when working with high voltages and high frequencies, many electrical characteristics of the components change causing undesired inductance into the circuit. This introduces noise at radio frequencies to the output signal and could interfere with other electronic equipment in the lab. Thus, we will be looking at ways to (1) mode lock a laser at 780nm and (2) create a steady, low noise high voltage pulse/square wave. By doing so, we would be able to have a stable laser that won't drift over time to be used for experiments going on in the lab. Also, we would have a stable high voltage source with minimal noise to delay the echo and increase the storage time of quantum information. There are many aspects of a quantum lab that requires accurate equipment and measurements, so it is crucial for us to calibrate and adjust the setups carefully.

Compact Control System for Superconducting Qubits

*Santiago Lopez, Botao Du, Ramya Suresh, Alex Ruichao Ma**
**PI: Department of Physics and Astronomy*

SURF ID: 191
10:30 AM - 10:45 AM

Keywords: Quantum computers, superconducting qubits, QICK (Quantum Instrumentation Control Kit), FPGA (field-programmable gate array)

Superconducting qubits are one way to implement quantum computers with relatively long coherence times and tunable frequencies allowing for high readout fidelity. Pulse sending devices are being implemented to control, calibrate, and get information from superconducting qubits by sending fast, precise pulses. However, building these devices for implementing experiments is exceedingly expensive and is mainly affordable to larger corporate groups. This is not the only option as many groups can also build and program their control system, but this is time-consuming and can be hard to maintain or upgrade. Thanks to the development of the Quantum Instrumentation Control Kit (QICK) running these experiments have been made more affordable and accessible for academic labs and smaller companies. In this work, we set up a new control and readout system and developed the software to characterize single qubits with the short-term goals of conducting multi-qubit experiments with flux control. Through the characterization process, we will optimize the readout fidelity and use the QICK system as a robust, feasible device to introduce qubit characterization to beginners in the field. This will help in building the quantum community as well as provide a gateway for academic labs and startups to run their qubit experiments.

Realizing Ruthenium Trichloride Josephson Junction

*Amit Rohan Rajapurohita, Kiranmayi Dixit, Ramon Guerrero, Jhinkyu Chio, Arnab Banerjee**
**PI: Department of Physics and Astronomy*

SURF ID: 224
10:45 AM - 11:00 AM

Keywords: quantum computing, quantum spin liquid, quasi particles. superconductor, Josephson junction, fabrication, transport measurements, cryogenic.

$\alpha - RuCl_3$ has been under immense interest as a prime Kitaev quantum spin liquid (QSL) candidate which has implications in fault tolerant quantum computing. In spin liquids, the spins do not order at low temperatures, but can have interesting dynamics which provides us with the possibility of exotic quasi particles, Majorana fermions, which are topologically protected. Interestingly, quasiparticle excitation in superconductors have the same mathematical structure of the Majorana equation from their underlying particle hole symmetry. The perfect blend to observe their interaction is the Josephson Junction, two superconductors connected by a thin layer of QSL candidate material $\alpha - RuCl_3$. This study aims to further our understanding of this new phase of matter and realize its potential applications by exploring the experimental realizations and techniques involved in observing its interactions with electromagnetic fields and supercurrents. Performing this experiment involves two major steps, fabrication of the Josephson Junction and low-noise transport experiments in a cryogenic device to collect data at low temperatures where quasi-particles exist to study the coupling between the QSL and the superconductors. In this paper, we talk about the various experimental methods used to measure these interactions.

Towards Quantum Sensing of Thermoreflectivity

Hal Owens, Hamza Ather, Hosseini Mahdi, Ali Shakouri*
**PI: Elmore Family School of Electrical and Computer Engineering*

SURF ID: 217
11:00 AM - 11:15 AM

Keywords: Quantum, Sensing, Optics

Classical thermoreflectance imaging allows us to detect small changes in the temperature of microscopic circuits. However shot noise places a fundamental limit on the precision of such techniques. In practice this limits us to imaging circuits much larger than those which are feasibly manufactured. Due to this, along with many other potential applications in the field of imaging, there is significant interest in methods of performing sub shot noise level imaging. There exist a handful of theoretical sensing techniques which could enable such levels of precision. Using a single mode quantum correlated source we have demonstrated single point measurements of temperature below the standard shot noise limit. We were able to achieve this thanks to a quantum light source capable of producing spontaneous emissions of single-mode entangled photons. This kind of imaging technique may have a range of applications in different domains of microscopic imaging. Biology, engineering, and healthcare are among the fields for which this kind of technology could potentially have meaningful impact.

Identifying The Heisenberg Uncertainty Principle in Quantum Cognition

SURF ID: 104
11:15 AM - 11:30 AM

*Pranav Ahuja, Alok R. Chaturvedi, Arezoo Ardekani**
**PI: Department of Mechanical Engineering*

Quantum cognition is a relatively new field that applies quantum mechanics to human cognition. Many scholars contend that the human brain obeys quantum mechanics but does not follow many of its unique features. In this study, quantum algorithms were used to investigate two questions. (1) Does the Heisenberg Uncertainty Principle, the core of quantum mechanics stating that we can only know one aspect of a system precisely, apply to human cognition when answering survey questions and cause cognitive interference when answering the other question? (2) Does the order of questions have an effect on the outcome answer and cause a commute in probability calculation? We investigated the Heisenberg Principle within the human mind by mimicking the 2-slit experiment and asking two questions (A & B) between 10 and 15 people over four days. For the first two days, the participants were asked one of the two questions. On the third day, participants were presented with both questions, and we reversed the order of the questions for the fourth day. By changing the order of the questions, we expect to encounter interference in how the person would respond to the questions. We want to focus on the "interference" observed since it showcases that if one state (A) or (B) is fully active, then the second state (B) or (A) would be uncertain.

Keywords: Quantum computing, quantum mechanics, quantum cognition, Heisenberg uncertainty principle, superposition, quantum-enhanced machine learning (QEML)

Track F: Sensors & Microsystems (WALC B066)

Perfect Picture: Investigation of Eyecon2TM for In-line Dry-granulation Roller Compaction

SURF ID: 257
10:00 AM - 10:15 AM

*Lily C. Waterman, Rexonni B. Lagare, Yan-Shu Huang, Gintaras V. Reklaitis**
**PI: Davidson School of Chemical Engineering*

Continuous pharmaceutical manufacturing requires real-time monitoring of process variables, using technologies such as spectroscopic sensors and imaging systems to provide data to identify relationships between process variables, build mathematical models, and control and optimize manufacturing processes. In the case of manufacturing systems involving streams consisting of particles and granules, the shape and size of particles are known to impact particle flow and thus product quality. Still, there are no effective ways to monitor size and shape in real-time without a proper procedure for inline data collection. This study aims to develop a model that can relate the particle shape and size distributions to particle flow properties using inline, real-time data collection using the Eyecon2 sensor. The Eyecon2 is effectively a high-speed camera that takes images using three colors hues, and different light intensities and provides analysis of particle size distributions and average shape measurements. This study required RC parameters, data collection, and flowability characterization from numerous runs. Eyecon2's settings and procedures, including features such as an air purge, were manipulated to determine the camera settings for the most reliable images. Image analysis software was used to determine the shape, size, and other essential outputs with the ideal images captured with this new procedure. The Eyecon2 has the potential for inline applications to obtain shape and size distributions. Still, in its present state, it is not accurate enough for reliable real-time monitoring of size and shape. Several changes that are required to make Eyecon2 a success will be discussed in this paper.

Keywords: Pharmaceutical manufacturing, programming, camera analysis, shape distribution, dry granulation

Height Prediction in Particle Images Using deep Learning

*Baoxuan Tao, Pranshul Sardana, Zhengwei Chen, Steven Wereley**
**PI: School of Mechanical Engineering*

SURF ID: 243
10:15 AM - 10:30 AM

Keywords: Particle Height, Lommel Function, Simulated Data, PIV, Convolutional Neural Networks

Particle image velocimetry, also known as PIV, is a technology to study the flow field in fluid by observing the change in locations of tracer particles over time. Typically, a single camera is used and the information in a 2D plane is obtained. However, the particles can be at different vertical distances, which changes the shape of the particles (as defined by Lommel function). Current methods either fail to measure particle heights beyond a certain range (5 microns) or require a secondary camera. We use ResNet-styled convolutional neural networks to approximate the inverse Lommel function and learn the relationship between particle shape and dimensionless defocused distance as a regression problem. To train the neural network, synthetic images are generated by solving Lommel differential equations. By analyzing the synthetic images, it is observed that the distribution of intensity as a function of radial distance from the center of the pattern is determined by the dimensionless defocused distance, no matter how large the pattern is. The trained CNN models were able to determine the dimensionless parameters of the test datasets successfully. This study provides a novel approach to obtain the height of particle from a 2D image, which can be done algorithmically instead of requiring a second camera. Knowing the particle height complements the traditional planar PIV technology by adding information about the third dimension.

Applying Quanta Image Sensors to Real-World Imaging

*Akshat Bisht, Yash Sanghvi, Stanley H. Chan**
**PI: Elmore Family School of Electrical and Computer Engineering*

SURF ID: 117
10:30 AM - 10:45 AM

Keywords: Quanta image sensor, image sensors, low-light imaging, CMOS, digital photography

The standard CMOS Image Sensors (CIS) has become the most prevalent image sensor among personal computing devices, it is found in phones, laptops and nearly all modern digital cameras. CMOS sensors have a high read noise making it difficult to extract details from scenes with low-light. Quanta image sensors (QIS) are a suite of photon-counting sensors that have a low read noise and strive to solve this problem. QIS sensors oversample binary frames creating large amounts of data which allows for high quality image reconstruction in low-light settings. However, this results in large data throughput on the order of tens of terabits per second. In order for QIS technology to be widely adopted in real-world imaging it must be computationally efficient to run on an edge device in real time. By selecting specific algorithms to run in parallel we are able to reduce computational complexity, making it possible for QIS to generate a video feed. Our contributions in this project include the use of a customised image processing pipeline using non-iterative image reconstruction and de-noising on an NVIDIA Jetson with the CUDA platform to operate a live feed demonstrating QIS in the real-world on an edge device.

Implementing Smart Sensing and Digital Twin for Automated Machining Coolant Delivery System

SURF ID: 262
10:45 AM - 11:00 AM

*Zekun Wu, Eunseob Kim, Martin Byung-Guk Jun**
**PI: School of Mechanical Engineering*

Keywords: IoT, smart manufacturing, machine sensing, digital twin, web-based monitoring

The advances in big data analytics, cloud computing, artificial intelligence, and IoT (the Internet of Things) enable the further development of smart manufacturing. To have smart decision-making in a manufacturing process, smart sensing and digital twin techniques are necessary for an efficient and meaningful way. A digital twin for the automated machining coolant delivery system was created to enable real-time, remote monitoring by a web-based interface. The target system is the FlexxCool CNC (Computational Numerical Control) coolant pumping and storage system for three CNC machines in IMT (Intelligent Manufacturing Testbed) of IMI (Indiana Manufacturing Institute). To make live data streams from the PLC (Programmable Logic Controller), the MTConnect framework was employed as a middleware for the digital twin. In addition, a power meter that functions Modbus RTU protocol was deployed to the system to measure the power consumption of the system. Live data from the system were retrieved via OPC UA communication protocol and were piped through the MTConnect adapters on an edge computer. The piped data from the PLC and the power meter were received by an MTConnect agent and collected into a MySQL database. Subsequential data processing was performed and prepared for a web-based dashboard using the Grafana interface. As a result, this project created a unidirectional, physical-to-virtual machine sensing method for CNC machines' coolant monitoring system so that the end users can see the status and sensor data of the system in real-time and remotely. It also provided a working base for constructing a bi-directional digital twin for all CNC machine functionalities.

Human Computer Interface Coupling for Complex Extraterrestrial Habitat Systems

SURF ID: 247
11:00 AM - 11:15 AM

Corey Tolbert[1], Chuanyu Xue, Zixu Zhang, Paul Parsons, Ilias Bilionis[†]*
*[1]Rice University *Co-PI: Department of Computer Graphics Technology [†]Co-PI: School of Mechanical Engineering*

Keywords: Extraterrestrial habitats, simulation, human-computer interface, human factors

Extraterrestrial ventures are complex and costly, as the environment of space is harsh and wholly unlike the conditions on Earth. Thus, modeling and simulating the space environment is crucial to mission success, especially when designing long-term, resilient habitat systems. Human factors are also essential to consider when testing habitat systems, to see how people respond to various off-nominal scenarios and ensuring that they can interact with the system in an effective and efficient manner. Thus, we seek to enable human interaction with a virtual habitat system mid-simulation, enabling human agents to make requests and send commands, as well as view how their decisions impact the habitat system. We integrated a visual interface with a data repository of telemetry points and connected the data repository to the virtual habitat system. In addition, we reconfigured the virtual habitat system to allow for more comprehensible communication with the temperature and pressure control modules. Through these human interaction modes, we tested the dynamic responses of the system when given human-generated values at arbitrary times during the simulation and found that it was sufficiently capable of adapting to human requests. This work proves that integrating human-controllable modules is useful for testing dynamic habitat system responses and paves the way for future research about human computer interaction for complex, extraterrestrial habitat systems.

Track G: Electronics and Computer Architecture (WALC 3084)

Implementation and Benchmarking of Branch Prediction on a RISCV Processor

SURF ID: 101
10:00 AM - 10:15 AM

*Humza S. Abdali[1], Cole A. Nelson, Mark C. Johnson**
*[1]New Jersey Institute of Technology *PI: Elmore Family School of Electrical and Computer Engineering*

Keywords: Branch prediction, computer architecture, RISC-V, branching, pipelining

Control speculation is a key performance optimization in modern high-performance processor design. The AFTx06 is a system on chip designed by Purdue University's System on Chip Extension Technology (SoCET) team. It is created using the System Verilog hardware description language and runs programs written in the RISC-V assembly language. RISC-V is an open source instruction set architecture that is free to use, unlike others that charge royalties for hardware and software deployments. This has skyrocketed the use of RISC-V in academic and hobbyist projects. The AFTx06 platform uses pipelining to split instructions into a fetch stage and an execute stage. These stages can occur in parallel, such that one instruction is executed while the next instruction is being fetched, increasing instruction throughput at the same clock frequency. This can fail if the computer does not know what the next instruction will be, as happens when performing a conditional branch. The next instruction is unknown and cannot be fetched until the branch instruction has finished execution, stalling the pipeline. Branch prediction methodologies were studied and catalogued based on accuracy, and select predictors were then implemented onto the preexisting AFTx06 chip, then evaluated using the Embench benchmarking suite. Future research will be required for new AFT chips as well as new implementations of AFTx06 to benchmark predictors for the new platform and adjust accordingly, as well.

Assessment of the Hybrid Zonotope Toolbox for Safety Verification of Linear Hybrid Systems

SURF ID: 209
10:15 AM - 10:30 AM

*Kasidit Muenprasitivej, Trevor J. Bird, Neera Jain**
**PI: School of Mechanical Engineering*

Keywords: Reachability Analysis, Hybrid Systems, Safety Verification, Hybrid Zonotope, Mixed-Logical Dynamical Systems

Reachability analysis is an effort to determine all possible states that are reachable by a dynamical system from a given set of initial states and admissible inputs. Many popular toolboxes for reachability analysis (e.g., CORA, SpaceEx, JuliaReach, and HyDRA) utilize convex methods to approximate reachable sets, providing computational efficiency at the cost of reduced accuracy. The *Hybrid Zonotope Toolbox* is a MATLAB-based toolbox which utilizes a newly-introduced set representation, called *hybrid zonotopes*, that can represent non-convex reachable sets of a broad range of dynamical systems, including hybrid systems, exactly in a computationally tractable way. Hybrid systems are dynamical systems with continuous dynamics described by differential equations, and discrete dynamics described by logic, making reachability analysis for such systems particularly challenging. This project explored the trade-off between accuracy and efficiency of the Hybrid Zonotope Toolbox and compared its performance with the pre-existing techniques. To reach consensus among aforementioned toolboxes, four standardized benchmark problems proposed in *Applied Verification for Continuous and Hybrid Systems 2021 competition* were selected and derived into Mixed-Logical Dynamical models, which are utilized by Hybrid Zonotope Toolbox to find reachable sets in the category of hybrid systems with linear continuous dynamics. Based on the benchmarking results, the Hybrid Zonotope Toolbox determined true reachable sets with a linear-growth in representation complexity, while other toolboxes experienced exponential-growth, which can quickly become intractable if approximation methods are not adopted. These results demonstrate the utility of the Hybrid Zonotope Toolbox for rigorous safety verification and applications that require exact reachable sets.

An Exploration of Pulsed Laser Single Event Effects Testing for Orbital Electronics

SURF ID: 118
10:30 AM - 10:45 AM

Trent W. Bloor, Allen Garner, Peter Bermel*, Charles Grey*
**Co-PIs: Elmore Family School of Electrical and Computer Engineering*

With over 7,000 satellites currently orbiting Earth and more than 1,000 new satellites going into orbit each year, satellite development is more relevant than ever. Traditionally, testing satellite electronics for radiation tolerance requires cumbersome and expensive methods like linear accelerators to mimic orbital radiation damage. Recently, pulsed laser radiation testing has become more common as its cost and time requirements have made it more accessible; however, even then, setups can still cost upwards of $100K. This project investigates the components of pulsed laser radiation testing setups with the aim of increasing the technology's accessibility. The primary cost barrier for this method of testing is the laser used for testing itself. Using several novel approaches to pulsed laser testing including two photon absorption-based systems and specific lenses like axicons to increase accuracy, the traditional setup can be modified, increasing its scope of use, while maintaining testing integrity. Using these methods, this project aims to construct an accurate pulsed laser testing setup while prioritizing affordability and accessibility. This project compares results of previous works detailing approaches of modifying pulsed laser single event effects testing and aims to propose a working design for a pulsed laser radiation testing system with an estimated parts and assembly costs to improve accessibility.

Keywords: Single event effects, single event transients, pulsed laser radiation testing, orbital electronics testing, radiation hardened electronics

Earth Radiation Effects on Analog/Digital and DC-DC Power Converters

SURF ID: 132
10:45 AM - 11:00 AM

Kayla M. Comer, Charles Grey, Peter Bermel, Allen Garner**
**Co-PIs: Elmore Family School of Electrical and Computer Engineering*

Radiation can cause unexpected failure or limit lifetime for devices on satellites orbiting Earth. Understanding the radiation environment and its effects may improve operational lifetime, possibly extending mission durations, and optimize shielding, minimizing cost and weight of materials. This project aimed to understand effects of Earth's radiation on three devices by comparing past test reports to the radiation environment, simulated by the Space Environment Information System. The devices–the LTC1272 analog-to-digital converter (ADC), AD5334 digital-to-analog converter (DAC), and AFL12028SX/CH DC-DC power converter–were highlighted as candidate spacecraft electronics by NASA and were chosen for their detailed test results and continued use in commercial electronics. Primary metrics for radiation damage are total ionizing dose (TID) to measure ionizing damage and single-event effects (SEEs) to measure transient performance effects. TID and SEEs were simulated over 1-20 years using 8 mm of aluminum shielding for Low, Medium, and Geostationary Earth Orbits (LEO, MEO, and GEO) and compared to past device reports. The LTC1272 ADC is unlikely to survive in any orbit for a reasonable duration due to SEEs and TID effects on the effective number of bits and differential non-linearity (DNL). The AD5334 DAC could survive in LEO but would fail in MEO or GEO due to SEEs and the effects from TID on DNL. The AFL12028 DC-DC converter was least sensitive to radiation damage and could likely survive in any orbit, but synchronization of multiple converters would not be possible in MEO due to TID damage.

Keywords: Earth radiation, spacecraft electronics, total ionizing dose, single-event effects, analog-to-digital, digital-to-analog, DC-DC

Wake Word Program for a RISCV Vector Processor

*Dilay Aygun, Cole A. Nelson, Mark C. Johnson**
**PI: Elmore Family School of Electrical and Computer Engineering*

SURF ID: 112
11:00 AM - 11:15 AM

Keywords: Edge applications, neural networks, model training, wake word

With today's ever growing and developing world, artificial intelligence and machine learning have become an indispensable part of our lives, hence the need for high efficiency and optimized electronics is augmenting relentlessly. Thus, one of the biggest challenges for edge applications is ensuring quick execution and response times by the systems developed alongside with low-processing power and memory footprint. One of the most relevant instances for this case is automated vehicles, where response time has the potential of saving lives. This project's focus is hardware and software optimizations to improve performance of ML applications on future iterations of the custom RISC-V micro-controller (AFTx06) developed by SoCET.To get the most performance out of AFTX06 software, it has been decided that we can challenge the micro-controller's processing abilities by running a wake-word trained model that will be established from custom coded neural network developed by this project. Furthermore, the hardware optimization constitutes of micro-architectural improvements to the vector extension implementation. With these methods, this project's main goal is to improve performance of ML applications and demonstrate this improvement on the target applications being developed. Another aspect of this project is to accelerate the advancements of AFX06's design both for hardware and software in order to run even more memory-dense and processing-dense programs for future iterations of SoCET micro-controllers.

Track H: Robotics 2 (WALC B093)

Software-In-The-Loop Simulation of UAS-UGV Cooperation in Precision Agriculture

*Saron Bhoopathy, Kenta Hirashima, Varun Aggarwal, Aanis Ahmad, Dharmendra Saraswat**
**PI: Department of Agricultural and Biological Engineering*

SURF ID: 115
10:00 AM - 10:15 AM

Keywords: Ros2, gazebo, px4, mavlink, unmanned aerial system, unmanned ground vehicle, precision agriculture

With the growing human population and labor shortages during critical farm operations, modern farms are expected to maintain larger yields at lower costs despite facing reduced labor availability. Studies have shown potential for Unmanned Aerial Systems (UAS) and Unmanned Ground Vehicles (UGV) to cooperatively perform farm operations and help farmers address these challenging issues. However, a collaborative system capable of autonomous crop scouting is still lacking. Furthermore, testing software and algorithms in simulated environments before real-world implementation is needed to avoid damage to expensive equipment. This project aims to develop a simulation environment for evaluating cooperative algorithms for UAS-UGV systems in agriculture. The simulation environment was developed using Robot Operating System 2 (ROS2) software framework, PX4 flight controller firmware, Gazebo 11 simulator, and QGroundControl ground station software. Computer vision was enabled on UAS using the You Only Look Once (YOLO) object detection algorithm. Communication between UAS, UGV, and the ground station was implemented using the MAVLink communication protocol. Preliminary results indicate that a scouting UAS successfully sends location coordinates of a target of interest to UGV in a simulated corn field. Overall, the project provides a viable simulation of cooperative agricultural robots that other researchers can use to evaluate their systems. Further, using open-source packages ensure seamless deployment of software and algorithms to physical systems with minimal code changes.

Discover the Vine Robot Locomotion Through Constrained Environments

*Quqi(Olivia) Zhang, Francesco Fuentes, Laura Blumenschein**
**PI: School of Mechanical Engineering*

SURF ID: 274
10:15 AM - 10:30 AM

Keywords: Vine robot, constraint modeling, soft robot, data modeling.

Unlike traditional robots with fixed joints and links, soft robots adapt to their environment passively using compliant materials. One specific type of soft robots, vine robots, were inspired by the growth of trailing vines. Possessing the ability to grow in a complex environment, vine robots have applications in search and rescue, space, and human assistance. This study focused on understanding the tip-centered growth of the vine robot, which is where the robot unfolds from the tip of the body using continuously applied internal pressure. Due to the complex wrinkling of its tip, researchers have not yet fully understood vine robot locomotion when passing through constraints. As such, we performed experiments to understand the relationship between growth pressure and shape of the constraint. The base of the robot was designed and implemented using a motor that allows the robot to continually grow at a set speed, supplying materials at its tip. Gaps with distinct parameters were 3D printed. We measured the tension experienced by the tip, the applied pressure, and the robot extending length (measured by encoder ticks of the motor) for each constraint experimental test run. As a reference for unconstrained growth, we also obtained the free growth data sets. In the end, the unique effects of different constraints on vine robot were discovered and elucidated. These data sets will help develop the kinematic equations of growing robots, which will further enhance the understanding of the full capabilities of vine robots.

Feeling Wired: Robotic Cable Routing using Visuo-Tactile Sensors

*Harrison McCarty, Raghava Uppuluri, Wenzhao Lian, Yu She**
**PI: School of Industrial Engineering*

SURF ID: 202
10:30 AM - 10:45 AM

Keywords: Robotic manipulation, cable routing, deformable objects, machine learning

Robotic manipulation of deformable objects has received attention in the last few years due to its overwhelming complexity and importance towards working in unstructured environments. Many manipulation techniques for rigid objects fail to transfer to deformable objects. Cable routing is one task that falls within the category of deformable object manipulation and applies to manufacturing settings. In this task, a robotic manipulator inserts a wire and routes it through a series of fasteners and physical constraints. Prior work completed this task in an unconstrained operating space, using external vision systems to decompose the environment into a simple, spatial representation then performed repeated pick-and-place primitives. However constrained operating-spaces, such as routing within a container, poses multiple challenges to this technique. Mainly its inability to rely on repeated manipulation primitives, since they fail to generalize to new operating-space constraints. To overcome this challenge, this work introduces the usage of an additional visuo-tactile sensor, known as GelSight, to learn robust routing primitives. Combined with prior planning and perception techniques, this study seeks to understand the improvement in a system's ability to generalize to constrained operating-spaces for the cable routing task.

Simulation Worlds to Assist the Generation of a Simulated Event Camera Dataset for Vision-based Autonomous UAV Navigation

SURF ID: 225
10:45 AM - 11:00 AM

*Samitha B. Ranasinghe, Amogh S. Joshi, Chamika M. Liyanagedara, Kaushik Roy**
**PI: Elmore Family School of Electrical and Computer Engineering*

Keywords: Event-Based Cameras, Vision-Based Navigation, Synthetic Dataset, Dynamic Gazebo Simulation

Event cameras which measure changes in brightness and not absolute illumination like traditional cameras are increasingly being used for machine learning algorithms on visual perception due to the numerous advantages. However, existing labelled datasets for developing and testing event-based algorithms do not contain all ground truths required for autonomous navigation and have relatively lower resolution due to hardware limitations. A separate work is producing a simulation-based dataset for UAV navigation with a variety of indoor and outdoor sequences that would consist of event, depth, IMU, and frame data. The use of simulation worlds would allow the inclusion of all ground truth, either directly sensed or post-processed, with data of much higher resolution. However, an accurate and usable simulation-based dataset requires extremely realistic and dynamic simulation worlds that includes models with adjustable textures to allow generation of accurate ground truth. This study focuses on building a set of dynamic and realistic worlds which consists of custom objects modelled after real world objects. Several methods for producing the indoor worlds are compared and the procedure for modeling the physical characteristics of the real-world UAV used for the project is shown. The result of the study includes an accurate indoor world of the third floor of the Purdue Electrical Engineering Building and a realistic four-way intersection.

Autonomous Exploration and Mapping of Unknown Environments Using Multiple Robots

SURF ID: 260
11:00 AM - 11:15 AM

*Dulani N. Wijayarathne, Abolfazl Hashemi**
**PI: Elmore Family School of Electrical and Computer Engineering*

Keywords: Multiple robots, autonomous, mapping, exploration, unknown environment

Multiple robots collaborating on a certain autonomous task increase the efficiency and accuracy compared to a single robot. This project investigates how to successfully utilize multiple robot agents to collaboratively perform tasks in an unknown environment with communication restraints. A multi-robot mapping algorithm operated by ROS (Robotics Operating System) was tested in a virtual gazebo environment using turtlebot3 as robot agents. The algorithm utilizes SLAM (Simultaneous Localization and Mapping) and RRT (Rapid-exploring random tree) algorithms to autonomously create a merged map of that environment unknown to each robot. The algorithm was optimized to merge the maps produced by each robot, without the knowledge of the robots' initial positions on the global map. After the proof of concept in the simulated gazebo environment, the algorithm was then tested on two real turtlebot3 robots. The raspberry pi camera of the turtlebot3 is used to produce a video recording of each robot's exploration. To understand the benefits of multiple robots collaboration we compared the time taken and the accuracy of the map created by two turtlebot3 robots to the map created using a single turtlebot3. The results verify that multiple robots are more efficient and accurate in exploring and mapping than a single robot. A potential application for multiple robot map merging includes mapping uncharted territory to better understand the topography and any hazards without risking human lives.

Day 2 — Afternoon Presentations

July 29th, 2:00 PM – 4:00 PM EDT

Track A: Material Modeling & Simulation (WALC 3138)

Pick and Roll: Impact of Roller Compactor's Parameters on Ribbon Properties

SURF ID: 236
2:00 PM - 2:15 PM

*David J. Sixon, Yan-Shu Huang, Rexonni B. Lagare, Gintaras V. Reklaitis**
**PI: Davidson School of Chemical Engineering*

Keywords: Roller compactor, ribbon splitting, ribbon density, dry granulation, continuous manufacturing

Dry granulation is a common process for making solid oral dosage tablets (pills), which are used every day by millions of people. Dry granulation involves mixing raw ingredients and compressing them into tablets. In some cases, the ingredient powders are too different in size and density to be effectively compacted into tablets. A roller compactor is needed to create larger particles of more uniform size (granules). The roller compactor works by pressing the blended powders into a thin ribbon and then crushing/milling that ribbon into granules of the desired size. Therefore, to create the granules, the properties of the ribbon must be understood. The purpose of this research is to investigate the connection between different parameters on the roller compactor and the properties of the resulting ribbon. An Alexanderwerk WP120 Roller Compactor was tested for several parameters, including hydraulic pressure, roll gap, and roll speed. The resulting ribbons were measured for density and thickness, as well as classified as split or not-split. Using multiple linear regression, the elasticity seemed to be impacted the most by roll gap in split and not-split ribbons. For the ribbon density, multiple linear regression showed that roll gap again had the largest effect, but the other two parameters were more involved than in elasticity. Finally, in the thickness distribution, the split ribbon had a larger variation than the not-split ribbon. The possible connection between roller compactor parameters and ribbon properties should give manufacturers more control over and further improve the granulation process.

A Fast Approach to Estimate Nonlinear Valve Plate Deformation in Axial Piston Machines

SURF ID: 269
2:15 PM - 2:30 PM

Austin Zapata, Nathan Hess, Lizhi Shang, Swarnava Mukherjee*
**PI: School of Mechanical Engineering*

Keywords: Tribology simulation, nonlinear deformation, lubricating film, fluid power

Designing efficient hydraulic pumps and motors requires accurate simulation of lubricating interfaces and fluid-structure interaction, where the calculation of the solid part pressure deformation plays an important role. State-of-the-art models use methods only able to capture pressure deformation based on the assumption that the relationship is linear. However, realistic deformation comprises nonlinear characteristics due to separation between two solid bodies. The goal of this study is to propose an inexpensive solver for nonlinear pressure deformation. This study compares three methods for computing deformation within the cylinder block-valve plate interface of an axial piston pump. The highest-fidelity approach leveraged a commercial finite element method (FEM) solver, which allowed nonlinear deformation to be considered. The second approach calculated deformation considering only the linear component using an influence matrix, as done in state-of-the-art tribology models. The third approach, the novel method proposed by this study, decomposed the total pressure into two components: a reference pressure distribution considering only diffusive terms of the Reynolds equation, and the remaining residual pressure. Nonlinear deformation was computed for the reference component and linear deformation for the residual component. Then, the solutions were superimposed to estimate total deformation. Results showed that the proposed approach was able to capture the shape and magnitude of the deformation distribution generated by the commercial FEM solver more accurately than the influence matrix method. This demonstrates the feasibility of accurately estimating nonlinear deformation in lubricating interfaces without the need for a coupled, nonlinear pressure-deformation solver, providing a faster method for computing nonlinear deformation.

X-Ray Fluorescence Spectral Analysis for In Vivo Bone Lead Measurement

*Anders Johnson, Alexis N. Webb, Linda H. Nie**
**PI: School of Health Sciences*

SURF ID: 166
2:30 PM - 2:45 PM

Keywords: X-Ray Fluorescence, spectral analysis, in vivo bone lead quantification

X-Ray fluorescence (XRF) is an analysis technique used to determine the elemental composition of a sample. In our lab, advanced XRF systems including a cadmium-109 induced K-shell system are used to quantify lead (Pb) concentrations in human tissues in vivo. Because Pb accumulates in bone over time, bone Pb is the best biomarker to assess long term Pb exposure and to study the related chronic health effects such as neurological impairment. In order to extract concentration values from the XRF machine's spectral output, in house analysis software was developed to fit the X-ray energy peaks in the spectrum and to determine the corresponding Pb concentration. The software is inconvenient and was designed for 32-bit computers using Fortran. To optimize the analysis, new code has been written in MATLAB to perform curve fitting algorithms and a calibration procedure. The peak fitting involves gaussian curves for the net peak and exponential curves for the background. Net counts from in vivo measurements determine bone Pb concentration using an established calibration line correlating counts to concentration. The new curve fit appears functional as the fit error statistics are relatively low, but the final concentration values given do not match the Fortran version. However, the process of analyzing the files is much more efficient and user friendly. Moving forward, performing the fit portion exactly as done in the Fortran code is the best course of action to achieve results that match those from the old program and take advantage of the new software improvements.

Flowability Prediction Using Granule Size and Shape Distributions

*Craig O. Bush, Rexonni B. Lagare, Yan-Shu Huang, Gintaras V. Reklaitis**
**PI: Davidson School of Chemical Engineering*

SURF ID: 122
2:45 PM - 3:00 PM

Keywords: Particle size distribution, material processing and characterization, pharmaceutical manufacturing, powder flowability, chemical unit operations

When operating a roller compactor, it is important to monitor the granules produced. Different operating conditions produce granules with different sizes and shapes. The size and shape distributions affect the flowability of the granules. Flowability, or how well a powder flows, plays a key part in tablet production, as granules need to flow easily into the tablet dies. Prior studies have shown a relationship between the size and shape of granules and their flowability. Knowing that size and shape of granules and flowability are related, the goal would be to predict flowability from the granules' size and shape in real time. Tablet making is a continuous process, hence, taking measurements while running the process is key. Unfortunately, there is no technology available to predict flowability in real time. This study aims to predict flowability from shape and size distributions of the granules through the analysis of size and shape distribution data. Powders were processed by the roller compactor under different operating conditions to generate different granules. Each batch of granules was characterized using various tools to identify key factors, such as flowability, and relate them to size and shape. The results from these experiments should prove that flowability can be predicted from the size and shape of granules. Being able to predict flowability from the size and shape of granules can lead to the development of a virtual sensor that can predict flowability in real time and integrated into a feedback control system, maintaining the desired flowability during continuous operation.

Assessment of Collisions in Crossed-Field Devices

SURF ID: 177
3:00 PM - 3:15 PM

*Allison M. Komrska, Lorin I. Breen, Amanda M. Loveless, Keith L. Cartwright, Allen L. Garner**
**PI: School of Nuclear Engineering*

Keywords: Crossed-field, diode, Hull cutoff magnetic field, magnetic insulation

Crossed-field diodes (CFDs), characterized by an applied magnetic field perpendicular to the electric field induced by the voltage drop across the anode-cathode gap, are used in multiple high-power applications. A critical quality of CFDs, the Hull cutoff magnetic field (HCMF), represents the maximum applied magnetic field that enables an emitted electron from the cathode to reach the anode. The traditional HCMF assumes a vacuum planar diode; however, actual devices do not operate at perfect vacuum. This study investigates the effects of incorporating collisions into electron trajectories in CFDs by introducing electron mobility, which represents particle collisions and recovers perfect vacuum conditions as it approaches infinity. We use numerical solutions of the electron force law and particle-in-cell simulations (XPDP1) to assess electron motion for various electron mobilities. For magnetic fields above the HCMF in vacuum, reducing the electron mobility increases the excursion distance of an electron. For finite electron mobility, electrons always cross the gap, so the HCMF condition corresponds to the minimum magnetic field for electrons to loop prior to crossing the gap. Reducing mobility below $\sim$21 C s/kg eliminates the HCMF condition, causing electrons to traverse the gap without looping. We derive the magnetic field, mobility, and electron transit time corresponding to this state by solving for the condition when electron velocity in the direction across the anode-cathode gap goes to zero at the anode. Reports from a parametric study of these conditions using theory and XPDP1 will be generated under different gap distances, voltages, and magnetic fields.

Development of a Virtual Cyber-Physical Testbed for Resilient Extra-Terrestrial Habitats and Real-Time Hybrid Simulations

SURF ID: 182
3:15 PM - 3:30 PM

*Jose E. Lara, Herta Montoya, Christian E. Silva, Shirley J. Dyke**
**PI: Lyles School of Civil Engineering*

Keywords: RTHS, control Systems, extra-terrestrial Habitats, autonomous structures

Developing settlements capable of tackling humanity's interplanetary needs in extra-terrestrial environments will be a pillar of success in society's venture into space. Establishing a self-sustainable habitat requires thorough research and testing, as these systems cannot be allowed to fail once in use. As such, we sought to test the viability and resilient capabilities of an extra-terrestrial habitat model using real-time hybrid simulation (RTHS) techniques, to understand the limitations of proposed structural systems better. This paper presents the problem definition and guidelines for developing a virtual cyber-physical testbed (vCPT) to validate and justify the design of a physically realized CPT capable of simulating the complex systems involved in an extra-terrestrial habitat. The CPT framework will consist of numerical representations of systems understood with a high level of detail that interact in control loops with physical specimens, which introduce realistic behaviors and uncertainties other than modeling. In addition, the hybrid model, must be able to show the habitat's quantized responses to disturbance events, such as meteorite impacts, dust accumulation, solar radiation, moonquakes, shuttle launches and fires. Designing a vCPT will help determine control requirements for a real RTHS within a completed CPT. The CPT will, in turn, help establish the viability of autonomous extra-terrestrial habitats with autonomous capabilities so that living conditions can be safely preserved as needed.

Track B: Environmental Characterization (WALC 2051)

A Methodology for Quantifying Infant Dust Ingestion Rates

*Lekha Durai, Brian Magnuson, Satya Patra, Chathura Viswanath, Brandon E. Boor**
**PI: Lyles School of Civil Engineering*

SURF ID: 135
2:00 PM - 2:15 PM

Keywords: Dust exposure, human movement, infant crawling, hand pressure

Infants spend much of their time near the floor and are thus largely in contact with dust. Dust contains melamine, volatile organic compounds, bacteria, and other components that can harm infant health. The effects of walking and crawling on dust accumulation in human breathing zones have been studied. However, attempts to simulate infant motion based on infant physical traits and the contact impulse of crawling infants are lacking. We modeled the movement of 6- to 24-month-old infants, ensuring dust contact transfer and dust ingestion rates for infants could eventually be determined. Physical properties of infants during crawling, such as the approximate forces and pressures exerted and the hand speeds, were calculated. We also developed and applied a procedure for minimizing the effects of external factors on the quantity and quality of collected dust. All dust collection materials were weighed multiple times, measures of the room's condition were recorded, and the weight and room condition data were analyzed to ensure there was consistency. In summary, we provided measurements, including high hand-to-floor contact velocities and low hand-to-floor contact times, to be incorporated in the design of a robotic platform that would recreate the approximate motion of a crawling infant's hand to ultimately quantify infant dust ingestion and inhalation rates. Additionally, we demonstrated a procedure for preparing dust collection materials to maximize the accuracy of measurements of collected dust taken from a large sample of US homes.

Influence of Plumbing Material, Stagnation Time, and Flow Rate on Biofilm Prevalence

*Rylan G. Elliott, Caitlin R. Proctor**
**PI: Division of Environmental and Ecological Engineering, and Department of Agricultural and Biological Engineering*

SURF ID: 138
2:15 PM - 2:30 PM

Keywords: Biofilm, plumbing, stagnation, management, removal, drinking water

Plumbing systems are prone to biofilm growth along pipe walls. Understanding the role of biofilm in drinking water systems is essential to addressing public health concerns for drinking water since biofilm provides a safe environment for certain pathogens. This study aimed to understand biofilm-water interactions in plumbing related to stagnation, plumbing material, and flow rate, with a focus on the small diameter pipes common in the final meters of plumbing. This was accomplished with a unique plumbing simulation rig that flowed drinking water through common plumbing pipes with different materials and diameters. Water was stagnated in the system for various periods of time and samples were drawn through both high flow and needle extraction. Flow cytometry was used to quantify total cell count (TCC) and intact cell count in the water (ICC). Flow rates were increased in phases to determine if high flowrate flushing can effectively remove biofilm. Results showed extended stagnation correlated with increased TCC and ICC. Furthermore, material selection of plumbing appeared to greatly effect TCC and ICC upper limits for all stagnation intervals. Results suggested that higher flow rate flushes through these plumbing systems only minorly reduced the upper limit of TCC and ICC in the water for all given materials. During the flush, with increasing time the TCC and ICC greatly decrease with low ICC present. This research indicates that flushing may not be effective for removal of biofilm in small diameter pipes and that more creative methods of biofilm removal are needed.

An Investigation of Polymer Composites Commonly Used To Repair Water Infrastructure

SURF ID: 123
2:30 PM - 2:45 PM

*Sydney N. Butler[1], Pritee Pahari, Andrew J. Whelton**
*[1]Howard University *PI: Lyles School of Civil Engineering, and School of Ecological and Environmental Engineering*

Keywords: Plastic; VOC; Styrene; Epoxy; Composite; Drinking water

Plastics are increasingly being used for sewer and drinking water pipe repairs and cured in place pipe (CIPP) is one such technology growing in popularity due it is speed and low cost. To better understand the environmental and human health impacts of CIPP caused air pollution, the chemical composition of the resins used to create the new CIPPs and chemical residual left inside the new plastic needs to be better defined. Previous investigators have found material safety data sheets (SDS) do not describe the totality of hazardous air pollutants and other toxicants in CIPP resins or generated during CIPP manufacture. This study focused on better understanding the chemical composition of styrene-based (sewer) and nonstyrene-based epoxy (potable water) resins and CIPP composites. Volatile organic compounds (VOC) present in the resin and remaining in new CIPPs due to optimum and sub-optimum manufacturing conditions were explored. The styrene-based CIPP was manufactured with one initiator while two sets of epoxy based CIPPs were manufactured with a single resin, but each with a different hardener. A gas chromatograph mass spectrometer was applied to tentatively identify the compounds detected in the composites that were extracted into dichloromethane for a minimum of 72hrs. Chemicals identified included bi-phenol A biproducts, glycidyl 2-ethylhexyl ether, heptane, and benzyl alcohol were present in the non-styrene-based epoxy composite after curing. A compound found in both materials is phenol, 4,4-(1-methylethylidene) bis. While the compounds found in styrene-based resin after curing included more VOCs at emissions less than 8wt

Characterization of Particulates in Indoor Environments for Infants

SURF ID: 195
2:45 PM - 3:00 PM

*Brian H. Magnuson, Lekha A. Durai, Satya S. Patra, Chathura Viswanath, Brandon E. Boor**
**PI: Lyles School of Civil Engineering*

Keywords: Indoor environments, infants/children, motor development, particulates, chemicals, exposure

The key periods of infant motor development can be negatively and permanently affected by the exposure to, and ingestion of, harmful substances found in household dust. The physical and chemical characteristics of dust and other particulates found in indoor environments can be used to determine the specific infant ingestion rates and surface transfer behaviors. The experimental procedure is divided into three key processes, which are sample collection, sample characteristic analysis, and surface transfer analysis. A standardized vacuuming method will be used for collecting samples from infant-occupied urban and suburban homes around the U.S. Dust samples will be sifted for fibers and analyzed to determine characteristics such as mass, density, particulate size, and chemical composition. Following the sample collection, an environmental chamber will house surface transfer experiments, which will employ a robotic platform with the collected household dust samples to simulate the resuspension and surface transfer of dust in interactions between surfaces and objects. The finalized dust sample collection method has a performance efficiency of 95-97% and by using ISO test dust as a reference baseline, the characterization of dust samples is the most accurate when Isopropyl Alcohol is used as the dispersant with no sonication in the Mastersizer 3000 Particle Size Analyzer. Based on these results, this project expects to provide comprehensive data about the characterization of dust in indoor environments and identify the mechanistic behaviors of surface transfer for dust and other particulates, which will contribute towards the EPA Exposure Factors Handbook.

Development of an HPLC Method for Carotenoid Analysis

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**PI: Department of Agricultural and Biological Engineering*

SURF ID: 105
3:00 PM - 3:15 PM

Keywords:
High-performance liquid chromatography, carotenoids, beta-carotene, astaxanthin

High-performance liquid chromatography (HPLC) is a widely used analytical technique to identify components within solubilized samples, which are pumped through a packed column and analyzed by an external detector. Proper HPLC use requires careful selection of a method, or a set of conditions under which compounds of interest can be singled out. This study investigated HPLC method development for the detection of carotenoids in bioethanol production corn remnants. A reverse-phase HPLC two-solvent system consisting of 98:2 methanol/1M ammonium acetate (v/v) as Solvent A and 100% ethyl acetate as Solvent B was used for analysis. An initial flow rate of 0.37 mL/min and linear gradient from solvent A to B was selected. The HPLC analytical system was composed of a Waters 2695 Autosampler, a Symmetry C18 4.6x150mm 5μm column and guard, and a Waters 2487 UV detector. Dilutions were performed on β-carotene and astaxanthin standards, and were iteratively analyzed using different parameters to develop a suitable method. Based on chromatographic results, analytical parameters were adjusted to determine the optimal operating conditions for carotenoid detection and separation. The ideal HPLC method provides clear separation between similar components in the sample. Once a method is developed, a correlation can be created between the measured peak area and the concentration of the sample. The method developed that meets these characteristics is one that can be used to accurately quantify valuable carotenoids and provide insight on their recovery from bioethanol production byproducts.

Track C: Social Perception Modeling & Learning Sciences (WALC 2088)

Improving The Accuracy of U.S. Elections Forecasts

*Ryan Branstetter, Menqi Liu, Manas Paranjape, Alexandria Volkening**
**PI: Department of Mathematics*

SURF ID: 119
2:00 PM - 2:15 PM

Keywords: Forecasting, Polling data, Elections, Mathematical modeling

Forecasting the results of United States elections is an interesting problem that draws on many fields, including applied mathematics. An existing mathematical approach by Volkening *et al.* based on an adapted disease-transmission model has comparable accuracy to popular forecasters. This model, a set of stochastic differential equations, depends on polling data to calculate the values of its parameters. The model assumes every poll is equally accurate. However, some polling organizations are more reliable than others or have dependable partisan leans. This motivates our project: we aim to grade each polling organization and adjust polls to improve the accuracy of forecasts. To do so, we calculate the average bias of each pollster across the polls they published for U.S. elections from 2004–2020. We define a pollster's bias as the average difference between poll margins and the election results. We tested the impact of three sets of biases on the model; FiveThirtyEight's biases, the biases that we calculated using all of the polls in our data set, and the biases that we calculated only using polls completed in the last three weeks before an election. We use our three sets of biases to generate forecasts of past elections, and we compare these to forecasts using the original method by Volkening *et al.* For our analysis of the 2020 Senate and governor elections, we find that all three biases performed better than the original method, in which polling data is not adjusted at all. The bias we calculated from all of our polling data performed the best, achieving an average improvement of 3.6 percentage points. These results suggest that adjusting polls by past pollster bias may be an effective method to improve the accuracy of forecasts.

Direct Influence of Math Courses and ALEKS Placement to Beliefs and Values of STEM Major Choices

SURF ID: 146
2:15 PM - 2:30 PM

Jonah Gerardus, Joyce Main, Jason Morphew**
**Co-PIs: School of Engineering Education*

Keywords: Expectancy Value Theory, ALEKs scores, math placement, STEM careers, motivation

There is an increasing need for qualified STEM graduates in the US. However, there is a lack of students enrolling in STEM majors; of those that do, only about half earn a STEM degree. This research study is based on the Expectancy Value Theory (EVT) theoretical framework, which involves expectations for success, achievement-related choices, and subjective task values. The findings aim to discover insights that help increase STEM retention. Using the High School Longitudinal Study data set, we conducted logistic regression to find EVT variables that predict STEM enrollment. The findings indicate that EVT impacts enrollment in STEM, and the impact differs by gender.

Top-Down Modulation of Visual Learning in Freely Moving Mice

SURF ID: 207
2:30 PM - 2:45 PM

Rylann A. Moffitt, Sanghamitra Narredula, Alexander Chubykin, Yu Tang, Michael Zimmerman*
**PI: Department of Biological Sciences*

Keywords: Top-down modulation, Lateromedial (LM), visual cortex, stimulus, optogenetics

Our brains are constantly being flooded with information we perceive from the world around us. Recently, a theory has emerged based upon the notion of predictive processing, that works to explain how we can process this influx effectively. This hypothesizes that the brain makes predictions regarding incoming sensory information based on its previous experiences. It is believed that these predictions are part of a feedback loop via functional connections from higher order brain regions back to the primary sensory cortices, formally called top-down modulation. Previous research in our lab shows such top-down modulation from higher-order visual areas, such as the lateromedial area (LM), to the primary visual cortex (V1), which when inhibited alters response to familiar visual stimuli in V1. This top-down modulation within the visual cortex could potentially convey predictive information, narrating the behavioral response as well. Furthermore, understanding LM can assist in curing neurological disorders and learning disabilities. To investigate LM's role further, mice will be placed in touchscreen chambers to perform a visually cued go/no-go task. During the presentation of the go stimulus, the mouse must touch the screen to receive a reward. Additionally, it must not touch the screen after presentation of the no-go stimulus to avoid a time-out punishment. Once the mouse has been trained to the tasks, and shows proper discrimination between the stimuli, we will optogenetically inhibit excitatory neurons in LM during the working memory period prior to decision making, but after the presentation of visual stimulus. We expect to see a drastic drop in mice performance on inhibition of the feedback loop from LM to V1, indicating the importance of such top-down modulation in predictive processing.

Seamless Integration of Security Education in Programming Courses

SURF ID: 162
2:45 PM - 3:00 PM

*Aryan Jain, Shashank Sharma, Akhil Guntur, Aravind Machiry**
**PI: Elmore Family School of Electrical and Computer Engineering*

Keywords: Cybersecurity, Fuzzing, AFL, AFL++, Collaborative fuzzing, Programming courses, Test cases

Programming Courses are an integral part of computer-related majors in a university. Test cases, part of all programming courses, are created by the professors and teaching assistants. The traditional method of manually writing test cases is not efficient and comprehensive enough and might miss security issues in student submissions. This will cause students to learn programming concepts without understanding security issues. We argue that students should be made aware of secure programming practices from the start. This research aims to create an efficient way of finding common security issues in student submissions. Our idea is to use Fuzzing, an automated software testing method. Using AFL++, a security-oriented fuzzer, we created a framework that efficiently finds security issues in student submissions automatically. Our idea is to use Collaborative Fuzzing, wherein each student submission will be fuzz tested and each fuzzing instance will share test cases with other instances continuously, thus improving the effectiveness and efficiency. To ease the adoption of our framework into existing classrooms, we created GitHub workflows that can be integrated into any course organized using GitHub classroom. Our evaluation of a course verified our hypothesis that existing testing methods are inadequate and Collaborative Fuzzing helps in effectively and efficiently testing student submissions compared to fuzzing independently.

Forecasting the 2022 U.S. Midterm Elections: Data Visualization and Website Design

*Mengqi Liu, Ryan Branstetter, Manas Paranjape, Alexandria Volkening**
**PI: Department of Mathematics*

SURF ID: 190
3:00 PM - 3:15 PM

The U.S. midterm elections will be held on November 8th, 2022. Our research project stems from a prior mathematical model for forecasting past U.S. elections by Volkening et al. We are building on this model to forecast the results of the 2022 Senate and governor elections and developing a website to post our forecasts throughout the fall semester. After testing many different website design styles to improve the usability and attractiveness of our website, we decided to build a responsive webpage by utilizing Bootstrap instead of creating a static webpage. Our design pattern significantly improved our website's readability and sped up its loading time. Additionally, employing responsive web design enables users to access our website from mobile devices. By combining JavaScript and CSS, we also improved users' experience with the interactive elements (including a rolling map and "Election Roulette") that we developed for our webpage. To sum up, our website design balances attractiveness, loading speed, performance, manageability, and accessibility, and we will be posting forecasts regularly in the months leading up to November 8th.

Keywords: Data visualization, website design, responsive web design, election forecasting

The Impact of Opinion Dynamics on Vaccination and Epidemic Spreading Over Networks

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SURF ID: 187
3:15 PM - 3:30 PM

The vaccine against epidemic diseases has proven its effects on saving lives and mitigating epidemic spreading. However, many factors make people not or no longer eager to get vaccinated, which may result in endemic disease. To study the correlation between epidemic spreading and vaccination willingness, we propose a networked $SIRS-V_o$ epidemic model with compartments of susceptible (S), infected (I), recovered (R), and vaccinated (V) populations. The model captures the communities' willingness to be vaccinated. We utilize Taylor's model for opinion dynamics, which contains a term for representing the biased vaccination motivation. With the vaccination hesitancy introduced by our previous study, the vaccination willingness affects the vaccination rate. We consider the imperfection of the vaccine and waning immunity, exploring the equilibria of the networked $SIRS-V_o$ model and their stability. Through the stability analysis, we are able to find the conditions for the healthy state (disease-free) equilibria and consensus. Simulation and numerical analysis are included to illustrate the impact of vaccination willingness on the severity of epidemics.

Keywords: Simulation, modeling, epidemiology, opinion dynamics, control engineering.

Exploration of the Characteristics of Electric Vehicle Crashes: A Case Study in Iowa

*Jiahe Ling[1], Xiaodong Qian, Konstantina Gkritza**
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SURF ID: 189
3:30 PM - 3:45 PM

With an increasing market penetration of electric vehicles (EVs) in the traffic mix, it become necessary to examine crashes involving EVs. In addition, there is a need to identify differences compared with traditional internal combustion engine vehicles (ICEVs), as EVs are heavier and have different performance characteristics than ICEVs. To date, there is limited research comparing crash characteristics among EVs and ICEVs and further, differentiating among different types of EVs: battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs). To fill this research gap, this paper estimates crash injury frequency and injury severity outcomes through statistical regression analyses. The statistical models and hypothesis testing results suggest both similarities and differences in crash characteristics among BEVs, PHEVs, HEVs, and ICEVs. The similarity lies in human-related factors and traffic-related factors, but the differences come from four types of factors including vehicle, roadway, crash, and environment. The potential reasons (in terms of vehicles' engine type, software, and hardware) that could contribute to the differences in crash characteristics among four types of vehicles are discussed. The findings of this paper can provide insights into devising safety regulations for EVs. For example, EVs equipped with advanced driving assistant technologies can help relieve crash injury counts. However, the high acceleration rate of the electric motor could be an implicit factor that increases the crash severity, and the front of BEVs needs more protection since head-on crashes of BEVs cause more severe crashes.

Keywords: Crash Analysis, Electric Vehicles, Negative Binomial Regression Model, Multinomial Logit Regression Model

Track D: Biomedical Sensing & Imaging 2 (WALC 2127)

Analysis of Electrical Patterns Coinciding with Learning to Detect Neural Microstimulation

SURF ID: 197
2:00 PM - 2:15 PM

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Keywords: Neural microstimulation, sensory processing, learning, neural data analysis

The act of learning is a complex process that is not fully understood at the level of changes in neural activity. Complex organisms with nervous systems receive and respond to stimuli and, over time, learn which response is best through association. This learning process is associated with specific neurological patterns indicative of the central nervous system's processes to facilitate learning. These neurological processes are known on a high level, but finding the specific electrical patterns associated with learning remain unanalyzed, despite the major implications for neurology, psychology, general understanding of the learning process, and brain-computer interface design. To discover and analyze these patterns, seven mice were implanted with stim/record electrodes–chronic implants that can simultaneously provide electrical stimulation and record data from electrical signals in the brain. The mice were trained in a custom-fabricated cage that housed the required sensors for the task. The mice were trained to poke to initiate a trial, then poke a left or right sensor based on whether they received stimulation, and a correct trial resulted in a reward. After completing behavioral training and analysis, we expect to find specific changes in neural activity patterns associated with learning to detect electrical stimulation.

Analysis of Neural Patterns Associated with Detection of Neural Microstimulation

SURF ID: 176
2:15 PM - 2:30 PM

*Kathleen R. Kisker, Thomas Makin, Maria Dadarlat**
**PI: Weldon School of Biomedical Engineering*

Keywords: Stimulation detection, neural recording, behavioral training, somatosensory cortex stimulation, motor cortex stimulation, artificial sensation

Treatment for patients who have lost sensation, whether touch, hearing, or sight, is focused on restoring this ability by creating an artificial sensation with targeted stimulation of various nervous system points. Neural data in response to stimulation can indicate how well the artificial sensation is replicating the natural sensation. Still, there is not extensive research on how neural activity changes when learning to detect stimulation to the brain. To investigate the neural response to stimulation, mice had an electrode implanted in the brain's somatosensory cortex (S1) or the motor cortex (M1). They were trained to detect the presence of stimulation delivered through the electrode using an Intan Stimulator/Controller. Behavioral data were recorded along with neural data through the Intan Stimulator/Controller. This task was performed in a custom-built acrylic box using the Sanworks nose poke ports controlled with Python code and a RasperryPi. Both the M1 group and the S1 group of mice failed to reach the confidence threshold of 80% or higher for multiple days in a row with the first iteration of the protocol. Preliminary results from the revised protocol are more encouraging, with the mice reaching above 75% accuracy for a few days. These results suggest that the hardware, software, and new training protocol developed during this study establish a foundation for future studies on artificial sensation.

Characterizing Strain Effects of Myocardial Infarction and Cardiac Patches Using 4-Dimensional Ultrasound

SURF ID: 275
2:30 PM - 2:45 PM

*Samuel X. Zhang, Luke E. Schepers, Conner C. Earl, Seokkyoon Hong, Chi Hwan Lee, Craig J. Goergen**
**PI: Weldon School of Biomedical Engineering*

Cardiovascular disease is the leading cause of death around the world, one third of which are due to myocardial infarction (MI) and the complex fibrotic remodeling process that follows. Following an MI, chronic fibrotic remodeling of the heart leads to decreased contractility, increased stiffness, wall thinning, dilation, and eventual heart failure. This study aims to reduce post-MI cardiac fibrosis through anti-proliferative pharmaceutical drugs eluted from implantable biopolymer cardiac patches. To evaluate the effect of these patches, we first induced MIs in a control group of mice (n=5) by ligating the left coronary artery. We implanted cardiac patches in another group of mice (n=5) without drug or MI for cytotoxicity testing of the biopolymer patch. We imaged mice using 4-dimensional high frequency ultrasound over 28 days and analyzed images using a custom MATLAB code to evaluate left ventricular ejection fraction and myocardial strain. Preliminary results in the MI-only group reveal akinetic muscle regions after infarction, along with signs of ventricular ballooning and myocardial thinning at ischemic sites. Pilot data also show a decrease in cardiac strain magnitude after MI. We expect a significant decrease in infarct size and preserved cardiac function with application of the drug-eluting patches. These early results indicate that MI causes a physiological remodeling response through cardiac fibrosis, which decreases cardiac strain. Finally, we can use our validated strain metrics to characterize the longitudinal therapeutic and mechanical effects of a drug-loaded cardiac patch in a mouse model of MI.

Keywords:
Cardiovascular, Myocardial Infarction, Cardiac Patch, 4-Dimensional Ultrasound, Biomedical Imaging, Cardiac Strain, Murine Models

Towards the Development of a Self-cleaning Implantable Biosensor

SURF ID: 172
2:45 PM - 3:00 PM

*Jocelyn Kenley[1], Angel Enriquez, Hyowon Lee**
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As the need for personalized medicine grows, implantable biosensors that can continuously monitor biological signals of interest will become necessary. The notorious effects of the foreign body response limit the lifetime of biosensors by fouling the active sensing sites and therefore hindering their functionality. This paper reports on the development of using magnetic microactuators as an active anti-biofouling method in implantable biosensors. The actuator was fabricated from a thin polyamide film with a ferromagnetic material for the magnet. To determine the performance of the device the static mechanical response was tested, quantitatively measured, and then compared to a theoretical value. Electrochemical characterization demonstrated the functionality of the sensor. The self-cleaning biosensor can clear nonspecific foulants from the sensor surface. By generating alternating magnetic fields, the magnetic actuator remotely sweeps foulants as it moves in and out of the plane in an implantable environment. The electrochemical characterization provided both quantitative and qualitative data to compare the degree of foulants that are on the sensors and the functionality of the sensors. This was compared to a theoretical analysis so that we could optimize the design of the magnetic actuators for the best results. By developing a self-cleaning implantable biosensor, we will be able to increase the lifetime and the functionality of the biosensor which will help with the development of personalized medicine for each patient.

Keywords: Biofouling, Magnetic Actuators, Implantable Biosensors, Anti-biofouling, Medical Science and Technology, Biosensors, Materials Processing and Characterization, Self-cleaning Implantable Biosensors

Development of Protein Labeling Methods to Identify Proteomic Changes in a Mouse Model of Autism Spectrum Disorder

SURF ID: 246
3:00 PM - 3:15 PM

*Erin A. Tobin, Karin F. K. Ejendal, Umm E Hani Abdullah, Tamara L. Kinzer-Ursem**
**PI: Weldon School of Biomedical Engineering*

Keywords: Autism spectrum disorder, azidohomoalanine, newly synthesized proteins, BONCAT, click chemistry

Autism spectrum disorder (ASD) is a complex neurodevelopmental disorder with many underlying causes, both genetic and environmental, that produce similar symptoms. In humans, mutations of the $SYNGAP1$ gene are heavily implicated in ASD development. Therefore, this study aims to further explore the proteomic differences between a mouse model with one allele copy of the $Syngap1$ gene (heterozygous) and its wild type littermates, while also optimizing current protein enrichment methods. Knowing that the amino acid analog Azidohomoalanine (Aha) can be incorporated into a developing mouse embryo and labels only newly synthesized proteins (NSPs), Aha, or phosphate buffered saline was injected into time mated pregnant mice. Embryos were then harvested at a defined time point and were genotyped to establish the embryos' $Syngap1$ genetic makeup. To enrich for labeled proteins, the tissue underwent an enrichment protocol for Aha, followed by several steps to prepare peptides for identification. Using mass spectrometry, the identity of the NSPs are compared to deduce proteomic differences between the two embryo genotypes. Additionally, the mass spectrometry data is used to compare the effectiveness of the various Aha enrichment optimization techniques. Studying the outcomes from the various preparation methods could lead to being able to streamline the overall enrichment protocol and yield more labeled proteins. Understanding the differences in NSPs between the ASD model and wild type mice can lay a foundation for future research of ASD, specifically in exploring distinct proteins at different developmental stages or the impact of experimental treatment for ASD, such as deep brain stimulation.

Simulation Study of Parkinsonian Tremor

SURF ID: 220
3:15 PM - 3:30 PM

*Rhutuja Patil, Aditya Shanghavi, Anne Sereno**
**PI: Department of Psychological Sciences*

Keywords: Parkinson's Disease, Resting Tremor, Accelerometer, Gyroscope, Signal Processing

Parkinson's Disease (PD) is a neurodegenerative disorder where the motor symptoms are characterized by impairments such as resting tremors (RT), bradykinesia, and muscle rigidity and postural and gait disturbances. The current clinical gold standard to measure the progression of PD is the Movement Disorder Society, Unified PD Rating Scale (MS-UPDRS). However, these assessments of the severity of PD tremor are subjective. This study aimed to determine the features of wrist acceleration that can be used as objective, reliable, and sensitive detectors of PD RT in patients. 45 Purdue students performed the MS-UPDRS task 3.17 (Resting tremor amplitude) twice, first normally and second simulating a PD patient after viewing an example video. Shimmer sensors with a 3-axis accelerometer and gyroscope, were placed on both wrists and used to acquire the linear and angular accelerations. Power spectral density (PSD) analysis of the accelerations during simulated tremor showed tremor frequency peaks in the range of 2-7 Hz, similar to ranges 3.5-7.5 Hz previously reported in PD patients and simulated tremor studies. Using a Support Vector Machine classifier, features of the signal from the PSD analysis were used to differentiate between tremor and non-tremor conditions. The algorithm was found to be 97.22% accurate, suggesting such methods are sensitive enough to show a difference in the simulated tremor and non-tremor conditions. These findings suggest a simple method and features with promise for providing objective measures of RT. Future work on examining the relation between peak frequencies and the tremor amplitude may provide further objective measures to supplement clinical measures of progression of PD.

Cardiovascular Remodeling during Gestational and Postpartum Periods in Lactating Mice

*Arden Shen, Jennifer L. Anderson, Molly Kaisser, Kyoko Yoshida, Craig J. Goergen**
**PI: Weldon School of Biomedical Engineering*

SURF ID: 233
3:30 PM - 3:45 PM

While the effect of lactation on the health of neonates is commonly studied, its consequence on maternal health is still ambiguous. Previous work has suggested that complications of pregnancy are often associated with increased risk of cardiovascular disease, further complicating the long-lasting effects of pregnancy. Conversely, other research suggests that longer lactation periods may decrease the risk of cardiovascular diseases. Thus, this paper aims to understand how pregnancy and lactation affects the remodeling of the cardiovascular system and if the remodelling itself could be attributed to altered risk of cardiovascular diseases. Ultrasound imaging was used to collect baseline cardiovascular images of virgin female mice paired with male mice to induce pregnancy. Once pregnancy was confirmed on the ultrasound, further cardiovascular imaging was done on gestation day 6.5, 12.5, 15.5, 18.5 and postpartum day 1, 4, 7, 14, 21. After delivery on postpartum day 1, mothers were placed in either a lactating group (n=5) or non-lactating group (n=4). Litters of mice in the non-lactating group were sacrificed the first day after delivery, while litters in the lactating group were not weaned until 21 days after delivery. Image analysis was performed using a custom MATLAB GUI at each timepoint. This study compares the postpartum cardiovascular remodeling that occurs in lactating and non-lactating mice. Analysis of the cardiac scans will provide information relating to the left ventricle volume, ejection fraction, and LV wall thickness. These metrics will provide conclusions and recommendations for further research in this area.

Keywords: Pregnancy, postpartum, lactation, breastfeeding, cardiovascular remodeling, ultrasound, maternal health, cardiovascular disease

Track E: Medical Science & Technology 2 (WALC B058)

Brain Imaging Identifiability through Tensor Decomposition

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**PI: School of Industrial Engineering*

SURF ID: 140
2:00 PM - 2:15 PM

Identifying or "brainprinting" subjects based on their brain activities is a promising research area as it could provide unmatched safety against biometric theft. The goal of this study is to maximize identifiability through the map of correlated regions in the brain, or functional connectome, by using multidimensional structures known as tensors. Tensors enable studying the brain's functional connectome's different dimensions through high-order decomposition techniques. Data from the Human Connectome Project, which consists of neuroimaging data from 1065 subjects during test-retest task completion (Gambling, Emotion, Language, Motor, Relational, Rest, Working Memory, and Social), was used to conduct all experiments. Identifiability was assessed by computing the correlation between all test-retest data extracted from the subject's dimension. Each test sample was matched with the retest sample for which the computed correlation was the highest. Results show that subjects can be correctly identified with 54-100% accuracy across all 8 evaluated tasks. This study also suggests that the degree of subject identification is task-dependent, yielding more accurate results in the resting state of the brain as opposed to an active state.

Keywords: Identifiability, brainprinting, functional connectome, tensors

Discovery of Novel Natural Products from Streptomyces Sp. CS.62

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**PI: Department of Chemistry*

SURF ID: 116
2:15 PM - 2:30 PM

Keywords: streptomyces, antibiotics, biological activity

Antibiotics have been sourced from Streptomyces bacteria for decades with great success. Though the discovery of novel antibiotics has been stifled due to rediscovery under standard laboratory conditions, many natural products remain undiscovered. We sought to isolate Streptomyces from the soil, determine if they produced any bioactive natural products, and elucidate the structures of novel bioactive natural products. Cross streaks were performed to assess biological activity. CS.62 was chosen for its biological activity against S.aureus NRS3, S. aureus 29213, and B. subtilis 6633, all gram-positive pathogenic bacteria. The following methods were used to isolate extracts for CS.62: HLB purification was used at a 10% gradient with ACN as the solvent. Amberlite extraction was performed with methanol at a gradient of 25%. Ethyl acetate extraction was performed, as well. The 30 collected extracts were then analyzed via bioactivity assays. It was found that extracts from CS.62 were biologically active against Gram-negative A. baumannii 19606 and A. baumannii KB349. These results suggest the presence of promising antibiotic leads. Future directions include isolation, structure determination, mechanism of action studies, and testing for their in vivo toxicity.

The Role of Lactobacillus Casei and Streptococcus Mitis in Regulating Cytotoxicity

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SURF ID: 228
2:30 PM - 2:45 PM

Keywords: Osteoarthritis, gut-joint axis, gut microbiome

Osteoarthritis is one of the most common musculoskeletal diseases, leading to a significant decrease in the quality of life for those affected. As more connections between the microorganisms residing within the gut, human health, and disease are discovered, studying the role of the gut microbiome on osteoarthritis progression may reveal new ways to slow or stop the disease. Therefore, it is important to evaluate the role of microbes and their metabolites in changing the behavior of cells found in healthy and osteoarthritic joints. The effect of microbe metabolites from two different bacterial strains on cell viability was examined to test one aspect of this potential relationship. Lactobacillus Casei is positively associated with osteoarthritis, while Streptococcus Mitis is negatively associated with osteoarthritis. These two bacterial strains were cultured, and the metabolites in the cultured media were collected. To compare these supernatants, we first need to determine a dilution of supernatant within mammalian cell culture media that is biologically active but not cytotoxic. To determine this dilution, we tested treatments of 1/4, 1/16, and 1/64 of each supernatant to culture cells. We hypothesize that a dilution factor of 1/4 will yield the lowest cell viability. A cell viability calculation was performed to determine which dilutions, if any, were cytotoxic. It was determined that a dilution factor of 1/4 created the least suitable environment for cells. This serves as a preliminary investigation into further understanding how microbe balance in the gut affects the extracellular matrix in joint tissues.

Coagulation Factor Thrombin Promotes Pancreatic Cancer Tumor Growth

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SURF ID: 264
2:45 PM - 3:00 PM

Keywords: PDAC, Inkjet 3D printing, tumoroids, coagulation factors, coagulation system, tumor microenvironment

Pancreatic adenocarcinoma (PDAC) has one of the highest mortality rates of any malignancy. Survival rates are low even for patients who undergo surgery for localized diseases. To find treatments for PDAC, the coagulation system of its tumor should be investigated as PDAC tumor growth is closely associated with coagulation factors. One avenue to study the intricacies of this system is to create tumoroids to mimic the tumor microenvironment. Poly(N-isopropylacrylamide) (PNIPAAm)-based bioink containing cancer and fibroblast cell lines was inkjet-printed and incubated to form tumoroids. Different dosages of thrombin were then added to fully grown tumoroids and their growth was observed and analyzed. By treating the tumoroids with coagulation factor thrombin, it is found that thrombin promotes PDAC tumor growth in a duration-dependent manner, which could be due to thrombin-protease-activated receptors-1 (PAR-1) interaction. This finding gives insight into possible treatment methods of PDAC, including eliminating PAR-1 receptors or the interaction between these receptors with thrombin.

Validation of Zinc Biosensor for Use to Quantify Dynamic Beta Cell Performance

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SURF ID: 231
3:00 PM - 3:15 PM

Keywords: Type 1 Diabetes, beta cells, Islets, insulin, glucose stimulate insulin secretion, islets on a chip, microfluidic chip, microphysiological device, biosensor, zinc sensor

Characterization of the dynamic insulin secreting performance of beta cells is critical in the research of Type 1 Diabetes (T1D) due to their role in its pathophysiology and the potential for beta cell replacement therapies to cure the disease. However, current methods of performing dynamic Glucose Stimulated Insulin Secretion (GSIS) assays, the primary way glucose-sensitive insulin secretion performance is quantified, are costly and time-consuming. Therefore, an easy-to-apply and cost-effective way to quantify this functional beta cell parameter is needed. To meet this need, an Islet-on-a-Chip microfluidic device is being developed that utilizes an in-line zinc biosensor, with the potential to provide dynamic functional data while reducing time and cost when compared to current methods. Zinc is a convenient electrochemical indicator for beta cells and is secreted at a ratio of 3:1 with insulin. Given its application of evaluating beta cell performance, the sensor's ability to detect biologically relevant concentrations of zinc GSIS samples was validated. To achieve this, secreted insulin and zinc samples were collected from INS-1 cells, a beta cell line, using static GSIS. The insulin concentration was determined using the zinc biosensor and was compared to the insulin concentration determined by an Enzyme-Linked Immunosorbent Assay to determine the device's effectiveness. Resultant data demonstrated that the zinc sensor could effectively measure zinc in biologically relevant samples and that the concentration of zinc was correlated with the concentration of insulin. Thus, the zinc biosensor can advance T1D research by providing a timely, economical alternative to current beta cell characterization methods.

Origins of the Self-Motion Neuronal Activity in the Superior Colliculus

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**PI: Department of Biology*

SURF ID: 266
3:30 PM - 3:45 PM

Keywords: Brain circuits, superior colliculus, cortico-collicular pathway, self-motion, optogenetics, electrophysiology

Over the years, the seemingly unsolvable brain has attracted many scholars to reason. The resulting discoveries shaped our understanding of the nervous system function, prompting successive advancements in the diagnosis and treatment of related diseases. Notably, finding the role of the superior colliculus (SC) as a sensorimotor transformation hub allowed scientists to identify the association between SC and attentional dysfunction disorders including Autism and Parkinson's disease. As an attention-attributing node, it is evident that SC receives and integrates sensory information with motor signals, but the source of SC's motor input remains unclear. Preliminary exploration of SC's motor input revealed a representation of a mouse's run speed in SC– suggesting a connection between SC and cortical motor input. In this project, we tested this hypothesis by investigating two regions of the cortex: (i) first, by identifying the structural connections from the somatosensory cortex (S1) and the motor cortex (MC) to SC by mapping axonal projections, then (ii) analyzing the functional role of each pathway by deactivating the identified neurons using optogenetic tools. Upon analysis, visualized axonal projections confirmed structural connectivity from S1& MC to SC. However, optogenetic manipulation did not result in a change in self-motion. The observed structural connectivity between MC-SC and S1-SC therefore suggests that these inputs are partly responsible for SC activity. Future studies with a higher efficacy virus will allow a precise optogenetic control for more accurate analyses of these pathways.

Track F: Transport Phenomena (WALC B066)

Configuration of a Low-Cost Mobile Platform for Particle Image Velocimetry

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SURF ID: 278
2:00 PM - 2:15 PM

Particle Image Velocimetry (PIV) is widely used in experiments to check the flow visuals of a particle in a fluid. However, PIV algorithms are conventionally implemented for computers in a laboratory-based setting. Previous studies showed that work done in PIV in a laboratory-based setting uses a high amount of computational resources to process the data generated from high-resolution cameras. This makes the applicability of PIV limited to high-end systems and limits the impact for a wider range of audiences. This study focuses on improving an existing Particle Image Velocimetry app (mI-PIV) that is a low-cost and open-source platform. The improvements were done by analyzing the functionalities and integrating a deep learning algorithm for PIV in the mobile app. Pre-trained convolutional neural network modules were used for image processing. With this approach, significant changes and results in the mI-PIV app were obtained after experimentation. These changes in the mI-PIV app provided additional functionality that was currently developed for computers in a laboratory setting.

Keywords: Mobile Integrated Particle Image Velocimetry (mI-PIV), Particle Image Velocimetry (PIV), Deep learning, Low-cost system/devices, Edge computing

Imagining Diagnostics in Subsonic Sprays

*Nicholas Mondora, Preetham R. Gowni, Aidan S. Tomlin, Ben J. Worrell, Terrence R. Meyer**
**PI: School of Mechanical Engineering*

SURF ID: 208
2:15 PM - 2:30 PM

Modeling of low temperature, subsonic jet in crossflow is already well documented in literature. High-temperature flows have not been included in these efforts due to the increased costs and infrastructure required. This project employs Phase Doppler Anemometry (PDA) and the generalized Lorenz-Mie theory (Planar Mie Scattering) to characterize high-temperature jet in crossflow. PDA and Mie Scattering are used together to simultaneously build a comprehensive model for the distribution, velocities, and particle sizes of evaporating droplets in the spray for both empirical correlation and computational fluid dynamics. Using a 532 nm burst-mode laser at 20 kHz, and Planar Mie Scattering techniques, data can be collected at 2 kHz using a high-speed camera. A laser sheet is formed with a series of 532 nm optics in order to slice the cross-sectional profile of the jet and are subsequently imaged with a 532 nm filtered high speed camera. These images are post processed to obtain droplet distributions for the spray at various x/d locations for certain momentum flux ratios, subsonic Mach numbers, and temperatures.

Keywords: Mie scattering, phase doppler anemometry, jet in crossflow, droplet vaporization

Simulation of Flow and Heat Transfer in Topologically Optimized Cold Plates

*Bruno Navaresse, Abhijeet Banthiya, Saeel Pai, Justin A. Weibel**
**PI: School of Mechanical Engineering*

SURF ID: 211
2:30 PM - 2:45 PM

The ever-increasing power density of electronics demands thermal management methods that can more effectively cool such devices to prevent overheating failures. The present study focuses on the design of cold plates using topology optimization (TO) techniques that can increase performance. This design method leverages the capability of additive manufacturing to build complex part geometries that are not possible with traditional manufacturing. Cold plates use a liquid coolant to extract heat from electronics. Topology optimization uses numerical fluid flow and heat transfer simulations to design the coolant flow path and surface geometry to minimize the device temperatures for a user-defined heating problem. However, fully three-dimensional computational fluid dynamics simulations are computationally expensive, preventing exhaustive exploration of the design space. So, several simplifying assumptions must be made for topology optimization to be feasible. Namely, a homogenization TO approach that simplifies the design problem by considering flow through square pin fins and varying their sizes to optimize a given cold plate. The model underlying the optimization algorithm then assumes flow through the pin fins as being a two-dimensional porous flow to dramatically reduce the computational cost. However, this simplifying assumption of a two-dimensional flow needs to be validated to ensure accurate results. This work performs high-fidelity three-dimensional simulations of flow and heat transfer through pin fins of various sizes using a commercially available numerical solver. The results are compared against the TO model predictions and correction factors are developed so the simplifying assumptions can be now applied in the design optimization process without any loss of accuracy.

Keywords: Topology optimization, cold plates, heat sink, computational fluid dynamics (CFD), thermal management, electronics cooling

System-Level Optimization of a Thermal Energy Storage Module

*Falak Mandali, Michael Shanks, Neera Jain**
**PI: School of Mechanical Engineering*

SURF ID: 198
2:45 PM - 3:00 PM

Keywords: Electronics cooling, thermal management, thermal energy storage, phase change materials, optimization

Electronics cooling is a well-established field that addresses challenges associated with maintaining the safety and efficiency of electrical components. Applications range from cell phones to aircraft. The systems designed to achieve electronics cooling are called thermal management systems (TMS). In this work, we consider a hybrid TMS that utilizes a combination of liquid water (via a heat exchanger) and a thermal battery to absorb heat. A thermal battery is also referred to as a thermal energy storage (TES) module and can store and dissipate heat by the melting and solidification of a phase change material. A key challenge with integrating a TES module into a hybrid TMS is that the component is often designed independently of the system it will be used with. The consequence is that a component-level optimization does not consider the requirements of the hybrid TMS. We address this challenge by optimizing the TES module while considering its performance in a controlled TMS. This method required modifying existing optimization solvers to handle certain complexities associated with solving non-linear optimization problems with constraints. It was observed that optimizing the TES with the TMS provided a TES design that could maintain the electrical component's surface temperature at the same value as an independently optimized TES but with a lighter mass. Additionally, the system-level optimized design absorbs heat at a higher rate and can recharge faster. Hence, it can be concluded that optimizing a TES module based on its direct application in a system can provide a design that outperforms a TES module optimized without regard to its intended use.

Effect of Air Velocity on a Hydrogen Air Premixed Jet Flame

*Priyal Chhawchharia, Sreetam Bhaduri, Jay Gore**
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SURF ID: 130
3:00 PM - 3:15 PM

Keywords: Hydrogen, air, premixed combustion, high speed imaging

Hydrogen is a zero-carbon dioxide producing alternative to today's hydrocarbon fuels. The present research is aimed at understanding a range of properties of premixed hydrogen-air flames. Experiments with a range of bulk velocities of the premixed air - fuel mixture led to a range of jet Reynold's numbers. The fuel and air were premixed at an equivalence ratio of 0.7, and the mixture temperature was maintained at $\sim$298 K for all conditions. A high - speed imaging camera is used to capture the intrinsic geometric features of the hydrogen - air premixed flames for comparison with the results of a computational model. The changes in physical features such as length, width, and shape of the flames were observed. Basic combustion principles were utilized to learn the underlying physical and chemical phenomena affecting these features. The data are of value for future assessments of computational analyses aimed at understanding the viability of hydrogen as a sustainable alternative fuel.

Characterizing Droplet Vaporization for High Temperature Subsonic Jet in Crossflow

*Preetham Reddy Gowni, Nick S. Mondora, Aidan S. Tomlin, Terrence R. Meyer**
**PI: School of Mechanical Engineering*

SURF ID: 149
3:15 PM - 3:30 PM

Keywords: Phase Doppler Anemometry, Jet in Crossflow, Droplet Vaporization

Modeling the dynamics of spray and droplet breakup in propulsion applications remains a difficult task due to processes occurring over several spatial and temporal orders of magnitude, significantly complicating computational effort. Experimental measurement techniques are important in validating existing models, as well as formulating new ones. Analyzing the breakup of a liquid jet in high temperature gas crossflow allows for the design of more efficient airbreathing propulsion devices such as gas turbine and ramjet engines. The purpose of this study was to analyze liquid fuel jet breakup and droplet evaporation in high temperature subsonic air environments. This was done by using Phase Doppler Particle Anemometry (PDPA) to measure grids of droplet size and velocity at different axial locations in a wind tunnel. Individual points were selected in an elliptical pattern motivated by Mie Scattering measurements of the droplet distribution. At these locations, discrete droplet size and velocity was measured at 2 kHz, with a 20 kHz 532 nm burst mode laser. These data were then extrapolated across a three-dimensional map of the test section allowing for bulk flow properties to be inferred, focusing on evaporation characteristics. Momentum flux ratios of 20 were tested with various air temperatures and pressures. These data can be used to validate modeling efforts of jet in crossflow sprays in airbreathing propulsion applications.

The HTGR: A Next-Generation Nuclear Reactor

*Andrew J. Bergeon, Benjamin C. Billett, Derek W. Kultgen, Shripad Revankar**
**PI: School of Nuclear Engineering*

SURF ID: 113
3:30 PM - 3:45 PM

The high temperature gas-cooled reactor (HTGR) is a next-generation nuclear reactor technology that can be more efficient, cost-effective, and accident-tolerant than the nuclear reactors in operation today. The technology is still in development and has yet to be approved for commercial implementation. The purpose of this study is to further understand the depressurization loss of coolant accident scenario: an accident where helium leaks out of the reactor into the surrounding containment. A scaled-down test containment facility was built to simulate an HTGR containment facility. This facility was repeatedly leak-tested and repaired. Pressure transducers, thermocouples, and oxygen detectors were installed and wired to a data acquisition system. As the project continues, the apparatus will be pressurized with high-temperature helium to 2 psi. Then a panel will be removed from the apparatus, simulating the opening of an automatic depressurization vent on an HTGR containment facility. The long-term thermal hydraulic behavior of the system will be observed and documented via thermocouples to read temperature, pressure transducers, and oxygen detectors. The results of this study will be compared to a similar study using low-temperature helium. The conclusions will provide feedback on the viability of the current HTGR safety system designs and hope to advance the approval of HTGR technology for commercial power production.

Keywords: Nuclear reactor, helium, gas-cooled reactor, safety

Computation of Boundary Layer Separation in Prandtl Meyer Expansion Fans

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SURF ID: 284
3:45 PM - 4:00 PM

Understanding boundary layer separation is essential in the design of flight vehicles for stability and performance. Studies have found that boundary layers in Prandtl-Meyer expansion fans do not follow traditional subsonic boundary layer theory that states boundary layers can only separate when exposed to adverse pressure gradients. Fluid flow in a Prandtl-Meyer expansion fan is subject to a favorable pressure gradient but can still experience separation. This project aims at explaining the mechanism of this separation phenomena and at quantifying how the radius of curvature and turning angle impact the separation point along a convex surface. Computational fluid dynamics (CFD) methods were employed using the ANSYS Fluent code to simulate laminar flow along a convex surface in order to better understand how the flow develops in the boundary layer. The boundary layer was found to grow exponentially along the convex surface. Within the subsonic viscous sublayer spreading of the streamlines should cause a pressure rise. However, the expected pressure rise is offset by the Prandtl-Meyer expansion favorable pressure gradient. As the curvature ends, the Prandtl-Meyer expansion favorable pressure gradient weakens which allows for the viscous sublayer pressure rise to take over if sufficiently strong, as occurs in the separated cases. This instigates the free-interaction between the boundary layer and free stream leading to self-induced boundary layer separation. Separation was found to be caused by smaller radii of curvature and larger turning angles as the rapid boundary layer growth and resulting free stream interaction was greater in those cases.

Keywords: Boundary layers, separation, Prandtl Meyer expansion, fluid mechanics

Track G: Biological Signaling, Simulation & Technology 2 (WALC 3084)

The Effect of Sucrose on Swelling Behaviors of Normal Maize Starch Suspension at Different Heating Time

SURF ID: 255
2:00 PM - 2:15 PM

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Keywords: Rheology, Viscoelasticity, Swelling ratio, Sucrose, Normal maize starch, Heating (processing) time, Volume fraction

This research aims to investigate the effect of sucrose concentration on the swelling and pasting behavior of starch paste. Two aqueous solutions of 8% normal maize starch with 10% and 20% sucrose were heated to 80°C and held from 30 to 1200 seconds. After the starch paste was cooled to 40°C, a rheometer (ARG2) measured its viscoelasticity through storage modulus (G') and loss modulus (G") over the frequency range of 0.01 radians/s to 100 radians/s on a parallel plate geometry. In addition, static light scattering was used (Malvern particle analyzer) to measure the size distribution of the starch granules at different heating durations. The control group (starch w/out sucrose) has a volume fraction in the suspension ranging from 0.38 to 0.47 as the heating time increases from 30 to 1200 seconds. While the 10% testing group (starch with 8% sucrose)'s volume fraction in the suspension increases from 0.39 at 30 seconds of heating time to 0.5 at 1200 seconds, the 20% testing group's volume fraction in the suspension reaches 0.4 at 30 seconds and 0.55 at 1200 seconds heating time. Storage modulus (G') for the control (starch w/out sucrose) at the frequency of 4Hz increases from 55 to 102 Pa as the heating time varies from 30 to 1200 seconds whereas it increased from 38 to 85 Pa for the 10% sucrose sample. The starch volume fraction and G' results suggest that the interaction between starch and sucrose facilitates the starch swelling and decreases the storage modulus.

Act1 Knockout effects on Interleukin 17 mediated neutrophil recruitment

SURF ID: 290
2:15 PM - 2:30 PM

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Keywords: Act1, Interleukin 17 (IL-17), Neutrophils, Inflammation control, Innate immunity, Zebrafish

Neutrophils, a type of immune cell, are critical components in host defense and active inflammation. The uncontrolled activity of neutrophils can lead to tissue damage. Nonetheless, the knowledge about the intrinsic signaling mechanisms that control neutrophil recruitment and activity is limited. To comprehend the role of neutrophils in inflammatory processes, the research focuses on studying interleukin-17, a cytokine that links T-cell activation to neutrophil mobilization and activation. Although, the regulation of IL-17 receptor (IL-17R) signal transduction remains an elusive topic. The recruitment of adaptor Act1 was manipulated to research the IL?17-mediated signaling pathways and the regulation of IL-17-mediated inflammatory responses. Zebrafish IL-17 have the same genomic organization as their human counterparts. The larval zebrafish model was used to analyze this interleukin and its proinflammatory role by counting their neutrophils in vivo after wounding the larvae's tail. Thus, by producing zebrafish Act1 -/- (Act1 deficient), the SEF/IL 17R (SEFIR) domains were inhibited, altering the molecular events of IL-17 signal transduction. Thus, this allows the inspection of the innate/epithelial immune cells or other IL-17 expressing cells response in zebrafish larvae. The tail wounding assay showed that, in terms of the numbers, there was no significant difference in neutrophil recruitment to the site of injury between the two groups. However, Act1 -/- larvae neutrophils treated with LTB4 showed higher migration rates in contrast to the wild-type neutrophil distribution patterns. All this data might suggest that Act1 may be a key molecule in neutrophil accumulation in tissue through its role in the IL-17R-Act1 signaling.

Live-Cell Probe for Monitoring Tau Protein Phosphorylation in Neuron

SURF ID: 276
2:30 PM - 2:45 PM

*Xihui Zhao, Han Zhao, Junkai Xie, Chongli Yuan**
**PI: Davidson School of Chemical Engineering*

Tau is a microtubule-binding protein abundant in neurons. Hyperphosphorylated tau disassociates from the microtubule and can undergo self-aggregation, leading to neurofibrillary tangles (NFTs), a neuropathological hallmark of Alzheimer's disease. The understanding of NFTs formation is critical for Alzheimer's disease pathological drug discovery and remains limited. Current strategies to track NFT formation mainly utilize antibodies and thus are only applicable to tissue slices and fixed cells. Few studies focused on the tracking of the tau phosphorylation dynamic. We designed a live-cell compatible fluorescent reporter for tau phosphorylation to fill this gap. A circularly permuted green fluorescent protein (cp-GFP) based probe can emit fluorescence when the target domains bind together. In this project, a cp-GFP-based probe is designed by inserting two tau protein segments into a cp-GFP plasmid. When two segments are phosphorylated, they will bind together to form a dimer and emit fluorescence. Both in vivo and in vitro assays will be used to test the probe's performance. In vivo test will be performed in HEK293T cells, while in vitro assay will be performed using recombinant tau. We will demonstrate our engineered probe's feasibility in detecting tau protein phosphorylation in neurons. We will devise future applications in neuron culture based on the results and data from experiments.

Keywords: Tau protein, neuron, live-cell probe, neurofibrillary tangle, Alzheimer's disease

Changes in Cardiac Function During Autonomic Dysreflexia Events

SURF ID: 136
2:45 PM - 3:00 PM

*Molly N. Dye, Zada B. Anderson, Bradly S. Duerstock**
**PI: Weldon School of Biomedical Engineering*

Spinal cord injury (SCI) patients often suffer with abnormal episodic hypertension due to dysregulation of the autonomic nervous system, or autonomic dysreflexia (AD). This condition most often arises in patients with a SCI at or above the sixth thoracic vertebrae. AD occurs when there is a stimulus below the level of injury, triggering uncontrolled episodic hypertension which can lead to complications including myocardial infarction, pulmonary edema, and in some cases death. This study aimed to understand changes in cardiac contractility during AD events through analysis of Echocardiogram (ECG) data. To reduce stress responses in data collection, a four-week acclimation period allowed rats to acclimate to researchers and equipment. High thoracic spinal cord injury was performed on each rat to disrupt the autonomic nervous system. To imitate the onset of AD in humans, 3 trials of colorectal distension (CRD) were preformed on days 5, 7, 9, 11, 14, 16, 19, and 21 after injury. During these procedures, radio telemetry and non-invasive surface electrodes were used to collect ECG data. A t-test was preformed to determine if any statistically significant changes in three ECG parameters occurred during trials where AD was elicited. The RR interval, P wave height and QRS interval showed a statistically significant change corresponding to AD. Thus, contractile function of the heart is affected during AD events.

Keywords: Autonomic dysreflexia, spinal cord injury, echocardiogram

Integration of Actin and Calcium in Embryonic Zebrafish Wounding Model

SURF ID: 287
3:00 PM - 3:15 PM

*Kioni Bush, Shelly Tan, Qing Deng**
**PI: Department of Biological Sciences*

While the theory that calcium second-messenger signaling and actin-myosin remodeling play a major role in wound healing is widely accepted in the field, the details of their exact roles and the ways in which these signals interact to control later regeneration are poorly understood. The in vivo embryonic zebrafish model provides a convenient and comprehensive method to examine how various drugs targeting calcium and actin pathways affect the regeneration process, thereby confirming the significance of their targets in the wound response pathway. Treating 3 days post fertilization (dpf) zebrafish with selected inhibitors (targeting calcium signaling and cytoskeletal function), followed by washout and tail fin transection, demonstrates the effect of these inhibitors on wound regeneration. Regrowth assays indicate that both disruptions of the calcium signal and disruption of cytoskeletal function decreased regeneration, but disruption of cytoskeletal function comparatively had a greater effect. At the conclusion of this project, we have established significance for more in-depth studies on the molecular targets of these drugs in the future.

Keywords: Wounding, Regeneration, Calcium, Actin-Myosin, Zebrafish

Simulating Rare Events in Systems of Multiple Tuberculosis Granulomas

*David R. Wagner, Elsje Pienaar**
**PI: Weldon School of Biomedical Engineering*

SURF ID: 253
3:15 PM - 3:30 PM

Keywords: Tuberculosis, multifidelity models, rare events, drug resistance, granulomas

Drug resistant tuberculosis is a serious threat to society due to its higher mortality rate and more costly treatment than drug susceptible tuberculosis. Observing rare biological events, such as the occurrence of drug resistance conferring mutations, using physical experimentation or computational simulation is difficult due to the time and resources required. This study is based on a multifidelity approach utilizing Markov Chains and Monte Carlo Simulations to minimize the high computational cost associated with simulating the occurrence of drug resistance in single tuberculosis granulomas. Here, it has been extended to describe more medically relevant systems containing multiple granulomas. Distributions containing probabilities for each possible number of mutant bacteria from randomly selected granulomas were outputted from the original multifidelity approach. These separate distributions were combined in a pairwise manner until a system containing 40 granulomas was yielded. Resulting probabilities of systemwide drug resistance and frequencies for each possible total number of drug resistant mutants were plotted. As the number of granulomas in the system increased, it was found that the overall probability of mutant bacteria also increased. In addition, it was observed that the frequency of occurrence for all possible numbers of resistant bacteria except zero increased with the number of granulomas. The frequency of zero resistant bacteria occurring dropped as the number of granulomas increased (reflecting the observations in the probability plots). These results indicate that individuals with more tuberculosis granulomas possess a greater risk of developing more drug resistant bacteria and may assist in making decisions regarding treatment options.

Swelling Properties of Normal Maize Starch as Affected by Xanthan Gum under Different Pasting Time

*Giao Nguyen, Ganesan Narsimhan**
**PI: Department of Agricultural and Biological Engineering*

SURF ID: 213
3:30 PM - 3:45 PM

Keywords: Viscoelasticity, Starch swelling, Normal maize starch, Xanthan gum

The objective of this study is to characterize the effect of xanthan gum concentration on swelling and viscoelasticity of normal maize starch paste. 8% aqueous suspension of normal maize starch in the presence of 1% xanthan gum concentration was heated at 80°C for different holding times (from 30 seconds to 20 minutes). Storage modulus (G') and loss modulus (G") of the cooled paste at 40°C were measured for a frequency range of 0.1 to 100 radians/s using a parallel plate geometry rheometer. The swelling of starch granules in the sample was measured using static light scattering, and the volume fraction of the starch paste for different heating times is obtained from these measurements. The volume fraction of starch increases from 0.61 to 0.70 in the presence of xanthan gum as heating time increases from 30 seconds to 20 minutes whereas the increase in volume fraction in the absence of xanthan was from 0.63 to 0.83 thus indicating that xanthan gum retarded starch swelling. Comparison of G' at 4 Hz for different heating times show that it increases from 103.56 Pa to 227.84 Pa as heating time increased from 30 seconds to 20 minutes in the absence of xanthan gum whereas G' increased from 41.55 Pa to 102.07 Pa thus demonstrating that xanthan gum augmented the viscoelasticity of starch paste. Comparison of starch volume fraction as well as G' with and without xanthan gum at different heating times show that xanthan gum retards starch swelling while increasing its G'.

Track H: Energy for Our Growing World (WALC B093)

Cobalt (II) Catalysts for the Conversion of Shale Gas into Gasoline and Diesel Fuel

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SURF ID: 401
2:00 PM - 2:15 PM

Keywords: Single-Site Catalysts, Cobalt, Shale Gas, Oligomerization, Fuel

The production of gasoline and diesel fuel from crude oil has led to an increase in greenhouse gas emissions. We aim to lower these emissions by studying single-site catalysts as a link to creating a more sustainable way to manufacture transportation fuels. Shale gas, which is found in sedimentary shale rock, is composed of methane, ethane, propane, and butane, and has higher potential ecological benefits, when compared to crude oil, as a feedstock for gasoline and diesel. This project studies single-site cobalt(II) catalyst compositions and specifically attempts to understand cobalt(II) supported on an alumina surface in hydrogenation and dehydrogenation reactions with propylene, and propane respectively. The cobalt(II)-alumina catalyst was synthesized using incipient wetness impregnation and was loaded into the reactor where the amount of catalyst, flow rate, temperature, and pressure were all manipulated. Quantitative data for the reaction results was analyzed using gas chromatography and the conversion and selectivity was evaluated at various space velocities. After successfully interconverting propylene and propane at a commercially relevant conversion, the cobalt(II)-alumina single-site catalyst will be utilized to react light olefins, such as ethylene and propylene, in small chain oligomerization reactions to form longer chain hydrocarbons which can be used in the production of transportation fuels. This process will help to reduce our carbon footprint while conserving crude oil which can bridge a gap between a conventional hydrocarbon economy and a sustainable future.

Storage Analysis for Zero-Emission Chemical Processes

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SURF ID: 403
2:15 PM - 2:30 PM

Keywords: Renewable energy, chemicals, process optimization

Global warming has been an increasingly discussed topic in recent years. A major contributor to rising temperatures is an accumulation of greenhouse gases trapping heat inside of Earth's atmosphere. Carbon dioxide is a greenhouse gas that is a byproduct of many processes in the oil and gas industry, where traditional processing methods are powered by the combustion of fossil fuels. Several publications suggest alternative processing methods that run on electricity from alternative energy sources such as wind, solar, and fuel cells. By nature, solar and wind energy are intermittent; however, by storing this intermittent energy in a battery and supplementing the electricity production with another method, a process could be reliably powered by renewable energy with zero carbon emissions. This project investigates the conversion of shale gas into materials needed for several major industries. It produces hydrogen as a byproduct, which can provide electricity by means of a hydrogen fuel cell. The process will also be powered by a battery charged by solar energy. Implementing batteries and solar panels into large scale processes have large material, maintenance, and land usage costs. To make these electrified processes cost-friendly, the battery storage will be minimized by determining a set of equations and constraints for the electricity requirements at every hour over one year (8760 hours). These equations and constraints will be put into an existing solver program to minimize the battery values. The results will provide insight into which processes would have the most success in being fully powered by renewable energy.

Chemical Kinetic Modeling of Steam Methane Reforming Under an Induction Heating Process

SURF ID: 404
2:30 PM - 2:45 PM

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If the trends of CO_2 emissions continue to rise at today's current rate, by 2050 around 43 billion metric tons of CO_2 will be released into the atmosphere by the US. Unfortunately, there has not yet been an efficient way in which commodity chemicals that require a plentiful amount of energy, such as ethylene and ammonia, can be produced in the large volumes that our economy demands using renewable energy instead of fossil fuels. We propose a unique reactor design that performs a new steam methane reforming process that produces hydrogen, with the aid of a nickel-based catalyst, and is heated by means of electromagnetic induction. Thus, the reaction will be heated using electricity, terminating the need to combust methane (fossil fuels). The reliability of this design will be supported by data generated from kinetic modeling using $SURFACE\ CHEMKIN$, a software that can predict desirable product conversion at any given condition. Three files consisting of reactions occurring in the gas phase and at the surface of the catalyst as well as the thermodynamic properties of all the species involved were developed to produce a reliable kinetic model. It is expected that the software will provide a precise model that matches data from literature, thus, the model derived from $SURFACE\ CHEMKIN$ will attest that our reactor's unique conditions can achieve high enough conversion that will contribute to meeting our economy's current demand for these and other commodity chemicals while significantly reducing CO_2 emissions from the chemical industry.

Keywords: Kinetic modeling, steam methane reforming, induction heating, CO2 emission reductions, renewable electricity.

Synthesis of Zeolite-Templated Carbon Supports for Metal-Catalyzed CO2 Electroreduction

SURF ID: 407
2:45 PM - 3:00 PM

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Global reliance on fossil fuels and the expansion of industry has led to the continuous rise in CO2 emissions and has directly contributed to climate change since the 19th century. Consequently, global research efforts are now focusing on fuel-production technologies that mitigate CO2 emissions. One promising alternative is CO2 electroreduction, which utilizes renewable energy to convert CO2 to other fuels and chemicals. Previous literature on CO2 electroreduction reports the production of C1 and C2 hydrocarbons when using copper-based electrocatalysts. However, data suggests that using microporous carbons may favor the formation of heavier hydrocarbons. Zeolite-templated carbons (ZTCs) are microporous carbons that can be synthesized using zeolites as templates. This ZTC synthesis included furfuryl alcohol impregnation into a NaY zeolite, followed by methane chemical vapor deposition, heat treatment, and hydrofluoric acid etching to obtain the carbon product. Copper nanoparticles were then deposited on the surface of the ZTC, and electrochemical tests were performed to assess the catalytic activity of the material . This study aims to interpret the structural integrity of ZTC formation at each step of the synthesis. Moreover, this study looks to clarify how the synthesis and structure of ZTCs relate to their electrochemical performance and reduction of CO2. The results have provided an understanding of how adjustments to the synthesis protocol correspond to variability in crystallinity and catalytic activity of the ZTCs when used for CO2 electroreduction.

Keywords: CO2 electroreduction, zeolite-templated carbon, copper-based electrocatalyst, renewable energy

Investigating the Catalytic Behavior of Cobalt(II) on Alumina for Hydrogenation and Oligomerization Reactions

SURF ID: 402
3:00 PM - 3:15 PM

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Fossil fuels and natural gas are limited resources that civilization depends on for energy and material resources. Because of their limited availability, it is crucial to develop new technologies to convert lower molecular weight hydrocarbons into liquid fuel components more efficiently. Previous research has investigated the catalytic properties of single-site gallium and zinc ions on silica for olefin hydrogenation and oligomerization, i.e., conversion of olefins to higher molecular weight olefins. Due to their similar structure, it is hypothesized that single-site cobalt on alumina will catalyze these reactions as well. In this research, we are testing the reactivity, selectivity, and stability of a cobalt(II)-alumina catalyst for olefin hydrogenation and conversion to higher molecular weight hydrocarbons via oligomerization. Hydrogenation and oligomerization share a common reaction intermediate, so the capability of the cobalt-alumina catalyst to hydrogenate propylene to propane indicates the possibility for oligomerization as well. Several synthesis methods were investigated and their performance for propylene hydrogenation was determined. Material characterizations were used to confirm the desired microstructure, and gas chromatography was used to analyze the reaction products. This study will compare the catalytic properties to those of gallium and zinc to determine if cobalt is a viable choice for further research. Establishing another transition metal catalyst that performs oligomerization will pave the way for investigations of better catalysts for fuel synthesis.

Keywords: Hydrogenation, oligomerization, single-site catalyst, Lewis acid catalyst, fuel synthesis, transition metal catalyst

Post-synthetic Modification of External Acid Sites of MFI Zeolite Catalysts using Chemical Treatments

SURF ID: 408
3:15 PM - 3:30 PM

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Shale gas resources play a significant role in the transition to renewable resources which can be further realized through catalytic conversion of shale gas components to higher-value chemicals and energy-dense transportation fuels. Mobil Five (MFI) zeolite catalysts contain catalytically active sites within their micropores (0.55 nm) which are relevant for industrial shale gas conversion chemistries such as alkene oligomerization. However acid sites, present on external MFI crystallite surfaces have been reported to favor bulkier reactions that are usually restricted by the micropores. The post-synthetic modification of external acid sites may allow for greater control over the rates, product selectivity and catalyst deactivation during alkene oligomerization. Previous work reports that ammonium hexafluorosilicate (AHFS) treatment of MFI zeolites preferentially removes external acid sites while retaining the internal acid sites. Via recently developed protocols, commercial MFI is treated with AHFS solution over 3 treatment cycles and characterized to assess the influence of AHFS on zeolite properties. X-ray diffraction patterns qualitatively suggest negligible degradation of the crystallites during treatments. Elemental analysis shows the MFI underwent progressive bulk dealumination (0-7%) over the treatment cycles. The selective removal of external acid sites is validated by mesitylene alkylation with benzyl alcohol which is a bulky reaction that only occurs at external acid sites. Overall, this work has broader implications for the design of catalysts that facilitate the upgrading of shale gas resources which are important for the current energy transition.

Keywords: Catalysts, shale gas conversion, energy, oligomerization, zeolites

Steel Frame Structure to Hold a Plug-Flow Reactor that Produces Hydrogen via Steam Methane Reforming

SURF ID: 406
3:30 PM - 3:45 PM

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Chemical commodities, such as ethylene and hydrogen, are crucial for society to exist and function now, in the present, and in the future to improve itself to a more efficient society. These chemicals account for much of the global carbon emissions released into the atmosphere. Just as it is crucial for these chemicals to society, it is crucial for society to find ways to decrease carbon emissions while not completely shutting down production of such chemicals. The project aims to reduce carbon emissions from the production of chemical commodities using induction heating. Induction heating uses electricity to produce electromagnetic heat around an electrically conductive material, thus replacing fossil fuels with electricity. With induction heating reactors in development, designing a structure to hold such a reactor is necessary. Through 3D modeling and structural analysis, this structure would sustain a reactor designed for the production of chemical commodities using induction heating from the top of the reactor. Thus avoiding the extremely hot part of the reactor at the bottom. This structure would allow such a reactor to be used and maintained safely within a small room, therefore incentivising companies to adopt this reactor. Thus reducing carbon emissions globally.

Keywords: Plug-Flow Reactor, induction heating, steam methane reforming

Polyselenide Chemistry For Photovoltaic Applications

SURF ID: 212
3:45 PM - 4:00 PM

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Solution processing of metal-chalcogenide thin films holds promise as a scalable process to increase the throughput of photovoltaics. In this work, the alkylammonium polyselenide solvent system is investigated as a chalcogen-based solvent system for the solution processing of Ag2ZnSnSe4 (AZTSe) thin films. These solutions then serve as molecular precursors for Ag2ZnSnSe4 (AZTSe). To realize the potential of alkylammonium polyselenide solvents, the dissolution of Ag, Zn, and Sn in butylammonium polyselenide (BAPSe) is studied. These precursors can then be used to coat thin films. While secondary phases are a common challenge when synthesizing AZTSe, pure phase AZTSe was achieved by utilizing this chemistry and annealing for 10 minutes at 250°C. Furthermore, we observed that high-temperature treatment (300°C to 400°C) of the AZTSe films leads to decomposition and the formation of secondary phases. This work establishes a promising route to fabricate AZTSe thin films and enables further research in designing an AZTSe solar cell.

Keywords: Photovoltaics, AZTSe, thin film, solution processing, kesterite, polyselenide