

**2020**

**PURDUE  
SUMMER  
UNDERGRADUATE  
RESEARCH  
SYMPOSIUM**

**JULY 30 – AUGUST 7, 2020**

West Lafayette, Indiana

# KEY OF PRESENTATIONS

To locate a project within a specific college, use this key to locate which category the presentation is found on the Conference website and then by the first author's last name.

## College: College of Agriculture

### ***DURI***

Gustafson, Lauren: "Soil Health Test Kits and Training for Farmers in Arequipa, Peru"

## College: College of Education

### ***Non-Program College of Education***

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## College: College of Engineering

### ***NCN URE/UCEE***

Kwon, Hae Ji: "Illustrative Mathematical Concepts and Applications for Undergraduate Engineering Courses"

Leichty, Anna: "Introducing Radiation Hardening through Interactive Notebooks to 1st Year Engineering Students"

Mosier, Rebecca: "ECG Data Analysis Using Machine Learning"

Nykiel, Jon: "Using Jupyter Notebooks to Introduce Radiation Hardening to Engineering Students"

Strachan, Alejandro: "Active Learning to Discover High Performance Alloys"

Williams, Joseph: "Data Analysis in Engineering: An Interactive Approach"

Williams, Mye'on: "Co-Production of Solar Energy on Maize farms – nanoHUB Simulation Tool"

### ***VIP - Vertically Integrated Projects***

Chen, Tianhui: "Crowds Detect and Quantify Biased Attributes in Synthetic Face Dataset"

Gan, Lin: "Disinfecting robot platform software design"

McArdle, Ana: "COVID-19 on surfaces"

Metwaly, Mohammed: "Analyzing Worldwide Social Distancing through Large-Scale Computer Vision"

Rasheed, Moiz: "Automated Behavioral Observations in a Multi-Camera Network"

Shen, Yezhi (Andrew): "Automated Image Processing in Forest Inventory Works Faster and Better than Humans"

Son, Kyeonghoon: "Quantum Transport Simulator"

Vivek, Naveen: "Purdue Solar Sail Team"

Xie, Yi: "Disinfecting Robotics --- Covid-19 Response, Biosensor subteam"

### ***Non-Program College of Engineering***

Acharya, Aditi: "Development of a Smartphone App to Automate the Supine Pressor Test"

Cobos, Maximilian: "Review and Comparison of Gaseous Carbon Dioxide Separating Membranes"

## **College: College of Health and Human Sciences**

### ***DURI***

Nayak, Amrish: "Knowledge Discovery from Healthcare Claims Data using Data Mining Techniques"

### ***HHS REACH Scholars***

Chen, Amity: "Palliative Care for Rural Growth and Wellbeing: Identifying Perceived Barriers and Facilitators in Access to Palliative Care in Rural Indiana"

Jarzombek, Candace: "Building semantic networks through play"

Kotapalli, Aditya: "Neurotoxicity of Per- and Polyfluoroalkyl Substances (PFAS): Examination of four recent studies in humans and animals"

McDonald, Abigail: "Close Relationships Neuroscience Project"

Meade, Jacquelyn: "Motivational Factors of Urban Exploration"

Medrano, Leroy: "Relations between parent-child math talk and dual language learner's math performance"

Muczynski, Brandon: "The role of aerobic fitness and motor competency in hippocampal volume and memory in children"

Novorita, Allison: "Evaluating the Impact of a University-Wide Free Menstruation Management Product Policy and Program"

Pawar, Parikshit: "Role of Fatty Acid Metabolism in Migration of Early and Late Stage Breast Cancer"

Schrader, Kate: "Heart Rate-Defined Sustained Attention as a Biological Index of Cognitive Responses in Children with Congenital Zika Syndrome"

### ***LSAMP***

Gandhi, Trishla: "A Meta-Analysis on the Cognitive Effects of Smartphone Presence and Separation"

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Kermani, Mansoorah: "Insulin Disparities: Racial and Economic Impacts on the Health of African American and Latino Type 1 and 2 Diabetics"

## **College: College of Liberal Arts**

### ***Non-Program College of Liberal Arts***

Desai, Hetvi: "Historical analysis of social effects of Orientalis and applications to the Coronavirus"

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Stanley, Dalton: "Utilizing Reduction Potentials to Synthesize Uranium Mixed Tris(imido) Species"

Woolsey, Ian: "A Molecular Dynamics Approach to Predict TetR-type Repressor-Small Molecule Binding Modes"

### ***DURI***

Frantal, Ian: "Determination of the microbial contribution to soils of Arequipa Urban Farms"

Jacoby, Ally: "Carbon Distribution in Arid Agricultural Soils"

Morris, Emilia: "Using TUnfold to Mitigate Errors from Distributions Generated by Quantum Computers"

Ramli, Raziq Raif: "Rebuilding A Geospatial Visualization And Analysis Tool In The Jupyter Environment"

Rao, Trishank: "Machine Learning Application for Cybersecurity Education"

### ***LSAMP***

Rondon, Hannah: "Mechanism Characterization of bacterial ubiquitin E3 ligase Ipg0634 using experimental docking"

### ***NCN URE/UCEE***

Nguyen, Cindy: "Practical Interactive Learning Tools for Scientific Computing and Data Analysis Using R"

### ***Non-Program College of Science***

Brady, Ethan: "The dependence of a freshwater mussel metapopulation on host fishes"

Fontan, Fabiola: "The biodiversity of zooplankton communities between permanent and temporary ponds"

## **College: Purdue Polytechnic Institute**

### ***DURI***

Pictor, Noah: "Portable and Low-Cost Solar Radiation Sensor from UV to NIR"

**Discussion Category:** Chemistry Summer Research

## **Utilizing Reduction Potentials to Synthesize Uranium Mixed Tris(imido) Species**

*Physical Sciences*

Author:

Dalton Stanley, Purdue University

Abstract:

Redox-active ligands provide a framework for facilitating multi-electron movement, enabling synthesis of uranium tris(imido) complexes from organoazides, where the imido ligands display a t-shape arrangement. These tris(imido) compounds demonstrate differing bonding patterns between the trans and equatorial U-Nimido bonds. Using more than one organoazide forms uranium mixed tris(imido) species, where the trans- and equatorial-imido substituents are different. Either bonding region selectively takes on imido ligands based on reduction potentials of the organoazide reactant, such that more oxidizing organoazides will prefer to react at the equatorial environment. Herein, our group reports the synthesis of uranium tris(imido) compounds, including those with mixed imido groups. These compounds help to elucidate differences in bonding depending on the location of the imido group; these differences are due in part to the inverse trans influence. Synthesis, characterization through spectroscopic and structural methods, and the importance of understanding the electronic structure of uranium mixed tris(imido) complexes will be discussed.

*Research Mentor:*

*Suzanne Bart, Purdue University*

**Discussion Category:** Chemistry Summer Research

**A Molecular Dynamics Approach to Predict TetR-type Repressor-Small Molecule Binding Modes**

*Physical Sciences*

Author:

Ian Woolsey, Purdue University

Abstract:

Abstract withdrawn.

*Research Mentor:*

*Elizabeth Parkinson, Purdue University*

*Bryon Drown, Northwestern University*

**Discussion Category: DURl**

## **Determination of the microbial contribution to soils of Arequipa Urban Farms**

*Physical Sciences*

Author:

Ian Frantal, Purdue University

Abstract:

Organic carbon (C) and nitrogen (N) inputs may come from a variety of sources, including plant and animal tissues as well as microbial biomass and residues (Liang et al., 2019). Some soil compounds can be traced to a particular biological origin and have been used to better understand the processes occurring in soils. Recently soil amino sugar analysis has grown in popularity because they provide insight into the microbial contribution to soil organic matter (SOM) turnover (Zhang & Amelung, 1996). While several amino sugars can be identified in microorganisms, only four of them are commonly used to determine the microbial necromass contribution to SOM (Joergensen, 2018). Glucosamine is the most common amino sugar in soil, contributed mainly by fungal cells. Muramic acid is traced to a bacterial origin; mannosamine has an unclear microbial origin while galactosamine is created from microbial cell walls, both in bacteria and fungi (Parsons 1981; Joergensen, 2018).

To determine the microbial contribution to agricultural soils, 10 samples from Arequipa Urban Farms were analyzed according to the protocol developed by Zhang and Amelung in 1996. Samples were hydrolyzed, purified, derivatized, and analyzed by GC/MS. Quantification of the microbial contribution to soil was determined by the mass of soil, of C, and of N (Liang et al. 2019). Preliminary results demonstrate that the microbial necromass contribution changes according to the sample site's location. As the collaborative research continues, the results will give a greater picture of the relative contribution of microorganisms to SOM turnover in different arid lands.

*Research Mentor:*

*Tim Filley, Purdue University*

*Martha Elena Jimenez-Castaneda, Purdue University*

**Discussion Category:** DUR1

## **Soil Health Test Kits and Training for Farmers in Arequipa, Peru**

*Physical Sciences*

**Author:**

Lauren Gustafson, Purdue University

**Abstract:**

In the face of global climate change, farmers in arid lands like Arequipa, Peru will likely face challenges to producing crops. Maintaining soil health, the capacity to sustain plants, animals, and humans through a balance of its components, will be of the utmost importance in ensuring sustainable agriculture. To better understand the extent to which agricultural activities and irrigation impact soil health in Arequipa, it is important to compare measurements of the same sampling locations over time or across different fields and treatments.

The Patcha Kit is designed to enable farmers to test various soil health components in the field and upload results to a database to compare management systems, diagnose potential soil problems, and monitor soil health over time. To accompany the kits in Arequipa, an instruction manual and video curriculum were developed in English and Spanish. The manual compiled methods covering physical, chemical, and biological factors of soil health, as well as indices on equipment and identification of soil macrofauna. Each method was filmed to provide an example of the methodology. It is important to recognize limitations farmers might encounter in the field. While building the kits, tests were conducted to determine the time to complete each method in the field, whether procedures were clear, and if any other materials were needed outside the lab setting. Conducting tests outside also determined whether data obtained from field tests were accurate compared to laboratory studies and whether the kits' cost could be reduced with cheaper substitutes for certain materials.

*Research Mentor:*

*Erika Foster, Purdue University*

*Timothy Filley, Purdue University*

**Discussion Category:** DUR1

## **Carbon Distribution in Arid Agricultural Soils**

*Physical Sciences*

**Author:**

Ally Jacoby, Purdue University

**Abstract:**

In the face of climate change, drylands are expected to expand from 41% of global land area to over 50% by the year 2100 (Feng and Fu, 2013). This rapid desertification, along with an increasing human population, creates pressure to develop agriculture on arid lands. However, desert agriculture is challenging and resource intensive, requiring large inputs of water, fertilizers, and pesticides to improve the naturally low productivity. One of the key components to successful agriculture is soil organic matter (SOM), which provides crops with essential nutrients and increases soil water retention (Bationo et al., 2007). The amount of SOM in arid soils is very low, but it can be increased through management techniques. In order to make informed management decisions to increase SOM accumulation, it is important to understand the distribution of SOM; studies suggest that soil fractions separated by density differ in the stability and decomposition rates of soil organic matter (Schnecker et al. 2016). This experiment examines soil organic carbon, which can be used as a proxy for SOM, in soils under vineyard cultivation in the desert region of Arequipa, Peru. The goal is to quantify the carbon concentrations in the dissolved organic matter (DOM), particulate organic matter (POM), and mineral associated organic matter (MAOM) fractions of the soil. In order to separate the soil fractions, a size and density fractionation using sodium polytungstate was performed on each sample, and the fractions will be individually analyzed for carbon content on an Elemental Analyzer Isotope Ratio Mass Spectrometer.

*Research Mentor:*

*Tim Filley, Purdue University*

*Erika Foster, Purdue University*

**Discussion Category:** DUR1

## **Using TUnfold to Mitigate Errors from Distributions Generated by Quantum Computers**

*Mathematical/Computation Sciences*

Author:

Emilia Morris, Purdue University

Patrick Kelly, Purdue University

Abstract:

Quantum computing uses an entirely different framework than classical computers to perform large, complex calculations quickly. Quantum computers promise exponential speed-up of certain algorithms but are delicate machines currently prone to errors in part due to the extreme requirements on a controlled environment needed to operate these machines. Quantum algorithms give probabilistic results with a level of noise based off the calibrations of the quantum machine. In this DUR1 Summer research experience, I explored a cross-disciplinary approach to mitigating this noise. Using TUnfold from CERN's ROOT package, a tool used in high-energy physics to find true distributions from detector data, we attempt to find the true results of an algorithm from the muddied data outputted by an IBM Qiskit machine. Finding new ways to reduce error allows the field of quantum computation to expand further with statistically verifiable results on more complex algorithms.

*Research Mentor:*

*Andreas Jung, Purdue University*

**Discussion Category:** DUR1

## **Knowledge Discovery from Healthcare Claims Data using Data Mining Techniques**

*Life Sciences*

Author:

Amrish Nayak, Purdue University

Abstract:

Opioid use disorder (OUD), a chronic, relapsing illness, is a major public health crisis. While evidence-based treatments such as medication-assisted treatment (MAT) can reduce overdose-related deaths, gender and race/ethnicity groups tend to have more barriers to accessing treatment services. This study aims to examine the type of treatment received for Medicaid enrollees diagnosed with OUD in Indiana for the period of 2015 and 2019 and determine if there are treatment variance among population subgroups.

To identify treatment disparities, we utilized the reimbursement claims data from the Indiana Family & Social Services Administration (FSSA) database. To identify our study population, we filtered the claims based on the ICD-10 diagnosis codes and used ICD-10 PCS codes to identify the treatments associated with OUD. Each diagnosis and treatment prescribed simultaneously were grouped in chronological order to form a treatment utilization sequence for each patient. We used descriptive statistics and applied Sequential Pattern Discovery using the Equivalence Classes (SPADE) algorithm to analyze each treatment utilization sequence. Then, we compared treatment disparities and its relationship with overdose among population subgroups. We found that between 2015 and 2019 there were 93,447 patients with OUD in Indiana, of whom 8,240 (8.82%) received evidence-based treatment. Further, we found that 97.4% patients received detoxification, 18.7 % received psychological services and 18.5% received pharmacotherapies. Analyzing healthcare reimbursement claims data can help offer insights into policymaking and capacity management by providing quantitative characterizations of treatment disparities.

*Research Mentor:*

*Carolina Vivas, Purdue University*

*Nan Kong, Purdue University*

**Discussion Category:** DUR1

## **Portable and Low-Cost Solar Radiation Sensor from UV to NIR**

*Innovative Technology/Entrepreneurship/Design*

Author:

Noah Pictor, Purdue University

Abstract:

Sensors capable of measuring the solar spectrum find applications in agriculture, renewable energy, and human health. Commercially available solar radiation sensors cost hundreds of dollars, the price increasing by a few more hundred dollars if a graphical user interface is included. The motivation of this project was to develop a low-cost and portable substitute for measuring solar spectral irradiance from the ultraviolet (UV) to the near infrared (NIR). To achieve a low cost, we employed a phone app to act as the user interface, to store sensor data, and to work as a bridge to long-term cloud storage. The physical circuitry was designed to be as minimal as possible consisting of integrated spectral photodiode arrays, a microcontroller to manage the sensors and the connection to the phone app, battery management circuitry, and peripherals to ensure successful operation. The size of the circuit board is 8.2 cm × 5.5 cm, components costing 50.19 dollars. This system will lower the cost of future experiments involving solar radiation, enabling experiments to take place and people to conduct such experiments.

*Research Mentor:*

*Daniel Leon-Salas, Purdue University*

**Discussion Category:** DUR1

## **Rebuilding A Geospatial Visualization And Analysis Tool In The Jupyter Environment**

*Mathematical/Computation Sciences*

Author:

Raziq Raif Ramli, Purdue University

Abstract:

SIMPLE-G is a multi-region, partial equilibrium model of gridded cropland use, crop production, consumption, and trade. It is an extension of the SIMPLE model that has been applied to study long-run sustainability issues in the global food-water-environment nexus. Deployed at MyGeoHub ([mygeohub.org](http://mygeohub.org)), the SIMPLE-G US tool allows users to run the SIMPLE-G model online and analyze the model outputs by visualizing geospatial data for agricultural prices, land use, and the environment in the United States region. One shortcoming of the SIMPLE-G US tool was that it is written with an outdated PyQGIS spatial data analysis/processing library, which makes it difficult to use newer/richer graphical libraries. In addition, it is a standalone application and thus does not look like a native web application when accessed via Virtual Network Computing (VNC) and takes much effort to modify the graphical user interface (GUI) to add new features.

To overcome these problems, I rebuilt the legacy SIMPLE-G US tool in the Jupyter Notebook environment to make it more flexible and up-to-date with spatial data processing libraries. The software's user interface is built using ipymaterialui, a graphical library for the Jupyter environment based on the Material UI framework. A new side-by-side raster output comparison feature was developed using the ipyleaflet library which was hard to implement in the previous version. In summary, converting the SIMPLE-G US tool into a Jupyter notebook overcame some map display restrictions and enabled integration with richer graphical libraries, making it more flexible and easier to develop.

*Research Mentor:*

*Jungha Woo, Purdue University - ITaP Research Computing*

*Rajesh Kalyanam, Purdue University - ITaP Research Computing*

*Lan Zhao, Purdue University - ITaP Research Computing*

**Discussion Category:** College of Science

## **Machine Learning Application for Cybersecurity Education**

*Mathematical/Computation Sciences*

Author:

Trishank Rao, Purdue University

Abstract:

Cybersecurity education has traditionally focused on demonstrating common cybersecurity flaws and their solutions. Recently with the rise of the field of machine learning (ML), novel approaches to cybersecurity evaluation have been developed to analyze and process large quantities of logging data (network traffic, system logs, etc.) to uncover and identify security flaws. The goal of this research is to develop an example of one such machine learning integrated cybersecurity lesson for a public, web-based cybersecurity education platform, CHEESE hub. The lesson aims to give instructors and students a hands-on approach to teaching or learning about the intricacies of machine learning while being able to explore network traffic data that simulates Distributed Denial of Service (DDoS) attacks. The steps of machine learning involve a sequence of exploring and understanding data. People new to the field of machine learning or cybersecurity are guided on how to read, explore, train and test ML models on large and complex data using various Python libraries while producing accurate and noteworthy results. A binary logistic regression classifier is used to train two models that can distinguish network traces pertaining to three kinds of DDoS attacks (NetBIOS, Portmap, and Syn) from benign traffic. The trained model is then tested on three different sets of un-seen data to gauge the accuracy of the model in predicting DDoS attacks from benign data and from other DDoS attack types. Evaluation metrics are used to measure the precision, recall, F1 score and overall accuracy of the model. The lesson also provides users with the flexibility to modify code based on certain useful plots such as correlation. The base logistic regression model outputs significant weighted accuracy scores for NetBIOS against benign and Portmap against benign and moderate accuracy scores for NetBIOS against Syn.

*Research Mentor:*

*Rajesh Kalyanam, Purdue University*

*Baijian Yang, Purdue University*

**Discussion Category:** HHS REACH Scholars

**Palliative Care for Rural Growth and Wellbeing: Identifying Perceived Barriers and Facilitators in  
Access to Palliative Care in Rural Indiana**

*Social Sciences/Humanities/Education*

**Author:**

Amity Chen, Purdue University

**Abstract:**

Palliative care is defined as an approach to improve patient's quality of life and their families while facing problems with serious, life-threatening complex illnesses. Inadequate access to palliative care can lead to delayed pain and symptom management, delayed decision making for end of life care, and dissatisfaction in care among patients and families. The purpose of this research is to investigate the barriers and facilitators of palliative care services in the rural population of Carroll County, Indiana. A qualitative descriptive approach will be used for the study. Participants for this study include family caregivers, healthcare providers, and stakeholders in Carroll County, Indiana. Semi-structured interviews will be conducted to collect the data. Data will be analyzed using a thematic analysis approach. Findings will assist us in developing potential strategies for improving access to palliative care in rural Indiana.

*Research Mentor:*

*Nasreen Lalani, Purdue University*

**Discussion Category:** HHS REACH Scholars

**Building semantic networks through play**

*Social Sciences/Humanities/Education*

**Author:**

Candace Jarzombek, Purdue University

**Abstract:**

Prior empirical studies have shown that building dense semantic networks in early vocabulary can boost word comprehension and learning skills. We expand on this research by asking how children build these semantic connections between words through everyday learning contexts, such as play with their caregivers. When children were 24 months, 78 toddler-parent dyads were recorded while playing with a set of toys including some objects that were related in meaning, such as farm animals and vehicles, and some unrelated objects, such as a Jacob's ladder and slinky. We coded whether participants tended to interact with related or unrelated sequences of toys via touching. Specific coding guidelines and iterative evaluations of the coding protocols allowed us to improve intercoder reliability. When coding is completed, we plan to compare the amount of time dyads play with related vs. unrelated toys in relation to toddlers concurrent and future vocabulary and language skills between 24-36 months of age. While it is possible that interacting with semantically related toys simultaneously could create confusion for the child in distinguishing between objects, we hypothesize that we will find positive correlations between language skills and the tendency to play with related toys, thereby extending recent findings that children tend to learn novel words that share semantic relations with other known objects. This project will contribute to the literature on parent-child interaction in play, could influence recommendations for how parents encourage interaction with toys in play, and assist in identifying early markers of language disorders and delays.

*Research Mentor:*

*Arielle Borovsky, Purdue University*

**Discussion Category:** HHS REACH Scholars

**Neurotoxicity of Per- and Polyfluoroalkyl Substances (PFAS): Examination of four recent studies in humans and animals**

*Life Sciences*

Author:

Aditya Kotapalli, Purdue University

Abstract:

Man-made chemicals used in commercial products have certain chemical properties that make the products marketable. Unfortunately, some of these chemical properties, like in the case of per- and polyfluoroalkyl substances (PFAS), result in presence of and bioaccumulation in the environment, which raises concerns due to potential adverse health outcomes following exposure. Increasing reports are indicating neurotoxic effects for PFAS. As such, the recent research literature was examined on studies evaluating neurological outcomes in humans and animals to understand the neurotoxic impacts of various PFAS. Studies included evaluation of PFAS behavioral effects in children, developmental neurotoxicity and behavioral effects in zebrafish, cytotoxicity and autophagy in rats, and neurotransmitter analysis in polar bears. These studies report decreased executive function as measured by an increase in metacognition score at 8 years old in children with increased PFAS serum levels at 3 years of age and that PFAS was able to pass through the blood brain barrier as seen when comparing serum PFAS to PFAS in cerebrospinal fluid. Developmental neurotoxicity was also seen in zebrafish with survival and morphological changes as well as locomotor abnormalities observed in behavioral studies. Autophagy and cytotoxicity was observed when rat-derived astrocytes were exposed to PFAS. In addition, positive and negative correlations between PFAS concentration and steroid and neurotransmitter concentration were found in a study with polar bears. Overall, these studies provide support for PFAS neurotoxicity warranting further analysis into the specific mechanisms of action for evaluation of health risk.

*Research Mentor:*

*Jennifer Freeman, Purdue University*

**Discussion Category:** HHS REACH Scholars

**Close Relationships Neuroscience Project**

*Social Sciences/Humanities/Education*

Author:

Abigail McDonald, Purdue University

Abstract:

There are two neurological markers of depression that have been identified using electroencephalogram (EEG): reward sensitivity and emotional disengagement. These allow for measurable indicators of depression vulnerability in high risk individuals. Yet, there has been no research in adults on how these markers associate with depressive symptoms in the context of stressful environments. Depression is the most common mental illness, thus there is an essential need to research one's individual risk for depression. A major stress and a risk factor for psychopathology in adults is committed romantic relationships. Our study seeks to identify if depression, in the context of romantic distress, is indicated by abnormal neurophysiological processing of stressor-related stimuli (an image of one's romantic partner). Our methods include gathering self-report, interview, and psychophysiological data to determine the associations between neurological indicators, relationship satisfaction, and depression. The study has a 6-month follow up to examine longitudinal prediction of depressive symptoms. We hypothesize that there will be significant associations between depression, neurological indicators, and relationship functioning. Additionally, we hypothesize an interaction between emotional and neural reactivity to partner's face and relationship stress will be a significant predictor of depressive symptoms.

*Research Mentor:*

*Susan South, Purdue University*

*Dan Foti, Purdue University*

*Samantha Ingram, Purdue University*

*Samantha Dashineau, Purdue University*

**Discussion Category:** HHS REACH Scholars

## **Motivational Factors of Urban Exploration**

*Social Sciences/Humanities/Education*

Author:

Jacquelyn Meade, Purdue University

Abstract:

Urban exploration is often conceptualized as an activity to seek out, visit, and document derelict manmade structures including rooftops, tunnels, and industrial complexes. As an emerging form of tourism practice, exploring hidden and abandoned urban spaces has gained increasing popularity over the past decade. Inspired by the unique and unguided nature of urban exploration, scholarly interests in studying this phenomenon has begun to emerge. Through textual analysis of secondary data from academic sources and online communities, this study investigates the motivational factors behind the rising trend of urban tourism. The results show that motivating factors to seek and explore urban spaces include historical curiosity, sentimental attachments, cultural milieu and art, desire for mysterious adventures, phenomenology, and photography.

*Research Mentor:*

*Jianan Zhang, Purdue University*

*Liping Cai, Purdue University*

**Discussion Category:** HHS REACH Scholars

## **Relations between parent-child math talk and dual language learner's math performance**

*Social Sciences/Humanities/Education*

**Author:**

Leroy Medrano, Purdue University

**Abstract:**

As children grow, language is one of the first skills they start to develop (LeFevre et al, 2010). When engaging in mathematics, language has a large component as words are needed to express mathematical ideas and concepts (Spelke, 2003). Within mathematics, the focus is on informal numeracy skills which comprise of counting, relations, and arithmetic operations (Purpura & Lonigan, 2013). It is important to start investigating dual language learners and their acquisition of mathematic skills through parent-child language interactions. Having a better understanding of this will allow for more accurate assessments of children's abilities and more appropriate interventions for them. To help close the gap in the lack of research, I will be coding a dataset of 70 families that read a non-mathematical book to their child, which was the Ugly Duckling in Spanish and there was nothing in the story that prompted any math discussion per se, but there were opportunities for parents to discuss mathematics with their child. Specifically, I am coding for the counting, use of numbers, words that represent mathematical language concepts (e.g., more, few, same) that are used by either child or parent. Mathematic directed questions from the parents (e.g., How many ducks are there) will also be coded. Children were also assessed on mathematic skills using a brief numeracy screener (Preschool Early Numeracy Skills – Brief Screener; Purpura, Reid, Eiland, & Baroody, 2015). We will examine the association of number talk and mathematic language talk that parents and children use with children's mathematical performance.

*Research Mentor:*

*David Purpura, Purdue University*

**Discussion Category:** HHS REACH Scholars

**The role of aerobic fitness and motor competency in hippocampal volume and memory in children**

*Life Sciences*

Author:

Brandon Muczynski, Purdue University

Abstract:

Due to a growing trend of childhood inactivity, young children are becoming overweight and unfit, resulting in not only poorer physical health but also suboptimal development of the brain and cognition. Specifically, aerobic fitness is important to the structural and functional integrity of the hippocampus, a brain region essential for memory function, with higher levels of aerobic fitness associating with greater hippocampal volumes and memory performance. However, it remains to be determined whether other domains of physical fitness may also contribute to the development of the hippocampus and memory in children. The purpose of this study is to explore the relationship of motor competency with hippocampal size and memory. Twenty children aged 9-10 years will be recruited to complete a graded exercise test, a movement Assessment Battery for Children (M-ABC), a structural magnetic resonance imaging (MRI) scan, and a pattern separation task to evaluate aerobic fitness, motor competency, hippocampal volumes, and hippocampal-dependent memory performance, respectively. We hypothesize that not only aerobic fitness but also motor competency would positively correlate with hippocampal volumes and memory performance. The expected results will provide evidence to support the development of physical activity designed to promote not only aerobic fitness but also motor competence as these fitness domains may play important roles in the childhood cognitive and brain health.

*Research Mentor:*

*Shih-Chun (Alvin) Kao, Purdue University*

*Nicholas Baumgartner, Purdue University*

*Christian Nagy, Purdue University*

**Discussion Category:** HHS REACH Scholars

## **Evaluating the Impact of a University-Wide Free Menstruation Management Product Policy and Program**

*Social Sciences/Humanities/Education*

Author:

Allison Novorita, Purdue University

Abstract:

HHS REACH Scholars

Evaluating the Impact of a University-Wide Free Menstruation Management Product Policy and Program

Undergraduate Researcher: Allison Novorita

Abstract

**Background:** Lack of access to menstruation products can negatively affect school attendance, academic performance, and individual health. To combat burdens menstruators face, the implementation of “period policies”, or programs offering free menstruation products, have become popular in schools, businesses, and communities. Purdue University announced in February 2020 that free tampons and pads will be stocked in all women’s and gender-neutral restrooms in campus buildings.

**Objective:** We are preparing to obtain data regarding: 1) knowledge and stigma Purdue members hold surrounding menstruation; 2) experiences students and staff have had with the free menstruation product program and its influence on campus culture; 3) how the program and policy can be improved.

**Methods:** Our research plan will include three phases: 1) product testing via daily diary surveys; 2) focus group discussions; and 3) a campus-wide survey, all of which will be conducted from August 2020 through May 2021. Data will be collected from Purdue University students, staff, and faculty. All protocols and measurement tools will be approved by the Purdue University Institutional Review Board prior to data collection.

**Expected Impact:** Outcomes from this project will significantly contribute to menstruation management and period poverty solutions for faculty, staff, and students at Purdue University. The availability of free menstruation products may alleviate harsh social stigma surrounding menstruation and positively affect menstrual experiences.

*Research Mentor:*

*Andrea DeMaria, Purdue University - Interdisciplinary Women's Reproductive Health Collaborative*

*Risa Cromer, Purdue University - Department of Anthropology*

*Sharra Vostral, Purdue University - Department of History*

*Audrey Ruple, Purdue University - Department of Public Health*

*Meghana Rawat, Purdue University - Brian Lamb School of Communication*

**Discussion Category:** HHS REACH Scholars

## **Role of Fatty Acid Metabolism in Migration of Early and Late Stage Breast Cancer**

*Life Sciences*

**Author:**

Parikshit Pawar, Purdue University

**Abstract:**

Breast cancer is a leading health issue, contributing to over 30% of estimated new cancer cases among US women this year. The metastasis of breast cancer cells accounts for the majority of breast cancer related deaths; therefore, preventing this progression is critical to reducing breast cancer patient mortality. A hallmark of cancer cells is their ability to reprogram cellular metabolic pathways. To produce sufficient energy for their metabolic demands, cancer cells may use fatty acids (FAs) as a substrate for fatty acid oxidation (FAO). Free fatty acids in the cell are primarily supplied by means of fatty acid uptake, fatty acid synthesis, or mobilization of FAs from cytoplasmic lipid droplets (CLDs). Although CLDs accumulate in metastatic breast cancer cells, gaps still exist regarding the extent to which each pathway contributes to the progression of breast cancer development. Our goal is to determine the mechanism by which FAs may support breast cancer migration. We hypothesize that FAs hydrolyzed from CLDs drive breast cancer cell migration by providing FAs for FAO. To test this hypothesis, we will compare cell migration between non-metastatic MCF10A-ras and metastatic MCF10CA1a human breast cancer cells treated with inhibitors of key enzymes involved in fatty acid synthesis (fatty acid synthase), triglyceride lipolysis (monoacylglycerol lipase), or either inhibitor in combination with FAO inhibitor, etomoxir. To measure migration, we will utilize a wound-healing assay and a transwell migration assay. The results of these experiments will determine which FA source is the greatest contributor to breast cancer cell migration

*Research Mentor:*

*Chaylen Andolino, Purdue University*

*Dorothy Teegarden, Purdue University*

**Discussion Category:** HHS REACH Scholars

**Heart Rate-Defined Sustained Attention as a Biological Index of Cognitive Responses in Children with Congenital Zika Syndrome**

*Social Sciences/Humanities/Education*

Author:

Kate Schrader, Purdue University

Abstract:

Congenital Zika syndrome (CZS) is an often severe disability characterized by birth defects resulting from mothers being infected with Zika during pregnancy. There is little research on CZS and how affected individuals respond to the world around them. CZS is associated with various conditions resulting in sensory and motor delays which make it difficult to use standard assessments. This, compounded with the additional barriers of language differences and low resources, makes the task of assessing these children difficult. One solution may be to supplement standard assessment tools with psychophysiological methods that don't rely on overt behavioral responses. Previous research has shown that heart rate-defined sustained attention (HRDSA) is a biological index of cognitive responses in typically developing children and kids with different neurodevelopmental disabilities. My project aims to use HRDSA to gain a deeper understanding of how infants with CZS perceive their environments. I am supporting data processing from a HRDSA task conducted with 57 infants with CZS. Participants are recorded watching an engaging children's video while their heart rates are monitored. Then, we code infants' looking behaviors and analyze whether and how their heart rate decelerations vary. I predict that infants which are shown to have greater developmental skills when measured on standard clinical assessments will display more HRDSA during the task. Caregivers of these children often don't know if these kids are responding to their environment due to limited behavioral responses, so this information is important in helping families and clinicians understand how children are developing over time.

*Research Mentor:*

*Bridgette Kelleher, Purdue University*

*Wei Siong Neo, Purdue University*

**Discussion Category: LSAMP**

## **A Meta-Analysis on the Cognitive Effects of Smartphone Presence and Separation**

*Life Sciences*

Author:

Trishla Gandhi, Purdue University

Abstract:

Over the last decade, smartphones have gone from a luxury to a necessity. This proliferation in smartphone use and dependency has led to many research papers looking at how smartphone presence or separation can be distracting and have negative consequences on memory and attention. The aim of this current paper is to conduct a systematic review and meta-analysis to examine the relationship between smartphone presence and its effects on memory. A search strategy using the PSYCinfo database was used to acquire studies and the subsequent meta-analysis was run using Comprehensive Meta-Analysis Software (CMA). Seven studies were included in this review. Results showed that the aggregated effect size did not significantly differ from zero (Hedge's  $g = .07$ ,  $p = .68$ ). However, the Q-test indicates a significant amount of heterogeneity for variables that drive the direction and magnitude of the effect smartphones have on memory and attention (Q test of heterogeneity = 45.51,  $p < .001$ ). Thus, there is no clear indication as to which theory has a larger effect. The effect of smartphone separation and presence has growing implications on our daily school and work lives. Further studies should ascertain whether smartphone presence or separation has a greater negative impact on memory.

*Research Mentor:*

*Thomas Redick, Purdue University*

**Discussion Category: LSAMP**

**Mechanism Characterization of bacterial ubiquitin E3 ligase Ipg0634 using experimental docking**

*Life Sciences*

Author:

Hannah Rondon, Purdue University

Abstract:

Legionella pneumophila is a gram-negative pathogenic bacterium that causes Legionnaires' disease, which is a severe form of pneumonia. During its infectious cycle, L. pneumophila secretes virulence protein effectors into the host cytoplasm to interfere with host cellular activities. One of these host pathways is the ubiquitin system, which is involved in host immune response and protein degradation. One of the effectors L. pneumophila secretes is Ipg0634, a ubiquitin E3 ligase, whose function is not well-characterized. While the structure of Ipg0634 has been solved, its catalytic mechanism is poorly understood. To investigate Ipg0634's catalytic function, we use computational approaches to characterize how Ipg0634 catalyzes ubiquitin ligation and the interaction between the E2~ubiquitin complex and the E3 ligase. Our analysis of structure suggests that Ipg0634 is likely to catalyze ligation by bringing the E2~Ub complex to the substrate, rather than forming an E3~ubiquitin thioester complex. We also identify residues that are likely involved in the interaction between Ipg0634 and the E2~ubiquitin complex. Our findings help elucidate the catalytic mechanism of Ipg0634 and provide insights into how L. pneumophila hijacks the host ubiquitination pathway. Understanding the strategies L. pneumophila uses to propagate can identify novel targets for therapeutics in Legionnaires' disease.

*Research Mentor:*

*Zhengrui Zhang, Purdue University*

*Chittaranjan Das, Purdue University*

**Discussion Category:** NCN URE/UCEE

## **Illustrative Mathematical Concepts and Applications for Undergraduate Engineering Courses**

*Mathematical/Computation Sciences*

**Author:**

Hae Ji Kwon, Ivy Tech Community College-Lafayette

**Abstract:**

Multiple studies have identified students' math skills as one of the primary factors directly correlated to student performance in engineering courses. Therefore, the objective of this project was to develop educational tools to illustrate fundamental mathematical concepts and applications to engineering. The tool consists of interactive modules to engage students in multi-step activities with instant performance feedback. The topics were selected from calculus, multivariate calculus, and linear algebra based on the authors' experience with past students' performance in these areas. Each module is designed to 1) illustrate key math concepts, 2) relate the concepts to practical applications, 3) supply example problems, and 4) provide sample codes for modification. Through multi-step activities, students will be able to review the fundamental concepts and engage in active learning processes.

The tool was developed with Python 3-based Jupyter Notebooks, an open-source web application selected for its accessibility and features specialized in interactive learning and data sharing. The modules will be published on the nanoHUB (<https://nanohub.org/>), a free online platform dedicated to serving STEM students, instructors, and researchers. The published tool will be accessible to all students and faculties. Furthermore, it will be implemented in engineering courses offered at Ivy Tech Lafayette.

*Research Mentor:*

*David Ely, Ivy Tech Community College-Lafayette*

**Discussion Category:** NCN URE/UCEE

## **Introducing Radiation Hardening through Interactive Notebooks to 1st Year Engineering Students**

*Physical Sciences*

Author:

Anna Leichty, Ivy Tech Community College

Jon Nykiel, Ohio State University

Abstract:

The field of Microelectronics, specifically the area of Radiation Damage and Hardening, are critical design components when developing technology. The Department of Defense recognizes the need for research and workforce development in those areas. The SCALE project is a partnership of colleges and universities created to address this problem. Our team focuses on one aspect of the problem by introducing engineering students to these fields early in their education by the way of homework assignments. We developed new homework assignments for ENGR 132, a course in Purdue's First Year Engineering Program, focused on data analysis and programming in the context of radiation damage and hardening. Importantly, these homework assignments are available in nanoHUB online, students only need a web-browser and access to the internet. All assignments are deployed as Jupyter notebooks, a program which combines Markdown text, powerful graphics, and live code. This makes completing the homework easier on students because everything they need to complete their assignment is in the same place. These assignments introduce students to a variety of concepts including material thickness needed to limit radiation damage, stopping power of a material, total ionizing dose, dose-depth curves, and factors in deciding orbits of space missions.

*Research Mentor:*

*Zachary McClure, Purdue University*

*Alejandro Strachan, Purdue University*

**Discussion Category:** NCN URE/UCEE

## **ECG Data Analysis Using Machine Learning**

*Mathematical/Computation Sciences*

**Author:**

Rebecca Mosier, Johns Hopkins University

**Abstract:**

Heart disease is the leading cause of death in the United States for men and women of most racial and ethnic groups. An electrocardiogram (ECG/EKG) measures the electrical impulse caused by a heartbeat in order to detect irregularities and heart diseases; however, ECGs are most often interpreted tediously through visual inspection and lack a method of convenient comparison that can be provided by a modern mathematical model. We developed a nanoHUB tool in Jupyter Notebook to model ECG data using a governing equation. This allows us to obtain a better understanding of heart disease by quantitatively comparing normal functioning and diseased hearts. The equation was developed by applying the sparse identification of nonlinear dynamics (SINDy) approach to model discovery for each patient. SINDy is a machine learning technique that uses sparse regression to find a linear combination of basis functions from a defined library that best models the dynamic behavior of the relevant data. The library of basis functions was determined by developing synthetic ECG data from a series of B-spline equations. Real ECG data were processed through a bandpass filter and modeled using this method. The ECG Data Analysis Using Machine Learning tool offers educational background material on ECGs, interactive synthetic ECG data analysis, and provides a new method to analyze real ECG data that can potentially be used to diagnose heart diseases.

*Research Mentor:*

*Guang Lin, Purdue University*

*Sheng Zhang, Purdue University*

**Discussion Category:** NCN URE/UCEE

**Practical Interactive Learning Tools for Scientific Computing and Data Analysis Using R**  
*Mathematical/Computation Sciences*

**Author:**

Cindy Nguyen, Florida Polytechnic University

**Abstract:**

Scientific computing is the combination of mathematical models and computational techniques to solve problems in science and engineering. Data analysis interprets complex data and extracts relevant information to create informed decisions. Learning skills in scientific computing and data analysis, with data and models playing a prevalent role in fields such as physics, engineering, and medical research, will increase efficiency in decision making and modeling. A Jupyter Notebook is an open-source web application used to create and share documents that contain live code, visualizations and narrative text. In this project, Jupyter notebooks are used to introduce root-finding techniques including Newton-Raphson and Bisection, with implementations and examples comparing different approaches to solve root-finding problems, and sample applications in science and engineering showcased. Additionally, optimization methods are presented to find the maximum or minimum of a given function, and an application in curve fitting is shown. Optimization problems arise in a wide variety of applications in engineering design, parameter estimation, and machine learning. Students and researchers interested in fundamentals and applications of numerical analysis, physics, engineering design, optimization, scientific computing, and calculus can benefit from exploring the examples and methods explained and developed here.

*Research Mentor:*

*Reinaldo Sanchez-Arias, Florida Polytechnic University*

**Discussion Category:** NCN URE/UCEE

## **Using Jupyter Notebooks to Introduce Radiation Hardening to Engineering Students**

*Physical Sciences*

**Author:**

Jon Nykiel, Ohio State University

Anna Leichty, Ivy Tech Community College

**Abstract:**

There currently exists a shortage of trained engineers in the microelectronics workforce, particularly in the field of radiation effects. To remedy this issue, a series of educational tools were created that will be integrated into first-year engineering assignments at Purdue University. These tools were created using Jupyter Notebooks, and run MATLAB kernels hosted by nanoHUB.org. The notebooks are intended to replace some of the current homework assignments at Purdue, and have the benefit of introducing radiation hardening to students early in their career path while still meeting the learning objectives of the course. These problem sets were created using data obtained from research papers in the field of radiation hardening, and a molecular dynamics tool is currently being developed to provide more data and visualizations to create more assignments. An additional advantage of these notebooks is that they can easily be implemented into coursework at other universities.

*Research Mentor:*

*Zachary McClure, Purdue University*

*Alejandro Strachan, Purdue University*

**Discussion Category:** NCN URE/UCEE

**Active Learning to Discover High Performance Alloys**

*Mathematical/Computation Sciences*

Author:

David Farache, Purdue University

Zack McClure, Purdue University

Saaketh Desai, Purdue University

Abstract:

Abstract withdrawn.

*Research Mentor:*

*Alejandro Strachan, Purdue University*

*Juan Carlos Verduzco Gastelum, Purdue University*

**Discussion Category:** NCN URE/UCEE

## **Data Analysis in Engineering: An Interactive Approach**

*Mathematical/Computation Sciences*

**Author:**

Joseph Williams, University of Florida

**Abstract:**

The aim of this project was to create an online, instructional tool that introduces data analysis and statistical concepts in engineering laboratories. This tool primarily serves as a resource for students taking the Junior-level laboratory courses EMA 3080C and EMA 3013C at the University of Florida. Embarking on this project now was also timely as the advent of COVID-19 has heightened the need for more remote laboratory resources. The platform used for this tool was Jupyter Notebook, an open-source web application that allows users to create and share documents that contain live code, equations, visualizations and narrative text [1]. The contents of the created notebooks stem from key concepts taught in materials science and engineering such as: hardness testing and electronic properties of materials, to name a few. A typical notebook contains pertinent background information on the topic at hand, then walks a student through how to import and organize laboratory/experimental data. Students will then learn how to use python code to display customized tables and plots from that data, and to apply statistical methods for analytical purposes. The notebooks are designed to be as interactive as they are explanatory, in an effort to provide an all-round learning experience. These notebooks will also be published in nanoHUB, thus professors, students, engineers, etc. worldwide will have access. In the coming months, surveys will also be sent out to students at the University of Florida to receive feedback that can help improve usability and overall effectiveness of the tool.

*Research Mentor:*

Nancy Ruzycki, University of Florida

**Discussion Category:** NCN URE/UCEE

## **Co-Production of Solar Energy on Maize farms – nanoHUB Simulation Tool**

*Innovative Technology/Entrepreneurship/Design*

Author:

Mye'on Williams, Tuskegee University

Abstract:

With the population on earth increasing rapidly the corresponding need for sustainable co-production of food, energy, and water does as well. Agrophotovoltaics is a potential technical solution; however, the relationship between light reduction and plant response is not well established. A tool is needed for researchers in order to design experiments to understand the relationship between agrophotovoltaic architectures and irradiance maps. Agrophotovoltaic researchers need to run both simplified and more detailed simulations such as infinite periodic structures for gaining basic intuition as well as those including edge effects in order to determine suitable architectures. The existing nanoHUB Agrophotovoltaics tool has numerous capabilities more are needed to tailor simulations to user's needs as well as more accurately model the structures. Here, we have restructured the tool and incorporated two new features that can now be toggled between. These features are simulation of infinitely periodic structures and non-infinitely periodic structures with edge effects. This allows simulation that can give a calculation of the shadow depth within a given area or as a whole. We have incorporated these features into the existing Rapture tool to give it more versatility. These updates will allow researchers to understand basic principles of shadow depth modeling and then leverage that to design novel agrophotovoltaic experiments.

*Research Mentor:*

*Elizabeth Grubbs, Purdue University*

*Peter Bermel, Purdue University*

*Li Jiang, Tuskegee University*

**Assessing Preference of Temperature or Light in Laboratory Mice**

Author:

Haley Davis, Purdue University

Amanda Barabas, Purdue University

Brianna Gaskill, Purdue University

Abstract:

Mice experience several stressors in the laboratory, which reduces welfare and data quality. First, they are typically kept in temperatures between 20-24°C; however, this is lower than their preferred temperature of 30°C. When given the option, mice will locomote to get to their preferred temperature or use nesting material as insulation. Second, it has been shown that rodents spend more time in the colored-tinted enrichments compared to clear. This is likely because they cannot see red wavelengths. Consequently red cages appear dark to them, which is likely preferable for them as nocturnal species. This study investigated lighting environment and surface temperature preference in laboratory mice by giving them free access between two linked cages: a heated cage and a red cage. Seven pairs of female mice were randomly allocated to two linked cages for eight days. Every other day, the temperature in the heated cage was randomly changed between 20, 24, 28, and 32°C and the weight of nesting material and nest complexity score was observed in each cage. This indicates the nest site where the mice preferred to sleep. The difference between the red and heated cage were analyzed as a repeated measures GLM. Temperature did not have a significant effect on nest weights ( $F_{3, 13.81}=1.03$ ;  $p=0.41$ ) or nest scores ( $F_{3, 14.29}=1.77$ ;  $p=0.19$ ). Indicating mice did not have a temperature preference for nest building but did prefer to build in the dark cages. This allows researchers to better understand the needs and preferences of mice; thus, improving overall welfare.

*Principal Investigator:*

*Brianna Gaskill, Department of Animal Sciences*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

**Investigation of a common canine Factor VII deficiency variant in dogs with unexplained, excessive bleeding on necropsy**

Author:

Jessica A. Clark, Purdue University

Stephen Hooser, Purdue University

Dayna L. Dreger, Purdue University

Kari J. Ekenstedt, Purdue University

Abstract:

Factor VII (FVII) protein is an integral component of the extrinsic coagulation pathway. Deleterious variants in the gene encoding this protein can result in factor VII deficiency (FVIID), a bleeding disorder characterized by abnormal (slowed) clotting that presents in a wide range of severity, from asymptomatic to life-threatening. In canids, a single FVIID-associated variant, first described in Beagles, has been observed in nearly two dozen breeds and mixed-breed dogs. Because this variant is widespread among dogs, it was hypothesized that it could be a contributing factor to unexplained excessive bleeding observed in some canine necropsy cases. DNA was extracted from tissue samples from 41 cases, and each dog was genotyped for the c.407G>A variant. Forty cases were homozygous for the wild type allele. One case was homozygous for a novel mutation at the same locus (c.407G>T, p.Gly136Val); this variant is predicted to be pathogenic. These results indicate that, while it is unlikely the common FVIID variant is responsible for most cases of unexplained bleeding at necropsy, the locus does appear to be susceptible to change, as we have now documented a second nucleotide substitution at the same position.

*Principal Investigator:*

*Kari Ekenstedt, Department of Basic Medical Sciences*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Behavioral Comparison of Comodulation Masking Release Between Chinchillas and Humans**

Author:

Fernando Aguilera De Alba, Arizona State University

Vibha Viswanathan, Purdue University

Andrew Sivaprakasam, Purdue/Indiana University

Michael Heinz, Purdue University

Abstract:

The auditory system is essential to human survival and communication. Moderate noise-induced damage to inner hair cells (IHCs) and outer hair cells (OHCs) within the cochlea leads to noise-induced hearing loss (NIHL) making it difficult to hear in noise (i.e. cocktail-party effect). Currently, the severity of NIHL in humans is challenging to quantify due to the inability to use the highly invasive neural assays performed in animals, and the overly simplified testing paradigms available for behavioral assays. Pure tone discrimination behavioral tasks fail to quantify the effects of NIHL in speech perception, which tend to involve background noise and multiple speakers. Comodulation masking release (CMR), known to occur in humans, has shown potential to non-invasively estimate sound detection thresholds in the presence of noise. This study examined CMR effects in normal-hearing chinchillas (a common pre-clinical animal model of human hearing) and human subjects using several paradigms to measure detection of a tone in different flanking-band conditions. Moreover, effects of task repetition and task complexity were studied for humans only. Tone-in-noise stimuli were comodulated for three masking conditions: reference (REF)<sup>1</sup>, correlated (CORR)<sup>2</sup>, and anti-correlated (ACORR)<sup>3</sup>. Experimental stimuli confirmed CMR effect in humans. In humans, CORR thresholds were significantly reduced compared to REF and ACORR thresholds. No task training effect was observed. Although no significant CMR effects were observed in chinchillas, ACORR thresholds were the lowest across all three masking conditions.

*Principal Investigator:*

*Michael G. Heinz, Weldon School of Biomedical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Development of Open-Source Beehive Monitoring Systems**

Author:

Nathan C. Sprague, Purdue University

Eric Kong, Purdue University

John Evans, Purdue University

Dr. Brock Harpur, Purdue University

Abstract:

Honeybees are a key part of agriculture and are necessary for the pollination of numerous crops, including the most common fruit trees. Continuous monitoring of beehive temperature, humidity, weight, and bee count can provide beekeepers with data to assess the health of their hives. Currently, beekeepers must manually inspect their hives and have little idea of their health until the next inspection, sometimes resulting in preventable actions such as swarming, where a large portion of the hive leaves. An entomologist needed a cost-effective and simple way to continuously record key data points for multiple beehives. Commercial hive monitoring systems are expensive for large scale operations. The 50 kilogram (kg) load cells meant to be used as bathroom scales were tested for accuracy by regularly recording weights between 0 to 55 kg indoors and outdoors. The temperature and humidity were measured with DHT22 sensors. Three controllers (Arduino, Raspberry Pi and ESP32) were tested to record data from the sensors and relay data to an app created for the project. The components were tested to note and correct failures and accuracy issues as necessary. Using OpenCV, an open-source computer vision library, a Haar Cascade was trained to detect bees by searching for features that are unique to honeybees. The Haar Cascade was trained with 2,000 images of bees to detect and count bees on a hive frame. Depending on the settings, the bee detection algorithm could correctly locate around half of all bees shown. The scales varied less than 0.5 kg when loaded to their maximum, over the course of two months in an indoor environment and 2 kg outdoors. Hardware failures were almost exclusively from unreliable SD card readers and incorrect scale setup, which is correctable. Indoors, the cost effective microcontrollers gave accurate continuous measurement of beehive weight, along with environmental characteristics such as temperature and humidity. Outdoors, the effects of temperature and humidity were greater than the daily changes of the hive's true weight, so the scale is only suitable for recording seasonal trends in the hive's weight.

*Principal Investigator:*

*John Evans, Department of Agricultural & Biological Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Improving biomass prediction of soybean using multispectral imagery**

Author:

Siddhant Singh, Macalester College

Bilal Abughali, Purdue University

Keith Cherkauer, Purdue University

Abstract:

Erratic weather patterns due to climate change and a burgeoning population have necessitated a better understanding of crop management and resource utilization in agriculture. We investigate the growth of soybean using Unmanned Aerial Systems (UAS) in order to build better models for biomass and leaf area index prediction. We calibrate reflectance values obtained from panels placed in the field using ground measurements in order to calculate the various vegetation indices and subsequently used them in empirical models for predicting biomass and leaf area index using python programs. In this project, we sought to determine the efficacy of using individual images over aggregating those images into a single orthophotomosaic for calibrating the reflectance values. Boxplots indicated different median values and greater spread of digital numbers (which quantify intensity of a pixel) for individual images than in the case of the resulting orthophotomosaics. This study further compares the vegetation indices and subsequent biomass predictions obtained from these separate calibration methods and compares them with laboratory measurements to see if calibration using individual images gives more accurate results. The results of this study can provide crucial insight on improving biomass models for UAS applications and understanding soybean growth.

*Principal Investigator:*

*Keith Cherkauer, Department of Agricultural & Biological Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Modeling Spatial and Temporal Emissions for Animal Farming Using Mechanistic Models**

Author:

Martina L. Macaggi, Purdue University

Gargeya Vunnava, SINCS Group, Purdue University

Yunru Chen, Johns Hopkins Biomedical Engineering

Dr. Shweta Singh, SINCS Group, Purdue University

Abstract:

Modeling the production technique of any live animal-based industry is often challenging as the mass transformation process from feed intake to biological body mass growth is very complex. The body mass of animals can vary based on several factors such as quantity and type of nutrient feed, water intake, age, gender, climate and living conditions, etc. In this study, we use a computational model developed in MATLAB to model the hog farming industry in Illinois. The model uses different biomass growth equations for different hog age groups. The nutrient and water intake data were obtained from the United States Department of Agriculture (USDA) databases. The environmental impacts of the hog farming in Illinois were also quantified by integrating environmental impact assessment equations to capture emissions such as CO<sub>2</sub> and methane.

Information regarding characteristics of the hogs and hog feed was gathered here:

<https://www.nationalhogfarmer.com/nutrition/gestation-diet-s-impact-pig-birth-weights>

Formulas derived by the LEAP program of the United Nation's FAO are being used to calculate the methane emissions of the farm. Certain assumptions were made regarding the environmental impact assessment: (1) Assume the hog farm uses a deep pit manure management system, (2) The deep pit system collects 100% of the manure, therefore 100% of manure produced is treated by the system.

*Principal Investigator:*

*Shweta Singh, Department of Agricultural & Biological Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

**NAPRA+ Model: Development of an Updated Version of the National Agricultural Pesticide Risk Analysis (NAPRA) WWW system Using Open Source Tools**

Author:

Julia Schneider, Purdue University

Benjamin Hancock, Purdue University

Dharmendra Saraswat, Purdue University

Ian Zimmer, Purdue University

Abstract:

The National Agricultural Pesticide Risk Analysis (NAPRA) model, used to provide farmers with agricultural management practices to prevent hazardous chemicals in ground and surface water, was integrated with Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model in 2003 to help develop a spatial decision support system (SDSS). The SDSS allowed numerous stakeholders such as researchers, consultants, and non-governmental organization (NGO) personnel to assess the impact of agricultural management practices on nutrient loss and pesticide runoff from individual fields. Due to advancement in web technologies and lack of maintenance, the SDSS became outdated and was taken off the internet in 2018. In addition, lack of source code documentation and rotation of personnel, made it difficult to implement revisions later on. In this project, open source tools were used to create an updated version of NAPRA named NAPRA+, with source code fully commented to make it easy to revise and maintain. The process entailed revising old source code written in Perl into Javascript. Another outcome of this project is the development of a user manual based on test data from the original project to help potential users learn to use NAPRA+ in a proper manner. The results showcase the effectiveness of using open-source tools for developing web-based environmental models and good software development practices for help any future enhancement and updates.

*Principal Investigator:*

*Dharmendra Saraswat, Department of Agricultural & Biological Engineering*

**The impact of extended stagnation on building water quality**

Author:

Danielle M. Angert, Purdue University

Kyungyeon Ra, Purdue University

Andrew Whelton, Purdue University

Caitlin Proctor, Purdue University

Abstract:

Water quality can change drastically within a building during periods of stagnation. This study aimed to better understand the change in water quality within a 10,000 sqft residential building over 5 months of stagnation. Building water stagnation is a public health concern: residual disinfectant agents such as chlorine can decay, leading to microbial growth, and metals can leach into the water over time. Hot and cold water quality was monitored within a large residential building over five months of little to no occupancy, with the long-term stagnation driven by the COVID-19 pandemic. Sampling events occurred once every month between April and July 2020, ranging from approximately 1 month to 5 months total stagnation time. Water samples were taken at ten locations within the building, including bathroom sinks, a kitchen sink, and showers on the basement, second, and third floors of the building. A total of 40 samples were collected. Samples were analyzed on-site for pH, temperature, dissolved oxygen (DO), and total chlorine, then transported to lab for analysis of metal content, total organic carbon (TOC), total cell count (TCC), quantitative polymerase chain reaction (qPCR), and *Legionella pneumophila*. Chlorine residual was not legally detectable ( $>0.2$  mg/L) at any sampling location throughout the five month stagnation period. Lead was detected at five hot water locations, in concentrations ranging from 1.92 ppb to 3.27 ppb. Apparent but unconfirmed *Legionella pneumophila* was present at 2 locations. These results suggest that building water may need to be refreshed after extended building closures prior to re-entry.

*Principal Investigator:*

*Andrew Whelton, Lyles School of Civil Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Design optimization of 3D printed micro-channel heat sinks**

Author:

Rafael L. Estrella, College of Engineering, University of Arkansas

Serdar Ozguc, Purdue University

Liang Pan, Purdue University

Justin A. Weibel, Purdue University

Abstract:

There is a need for more efficient thermal management solutions to keep the next generation of electronic devices within the operational temperatures. Additively manufactured liquid-cooled microchannel heat sink designs with complex geometric features in particular have been demonstrated to achieve high cooling performance. Topology optimization shows potential in effectively leveraging the design freedom brought by 3D printing as a means to generate high performance designs. This study focuses on generating high performance designs with complex geometries using topology optimization which can be easily 3D printed. Effects of different hyperparameters and operating conditions such as design resolution, flow rate, hot spot geometry on topologically optimized microchannel heat sink thermal resistance and pressure drop were investigated. The performance of topologically optimized designs was evaluated against conventional microchannel heat sink designs at different hot spot geometries. It was shown that optimum grid and unit cell resolutions exist for a given set of operating conditions that minimizes thermal resistance and pressure drop, beyond which returns are reduced. The relative performance enhancement achieved by topology optimization was found to highly depend on the hot spot size and geometry.

*Principal Investigator:*

*Justin A Weibel, School of Mechanical Engineering*

## **Design and Manufacturing of Bio-inspired Nanocomposites for Radiative Cooling**

Author:

Fernando J. Barrios, Purdue University

Richard Smith, Purdue University

Andrea Felicelli, Purdue University

Joseph Peoples, Purdue University

Xiulin Ruan, Purdue University

George Chiu, Purdue University

Abstract:

Cooling buildings correspond to 10 percent of energy consumption or 380 billion kWh. Furthermore, conventional cooling systems transport heat from inside to outside the building, creating the heat island effect and worsening global warming. In recent years, radiative cooling has emerged as a better technique to dissipate heat by dumping it into deep space, providing cooling without power consumption and addressing the global warming challenge. In this work, our objective is to understand how radiative cooling properties appear in animal shells and aim to mimic these structures and test the properties. We used two MATLAB codes, based on Monte Carlo and transfer matrix methods, to compare optical properties of two nanoporous shells with different morphologies. Variables based on measurements were needed to perform the simulations. Therefore ImageJ, an image processing program, was used to analyze SEM images of the two shells and obtain them. The main results of the current research are a graph that contains reflectivity of both structures over the solar spectra. It was found that both morphologies show promise as radiative cooling materials, while the new bio-inspired shell had a better reflectivity than its predecessor with same thickness. Nanocomposites are being manufactured to mimic the identified optimum shell structures, and their properties will be characterized with optical spectroscopies. To conclude, our research provides insights on which structures give the better radiative cooling performance. Moreover, the new bio-inspired structure can give good reflectivity with lower thickness, meaning it can be used in various situations to cool down objects.

*Principal Investigator:*

*Xiulin Ruan, School of Mechanical Engineering*

## **Design and Analysis of a Novel Membrane Heat Exchanger**

Author:

Bryan Pamintuan, Purdue University

Andrew Fix, Purdue University

James Braun, Purdue University

David Warsinger, Purdue University

Abstract:

Traditional heating, ventilation, and air conditioning (HVAC) systems utilize the vapor compression cycle to dehumidify air through condensation at very low temperatures. Operation of this cycle at low temperatures and the phase change involved in condensing a vapor to a liquid are associated with significant energy usage. Thus, this conventional method of air treatment suffers from energy penalties in hot, humid climates where large amounts of dehumidification are required. Membrane dehumidification has recently been studied as an alternative method of dehumidification that utilizes a pressure gradient across a semipermeable membrane to mechanically separate water vapor from air, avoiding condensation altogether. An HVAC system that integrates and optimizes membrane dehumidification and cooling could result in substantial energy savings. In this study, thermodynamic modeling is used to analyze the overall air treatment performance of the existing vapor compression, adsorption dehumidification, and membrane HVAC systems for a range of outdoor conditions. Then, a novel membrane system configuration of simultaneous cooling and dehumidification (the membrane heat exchanger) is proposed and similarly analyzed. The performance of the membrane heat exchanger is simulated in a variety of climates using EnergyPlus (modeling software developed by the US DOE). Modeling of the system demonstrates the potential improvements in air treatment efficiency. An experimental testing apparatus is designed and modeled for future small-scale validation of the proposed configuration. The results demonstrate the viability of the proposed membrane heat exchanger and the possible electrical energy savings in different areas of the world.

*Principal Investigator:*

*James Braun, School of Mechanical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Income equality effect on travel pattern during COVID-19**

Author:

Chengyuan Yang, Purdue University

Takahiro Yabe, Purdue University

Satish Ukkusuri, Purdue University

Abstract:

COVID-19 is the largest catastrophe people encountered in the year 2020. The situation is severe for the people who stay in the United States, with the total number of cases reaching 4 million. Studies on the behavior of people during the COVID-19 crisis are necessary to inform government decisions on non-pharmaceutical interventions. Using large scale mobility data collected from mobile phones and open census data, we unravel human mobility patterns during the COVID-19 pandemic. More specifically, we understand travel behavior and exiting inequality across income groups. To achieve these goals, we apply time series analysis methods and statistical analysis techniques. In this study, we have focused on the states of New York and Indiana. In New York state, the higher-income class intended to travel further, while Indiana people had an opposite trend. Further analysis of the New York residents showed that New Jersey, Florida, and Connecticut were among the three most popular destinations for the high income group population in New York.

*Principal Investigator:*

*Satish Ukkusuri, Lyles School of Civil Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Analyzing Social Distancing using Large Scale Computer Vision**

Author:

Isha Ghodgaonkar, Purdue University

Abhinav Goel, Purdue University

Yung-Hsaing Lu, Purdue University

Subhankar Chakraborty, IIT Madras

Fischer Bordwell, Purdue University

Kohsuke Kimura, Purdue University

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Vishnu Banna, Purdue University

Akhil Chinnakotla, Purdue University

Ellen Zhao, Purdue University

Caleb Tung, Purdue University

Dr. George K. Thiruvat

Abstract:

With the development of the COVID-19 pandemic, countries around the world have published social distancing guidelines to constrain the spread of the disease. However, monitoring the efficacy of these guidelines is difficult without knowing whether social distancing is being practiced. Lack of traditional observational methods, such as in-person reporting, make it difficult to collect visual data in order to confirm that persons are following social distancing guidelines. An existing network camera database developed by Purdue University researchers provides a unique opportunity to investigate social distancing around the world without putting researchers at risk. In this work, we investigate crowd sizes in public areas over time. We also analyze whether citizens are observing a distance of 6 feet between one another. To perform these analyses, we narrow down over 8 TB of video and images to about 4 TB. We run person detection to detect people in the images and video. We then plot these data in a time-series fashion and observe changes over time. To detect physical distancing of 6 feet, we develop a camera perspective-independent, automatic algorithm to determine whether 2 detected people are 6 feet apart. We find that in the United States, there is no change in crowd sizes over time, but in European countries such as France and Germany, there is an increase in crowd sizes following lifting of lockdown policies. Our work will inform future pandemic policies by elucidating which policies are better at controlling the spread of the virus.

*Principal Investigator:*

*Yung-Hsiang Lu, School of Electrical and Computer Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Impact of State HCBS Waiver Policies on Patient Outcomes**

Author:

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Jennifer Leising, Purdue University

Ping Huang, Purdue University

Paul Griffin, Purdue University

Abstract:

With long term care costs on the rise, states have begun to expand home and community based services (HCBS) using 1915c waivers in hopes of lowering institutional and long term care costs. The use of these waivers varies greatly among states making it difficult to assess patient outcomes. The objective of this study is to determine the impact of different state waiver policies on patient outcomes. Two separate stepwise ordinal logistic regression models were used to determine HCBS policy impacts on patient outcomes of cost and quality. The results of our study indicate that use of cost controls, geographic controls, and stricter financial eligibility are associated with increased inpatient services spending, while the use of self-direction, and 1115 waivers are associated with less spending on inpatient services. The use of service controls and cost controls were associated with higher level of readmissions as well while, the use of self-direction is associated with lower levels of readmissions. From these results we can conclude that there is an association between poorer patient outcomes and the following policies: cost controls, service controls, and geographic controls. It is possible these policies are limiting HCBS waiver usage providing inadequate care resulting in higher spending on patients and higher readmission levels. While these policies try to limit waiver expenditures, the results of our study indicate these policies may actually be increasing patient costs and decreasing quality.

*Principal Investigator:*

*Paul Griffin, School of Industrial Engineering*

## **Effects of lifting task on heart rate**

Author:

Nan Chen, Purdue University

Guoyang Zhou, Purdue University

Denny Yu, Purdue University

Abstract:

In the working field, work injuries can be easily caused by overload and repetitive lifting. Experts have developed numerous task-factors based guidelines to evaluate lifting risks, such as the NIOSH lifting equation. However, most of the existing guidelines require task factors that are hard to attain in real life, for example, the object's weight. Previous works have also been focused on measuring muscle activity or body movements to evaluate lifting risks. However, sensors that can measure muscle activity (e.g., sEMg) or body motion (e.g.,IMUs) are highly intrusive and expensive. Wearable devices that can measure heart rate are becoming more and more popular in the market these days. In this study, we purposed using wearable heartrate sensors to evaluate people's risk in lifting. In the experiment, we have designed three different lifting tasks with different lifting indexes for subjects to perform. While the subjects are performing the lifting tasks, we record their heart rate data and provide conclusions and recommendations based on our observation of the changes in the subjects' heart rate.

*Principal Investigator:*

*Denny Yu, School of Industrial Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

### **Three-Dimensional Structural Real-Time Hybrid Simulations Applied to Extra-Terrestrial Habitats**

Author:

Sterling Reynolds, University of Texas at San Antonio

Yuguang Fu, Purdue University

Shirley Dyke, Purdue University

Montoya, Department of Civil Engineering, University of Texas at San Antonio

Amin Maghareh, Purdue University

Dr. Davide Ziviani, School of Mechanical Engineering, Purdue University

Arsalan Majlesi, Department of Civil Engineering, University of Texas at San Antonio

Adnan Shahriar, Department of Mechanical Engineering, University of Texas at San Antonio

Abstract:

Extra-terrestrial habitats must be resilient with capabilities in adapting, absorbing and rapidly recovering from expected and unexpected disruptions without fundamental changes in function or sacrifices in safety. Multi-physics cyber physical testing is crucial in understanding the resiliency of extra-terrestrial habitats where physical loading conditions are applied, and structural software is evaluated. The novel test-bed being constructed at Purdue University serves partially to validate and assist development of structural software methods using computational mechanics under nominal and hazardous operational or dormant states. Emulating emergent behaviors of deep space habitats on Earth is physically limited and pure numerical models need validation, thus the authors propose using real-time hybrid simulations (RTHS). RTHS joins physical structures and computational models, where numerical models are updated with physical measurement data to obtain structural system responses in real time. The authors implement RTHS methods with three-dimensional computational mechanics using OpenSees open-source finite element (FE) software. The OpenSees model is reduced from 276 to 138DOF by neglecting nodal rotations, resulting in real-time capabilities under ground acceleration loading using truss elements. The mass matrix of the reduced model is updated to resemble the addition of shell panels while neglecting their stiffness contribution to the structure and is verified using Abaqus commercial FE software with a natural frequency analysis. By using OpenSees software with many FE methods, materials, and solvers available, researchers can accelerate evaluating resiliency of extra-terrestrial habitats by altering geometries and configurations for real time hybrid simulation application.

*Principal Investigator:*

*Shirley Dyke, School of Mechanical Engineering*

**Finite element modeling of transmembrane potential under applied electric fields**

Author:

Lorin Breen, Purdue University

Allen Garner, Purdue University

Abstract:

Pulsed electric fields (PEFs) are well known for disrupting cells by inducing a transmembrane potential on the order of 1 V to cause electroporation, which is a process in which the cell membrane begins to produce pores. PEFs of sufficient electric field strength and duration can create sufficiently large pores that cannot reseal after exposure, leading to cell death. While many studies have modeled PEF exposure, most have focused on simple models, such as spherical cells representing mammalian cells (with or without a nucleus) with the electrodes in direct contact with the suspension. While these models have been extended in one or more ways (for instance, using non-spherical cells or incorporating a dielectric between the electrodes and the suspension), a more generalized model that can guide experiments with non-spherical cells with cell walls could provide valuable information for applications in agriculture and decontamination. Examples include microorganisms, such as algae and bacteria, in Petri dishes where one cannot leverage the standard planar geometry used in simpler experiments. Initial calculations using Maxwell 3D have reproduced transmembrane potential for spherical mammalian cells with and without a nucleus for a PEF and an alternating current (AC) field. Next, Maxwell 3D will be used to model the transmembrane potential and the potential drop across the cell wall for spherical and non-spherical cells under various conditions. These results will eventually be compared to experimental results for various conditions to assess the feasibility of using Maxwell 3D simulations to guide parameter selection for optimizing biological response to PEFs and other electric waveforms, such as AC fields.

*Principal Investigator:*

*Allen Garner, School of Nuclear Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Automatic Machining Feature Generation**

Author:

Siying Chen, Purdue University

Xingyu Fu, Purdue University

Martin Jun, Purdue University

Abstract:

In the era of fourth industrial revolution, a high level of automation in manufacturing is required. Automatic machining feature generation is needed for training the Convolution-Neural-Network-based automated feature identification. The objective of the research is to develop an automatic machining feature generation system that can demonstrate and save massive CAD models with machining features spontaneously. In this research, a feature generation algorithm was built based on FreeCAD geometrical calculation library. About 200 of CAD models were collected to learn about machinability and machining processes. Basic CAD functions include building geometries, setting view, importing and exporting files, extrusion, and operating Boolean. Compiling code for these CAD functions set up a database of functions for further machining feature generation. Machining features like slot were generated by using Boolean operation. The size of the cubic base was set as 50x50x50. When generating the features, tolerance of 1 was set to avoid the appearance of thin walls that cannot be manufactured or small features that cannot be identified. The sizes of the features were set as random by using uniform random parameter with the consideration of the sizes and other parameters of actual cutting tools. Four types of slot features were generated, which included T-slot, V-slot, ball end slot and dovetail slot. Folders for the features were created automatically. 100 CAD models for each of the slot features were displayed in the window of FreeCAD and saved in these folders spontaneously by iteration. Automatic feature generation developed in the research provides the foundation for developing the automated identification of machinability and the processes of machining.

*Principal Investigator:*

*Martin Jun, School of Mechanical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Optimization of Centrifugally Tensioned Metastable Fluid Detectors (CTMFD) for Alpha and Neutron Detection**

Author:

Jacob Minnette, Purdue University

Nathan Boyle, Purdue University

Rusi Taleyarkhan, Purdue University

Abstract:

Tensioned metastable fluid detectors (TMFDs) boast the ability to detect neutron, alpha, and fission fragment particles with high intrinsic efficiencies approaching 95%+ while remaining blind to background gamma-beta radiation. Consequently, TMFDs are able to differentiate, with great accuracy, the decay signatures from specific radioisotopes that may either pose a health or national security hazard, e.g. Actinides (like Pu, and U) and Radon and its related progeny isotopes. In TMFDs, the detection fluid is placed under tension or in other words sub-vacuum (negative) pressure (Pneg) states, whereby it can become selectively sensitive to various types of radiation and neutron-alpha type particles can be detected via transient cavitation bubble formation – a process that can be seen, heard and recorded electronically. Desired Pneg states can be induced via tailored acoustics, or use of centrifugal force. For the purposes of this project the centrifugally tensioned detector (CTMFD) design was utilized. Of importance involves ensuring absence of false bubble detection events caused due to pre-dissolved gases in the CTMFD fluid – a time consuming process. Optimizing (reducing) the time for such degassing was the focus of this project. This was accomplished via acoustic agitation, vacuum pulling, and further accelerated gas removal induced via external neutron source. All such methodologies make use of Fick's Laws of Diffusion in expediting the process of removing non-condensable gases from the liquid media (mainly via creating of large concentration gradients between liquid-vapor phases). The results of this research enabled ~60-80% functionality improvement.

*Principal Investigator:*

*Rusi Taleyarkhan, School of Nuclear Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

**Automated fitting of freeform surfaces to point cloud datasets for comparison of manufactured components**

Author:

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Saikiran Gopalakrishnan, Purdue University

Michael Sangid, Purdue University

Abstract:

During manufacturing, the produced components often possess variations in their geometries due to manufacturing variability, potentially resulting in components with features that exceed allowable tolerances. Before eliminating these components as scrap, their structural integrity can be analyzed within a materials review board (MRB) process, to make more informed decisions to use as-is, repair and use, or eliminate the component. However, to perform the structural analysis for disposition of these components, creating models replicating the manufactured geometries is necessary. Currently, this process would involve physically measuring each component, followed by interpreting and utilizing the data for manual creation of CAD models, which is error-prone and time-consuming. To improve this process, we present a framework which enables an automated approach of creating CAD models of individual manufactured components, starting from their nominal CAD models. Firstly, the framework facilitates integration of point cloud measurement data from a manufactured component obtained using a coordinate measurement machine (CMM) to measured surface features within the nominal CAD model. Secondly, it enables retrieval of these datasets and applying a suitable surface fitting algorithm, to update the surfaces in nominal CAD model to create an as-manufactured CAD model of the component. A specific use case has been demonstrated for components with a machined surface with varying geometries, wherein the as-manufactured surfaces have been generated by fitting the scanned point cloud dataset using freeform spline surfaces to generate as-manufactured instances of CAD models of individual components. The demonstrated framework presents opportunities to create digital twins of serialized physical components.

*Principal Investigator:*

*Michael Sangid, School of Aeronautics and Astronautics*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Abdominal Aortic Aneurysm Progression and Thrombus Formation Displayed Using Various Murine Models**

Author:

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Jennifer Anderson, Purdue University

Craig Goergen, Purdue University

Abstract:

An abdominal aortic aneurysm (AAA) is defined as the pathological expansion of the abdominal aorta. This vascular disease is often asymptomatic, which can leave patients at high risk of rupture if left undetected. Even when diagnosed, the current metrics that define rupture risk are vessel diameter and growth rate, which are not always accurate. Further research is needed to fully understand the progression that leads to the rupture of an aneurysm. This study uses four different murine aneurysm models to display the progression of aneurysms over time. The four models include elastase, calcium chloride (CaCl<sub>2</sub>), BAPN-elastase, and Angiotensin-II-BAPN. Ultrasound imaging allows us to view and analyze aneurysm progression. These images can be used to obtain various metrics that can define the state of the vessel. First, images can be used to define strain, vessel area, and diameter. When three-dimensional ultrasound images are processed, they can be used to produce 3D segmentations of the lumen and wall. The segmentations can also show thrombus formation within the lumen. Using these 3D segmentations, aneurysm progression can be displayed, and various measurements can be taken throughout the vessel. Through this study, three models were compared by their 3D segmentations, and the last was analyzed through quantitative data taken from ultrasound images. The BAPN-elastase model showed the greatest growth of the four models. With further analysis of these murine models, we hope to provide insight to aneurysm progression and thrombus formation.

*Principal Investigator:*

*Craig Goergen, Weldon School of Biomedical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Characterization of In Vivo Aortic Valve Dynamics Using Four-Dimensional Ultrasound**

Author:

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Frederick Damen, Purdue University

Craig Goergen, Purdue University

Abstract:

The aortic valve (AoV) is a structure that aims to maintain unidirectional flow of newly oxygenated blood from the heart to the rest of the body. Unfortunately, the AoV frequently becomes diseased through progressive calcification and stiffening that, when severe, can be detrimental to a person's quality of life. Aortic valve disease affects 2-5 percent of Americans over the age of 65; a prevalence that is expected to double by 2050. While three-dimensional in vivo imaging is used clinically to monitor AoV function in humans, similar methods are not currently available to study preclinical small animal models. This hinders the ability of researchers to better understand disease mechanisms in vivo and explore new potential treatments through these models, which allow systematic control of disease inducing factors. We demonstrate a technique that overcomes this limitation through a novel implementation of high-frequency ultrasound that provides four-dimensional imaging data of the murine AoV. Volumetric data are digitally reconstructed and stabilized against spatial AoV translation to isolate leaflet motion. Enabled by the high temporal and spatial resolutions, 2D and 3D measurements are extracted from the imaging data to characterize AoV structure and function over the full cardiac cycle, such as tracking individual leaflet motion in 3D space to quantify valve kinematics. Our work provides a previously unavailable research tool to both better characterize, and study progression of, valvular heart disease in mice.

*Principal Investigator:*

*Craig Goergen, Weldon School of Biomedical Engineering*

**Localization Imaging of Neuronal Signaling with Spatiotemporal Fluorescent Reporter Data**

Author:

David M Czerwonky, Purdue University

Justin Patel, Purdue University

Paula Ivey, Purdue University

Kevin Webb, Purdue University

Abstract:

Many inner workings of the brain remain unknown. Calcium is a crucial component in brain cell communication, and it would provide tremendous insights into neural networks, the inner workings of the brain, and neurodegenerative disease if the calcium interactions could be imaged. We have previously developed an imaging technique allowing us to localize fluorescent markers of calcium known as calcium fluorophores in brain tissue using computational tools such as cost functions, temporal scanning, and multiresolution analysis. A remaining question is how the properties of certain calcium fluorophores can be an asset or a hindrance to our imaging technique. We simulate the imaging process of nine types of calcium fluorophores in a tissue-like medium with a calcium concentration typical of a neuronal region. The localization accuracy of eight calcium fluorophore variants show no significant difference in localization accuracy. However, Rhod-2 performed at a significantly lower level than the other choices. In terms of greatest intensity, Cal-520 and Oregon Green 488 BAPTA-1 are the leaders with Cal-590 falling close behind. The intensity results provide an important insight into the fluorescent source response model used in this research. The low-affinity choice Mag-Fluor-4 nearly outperforms its high-affinity derivative in terms of fluorescence intensity. Indicating that the fluorescent source response derived from solely optical properties is insufficient for modeling a variety of fluorophores. We propose that a fluorescent source model needs to be constructed to represent the optical-chemical duality of fluorophores to yield better results by working in the dissociation constant.

*Principal Investigator:*

*Kevin Webb, School of Electrical and Computer Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Using Automated Image Processing to Characterize the Osteocyte Lacunar-Canalicular System**

Author:

Rachel Wang Zhang, University of Michigan

Brennan Flannery, Purdue University

Melanie B. Venderley, Purdue University

Roy Lycke, Purdue University

Dr. Eric A. Nauman, Purdue University

Dr. Russell P. Main, Purdue University

Abstract:

Osteocytes, cells that regulate bone remodeling, reside in a large network of lacunae and canaliculi within the bone matrix of most vertebrates. This osteocyte lacunar-canalicular system (OLCS) plays an important role in regulating the biological and mechanical properties of bone. Despite having extensive knowledge on the qualitative structure and function of the mineralized matrix, there is a lack of quantitative data on how the OLCS is organized. Quantitative data will help us better understand how the OLCS adapts to new stress regimes and provides insight for diagnosis and treatment of diseases. An automated image analysis algorithm was previously developed to produce these results from confocal microscopy volumes of bone. The focus of this study is to validate and optimize this processing algorithm. Simple computer-generated geometries were used to verify the algorithm's results and performing Cotter's sensitivity analysis optimized the parameters for confidence in the program outputs. Completing the analysis revealed select input parameters to be more impactful on the resulting measurements. This knowledge allows future researchers to better understand which inputs require more consideration to accurately retrieve their output variables. The validated algorithm can be used to reveal the effects of various mechanical stresses and biological changes on the OLCS organization.

*Principal Investigator:*

*Russell P. Main, Weldon School of Biomedical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Salinity in Arid Landscapes: A Case Study from Arequipa, Peru**

Author:

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Alejandro Rodriguez Sanchez, Purdue University

Lori Hoagland, Purdue University

Sara McMillan, Purdue University

Abstract:

Soil salinization occurs in many arid climates around the world and leads to decreases in agricultural productivity. This is detrimental for citizens in developing countries where local agriculture is typically their main source of income and food. Soil salinization is caused by both natural processes, such as the weathering of surrounding geology, and anthropogenic processes, such as agricultural irrigation and poor drainage systems. The goals of this project were to characterize patterns in salinity and potential drivers of salinization in the region of Arequipa, Peru. Arequipa has an arid climate, receiving 100 mm of precipitation per year, and water for the city is provided by the Chili River, which runs through the middle of Arequipa. Soil samples from 50 agricultural fields in Arequipa were analyzed for soil texture, cation exchange capacity (CEC), pH, organic matter (OM), and electrical conductivity (EC), which we used as a proxy for quantifying salinity. Linear regression correlations were computed to characterize salinity patterns and potential drivers. To analyze how location plays a role in salinity, ArcGIS was used to calculate the distances of field sites from the Chili River and to categorize whether the sites were floodplain (in the floodplain of the Chili River) or terrace (uplands). The age of agriculture and the irrigation network density of the sites were also explored to see their effect on the soil's retention of soluble salts. Through linear regression, the only significant correlation to EC was CEC. Floodplain areas tended to have higher EC as well as higher CEC. The oldest agricultural area in Arequipa had one of the highest average EC and CEC, and it was also located closest to the river. The relationship between CEC and EC suggests that due to the higher CEC, the soil is more capable of retaining ions that lead to increased salinity. It was also found that sites irrigated with saline water tended to have higher soil salinity, suggesting that irrigation with saline water may be leading to soil salinization in Arequipa fields.

*Principal Investigator:*

*Sara K McMillan, Department of Agricultural & Biological Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Fragmentation and Carbon Storage in Forest Ecosystems**

Author:

Breanna E. Motsenbocker, Purdue University

Benjamin McCallister, Purdue University

Brady Hardiman, Purdue University

Abstract:

Storage of atmospheric carbon by forests is an essential method of mitigating climate change. As urban areas expand, fragmentation of forest ecosystems is a growing concern. Forest fragmentation causes an increase in unconnected forest patches that consist mostly of edge, which is defined as areas where trees experience a loss of protection on one side. The edge of a forest experiences a unique microenvironment which may have implications for its ability to store carbon. This study examines the relationship between forest fragmentation and carbon storage capacity of forests. We used publicly available data on land cover, tree canopy cover, and carbon storage from ten counties around the greater Chicago region. We analyzed landscape patterns between these data to quantify the effect of fragmentation on carbon storage in and around the Chicago area. Our results show that while forests store 40% more carbon than non-forests, forest edges store 18% less carbon on average compared to forest interiors. These results suggest that global patterns of urbanization and the resulting fragmentation of adjacent forest ecosystems may impair forest's capacity to take up and store carbon, exacerbating anthropogenic climate change effects.

*Principal Investigator:*

*Brady Hardiman, Environmental and Ecological Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Recent Lake Michigan Shoreline Changes Along Indiana's Coast**

Author:

Ben T. Nelson-Mercer, Purdue University

Cary Troy, Purdue University

Abstract:

Near-record Lake Michigan water levels are rapidly changing Indiana's shoreline. Understanding how the shoreline responds to water level changes will help predict the future shoreline of Indiana to better prepare for risks posed by shoreline recession. The comparison between the current shoreline state with historical shoreline positions can provide important insights to further this understanding. This research hypothesizes that in spite of the widespread shoreline changes currently being experienced along Indiana's coast, the current shoreline condition is consistent with historical shoreline responses to similar high water levels. To quantify how Indiana's shoreline has changed, orthorectified aerial images were analyzed with the Digital Shoreline Analysis System (DSAS) software, an add-in for ArcGIS. This system allowed for the delineation of the shoreline position, and the temporal tracking of this position along discrete shore-perpendicular transects. Imagery was analyzed from two high water years, 1997 and 2019, and one low water year, 2013. Indiana's 2019 shoreline has receded due to high water levels, but it still hasn't receded to its 1997 position. This study theorizes that the period of low wave and low water conditions preceding the recent increasing water levels contributed to this difference. While the shoreline generally grew during decreases in water level and eroded during increases in water level, the amount of growth or erosion was highly variable throughout Indiana's coastline. These findings indicate that variables like human-caused sediment transport and shoreline structures need to also be considered when analyzing Indiana's shoreline changes.

*Principal Investigator:*

*Cary Troy, Lyles School of Civil Engineering*

## **Results of a Nearshore Lake Michigan Mixing Experiment**

Author:

Kira M. McCorry, Purdue University

Cary Troy, Purdue University

Abstract:

In order to better understand the role of invasive quagga mussels in the Lake Michigan food web, it is essential to examine the motion and mixing of the lake's waters. While factors that impact lake turbulence such as wind stress, inertial waves and radiative convection have been studied extensively at deep regions of the lake, the shallower regions remain largely unanalyzed. This study aims to quantify the mixing of the typically unstratified Lake Michigan water column nearer to the lakeshore. Velocity, temperature, and microstructure data taken from a 10m depth site in Lake Michigan near Milwaukee, WI are analyzed in order to characterize lake mixing. Strong correlation between the winds and near-surface currents is observed while examining the experiment's conditions. Vertical structure of the currents is evaluated through the law of the wall, which predicts velocities near boundaries. The law of the wall model is found to occur at a range of .159-.299 m and is used to calculate several directly related values: hydrodynamic roughness is estimated as .021741 m, friction velocity as .0030468 m/s, and the drag coefficient as .01142. Spectral analysis also demonstrates heavy wave influence on the currents. Despite the shallow range of this study, through in-depth analysis, the 10m depth is observed to be an extremely dynamic and layered region. The observations made in this study of Lake Michigan may be applied to the shallower waters of the Great Lakes and used to contribute to the full understanding of the health of Lake Michigan.

*Principal Investigator:*

*Cary Troy, Lyles School of Civil Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Computer Simulations of Polar Ice Calving**

Author:

Jacques Barsimantov Mandel, Purdue University

Akshay Dandekar, Purdue University

Marisol Koslowski, Purdue University

Abstract:

The objective of this work is to generate a predictive model for ice calving in polar regions. Over the past decade, several new cracks have nucleated in the Antarctic ice sheets due to the global warming and the motion of glacial ice. These cracks could lead to huge masses of ice floating in oceans, eventually melting and increasing the global sea level which can lead to catastrophic scenarios around the world. Previous studies showed simulations on ice calving process in relatively short periods of time such as 9000 hours whereas such processes can take more than 10 years. Ice is modeled as a viscoelastic material. The hydrostatic and gravitational forces acting on floating tips of glaciers may generate bending moments large enough to cause fracture. A parametric study is performed using a representative ice structure to see the effect on the crack nucleation and propagation. The purpose of this parametric study is to better understand how the geometry will behave and where to expect crack nucleation. Results suggest that the time required, and location of the crack nucleation is very sensitive to the geometry. The model would also help to understand the effects of basal boundary condition angle and earthquakes effect on the crack propagation.

*Principal Investigator:*

*Marisol Koslowski, School of Mechanical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Sputter Deposition with Transparent Conducting Oxide**

Author:

Xingyu Wang, Purdue University

Sunghwan Lee, Purdue University

Abstract:

Discovered last century, there have been tremendous progress in transparent conducting oxides due to their unique combined properties of high transparency in the visible regime and high conductivity. Major applications of transparent conducting oxide thin films include circuitries and opto-electronic devices such as touch screens and solar panels. Nowadays, with the increase in the demand of these products, TCO materials have been widely applied, so there is no doubt that the great potential of such TCO material will lead to further study, in order to maximize the efficiency and stability of the products. The objective is to study for thin films that are made out of Tin oxide, with other doping materials, and find out the effect of deposition condition and after-deposition treatment on the properties of thin films such as transparency and sheet resistance. The method used in the lab for thin film production is a DC/RF magnetron sputtering system. Resulting properties of sputter-deposited TCO thin films depend on process parameters such as power applied to target material, substrate temperature and working pressure in the chamber. Due to the very special characteristics of this Tin oxide material, sheet resistance may not be measured for pure Tin oxide from equipment in the lab, and therefore it will need further doping process to have a decreased sheet resistance. Compared to previous works found in the literature, higher transparency and lower sheet resistance have been achieved with better stability, which is promising for next generation electronic and optoelectronic devices that require high conductivity and high visible regime transparency.

*Principal Investigator:*

*Sunghwan Lee, School of Engineering Technology*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

### **3D simulation of shrinkage during femtosecond two-photon polymerization**

Author:

Yijie Chen, Purdue University

Paul Somers, Purdue University

Xianfan Xu, Purdue University

Abstract:

3D microstructures fabricated by femtosecond two-photon polymerization (TPP) face the problem of volumetric shrinkage, resulting in reduced sizes and structural deformation. Despite the vast research concerning stability and printing accuracy, little is known about material shrinkage from the perspective of polymerization dynamics. In this work, a mathematical model is presented to simulate the photochemical processes during TPP, including initiation by laser irradiance to generate free radicals, polymer chain propagation, and termination as well as inhibition, which end up with dead polymer chains. Molecular diffusion and non-local polymer chain growth are incorporated in this model. The partial differential equations are solved using forward time centered space (FTCS) method to obtain the spatial distribution of monomer conversion during and after laser exposure, with which the volumetric strain development in the sample is predicted. Using this simulation approach, the contraction of simple structures such as a suspended line is estimated. Comparisons between different scanning parameters are present, showing that an increased laser power causes larger chemical shrinkage at a certain scanning speed. This study also provides a method to qualitatively reflect the locations prone to shrinkage-induced deformation near a fixed boundary.

*Principal Investigator:*

*Xianfan Xu, School of Mechanical Engineering*

**Stress and failure analysis of thin film electrodes induced by the volumetric strain**

Author:

Gary Li, Purdue University

Xiaokang Wang, Purdue University

Kejie Zhao, Purdue University

Abstract:

Nowadays, Organic Electrochromic Devices play an important role in our daily life. Organic conductor becomes a popular choice to build the electrode since it is cheap, soft, and flexible. Meanwhile, the lifetime of the organic conductor becomes an important factor to be considered. The transportation of ions makes the electrodes inflate and shrink cyclically which makes itself deform. This phenomenon is called mechanical breathing. The cyclic deformation will lead to failure. We sought to simulate and understand the stress distribution of the film electrode when the mechanical deformation is presented. We built a thin film-substrate model in the cylindrical coordinate system since the bubble on thin film is circular shape. By using the constitutive law, we applied a volumetric strain to the thin film. With the help of the COMSOL, we were able to solve three sets of governing equations which were the constitutive law, the momentum balance, and the strain-displacement relation. We analyzed the stress and deformation of the model with respect to the number of cycles. While the volumetric strain was applied, the center part of thin film inflated upward, the bubble tended to expand horizontally outward, and the magnitude of stress increased. With the number of cycles increased, the unrecoverable deformation became obvious, the crack between the thin film and substrate started to grow, and finally resulted in a failure. This simulation shows that the deformation makes the crack between the thin film and substrate bigger so that more efforts can be made to alleviate the effect brought by the volumetric strain to elongate the lifetime of the electrode.

*Principal Investigator:*

*Kejie Zhao, School of Mechanical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Single Crystal HMX Under Quasi-Static Loading**

Author:

Kristyna Hyblova, Walla Walla University

Christian Blum-Sorensen, Purdue University

Steven Son, Purdue University

Abstract:

Models of Octahydro-1,2,5,7-tetranitro-1,3,5,7-tetrazocine(HMX) that accurately predict its response under various levels of insult (e.g., impact) are paramount to safety and effectivity. In recent years the models of HMX behavior have been improved and verified by experiments at different loading conditions. However, few experiments have been conducted with single HMX crystals at a quasi-static loading. It is thought that the initiation of chemical reactions leading to detonation begin at small regions of high temperature near defects in the crystal. Therefore, studies of single crystal HMX with engineered defects have been conducted to improve understanding of this high temperature region formation. This study seeks to investigate the stress gradients near engineered defects in single crystal HMX with quasi-static loading in compression. Engineered defects are machined into single crystals of HMX by mechanical means (microscale drilling) or via laser ablation. These crystals are loaded in compression until fracture. During the test, the fringe patterns in the crystal are captured using circular polarizers and a 520-540nm LED. The fringe patterns are analyzed to determine the stress gradients caused by the engineered defects. Additionally, a PVDF (thin film piezoelectric) gauge is used to record the changes in stress on the crystals. Because of the fast response of this gauge to changes in pressure, a high-speed camera records the progression of strain relief through cracking in the crystal. This study draws conclusions about how various engineered defects in single crystal HMX effect the stress gradients and nucleation of crack formation under quasi-static loading.

*Principal Investigator:*

*Steven Son, School of Mechanical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **High Pressure Burning Characteristics of Additively Manufactured Gun Propellants**

Author:

Chase W. Wernex, Mississippi State University

Aaron Afriat, Purdue University

Timothy Manship, Purdue University

Steven Son, Purdue University

Abstract:

Vibration Assisted printing (VAP) has been demonstrated as a manufacturing technology for printing extremely viscous materials. VAP has been shown to have high printing speed and precision allowing for the creation of novel internal geometry. This project investigated extending VAP to two well-studied gun propellant formulations with little to no change to their original formulation. Manufacturing gun propellants using this approach also allows for a minimization of solvent which can reduce the environmental impact of manufacturing. Multiple cross sections were manufactured including thin strands, perforated cylinders, and gyroidally infilled cylinders. Testing was performed by burning the thin strand samples in a high-pressure strand burner at up to 13.8 MPa. VAP consistently had enhanced flow rates when compared to direct write printing of the gun propellant. This is due to a decrease in wall friction for the flowing propellant when subjected to the ultrasonic vibrations. Additionally, VAP allowed for the printing of several formulations that were too viscous for direct write alone. Data from burning tests was compared to other published results in order to make recommendations on how to best leverage the advantages of additive manufacturing using VAP.

*Principal Investigator:*

*Steven Son, School of Mechanical Engineering*

## **Applications of Deep Reinforcement Learning**

Author:

Anurag Lalit Shah, Purdue University

Abishek Umrawal, Purdue

Vaneet Aggarwal, Purdue

Phu Pham, Purdue

Abstract:

When compared to conventional vehicles, electric vehicles are not only environmentally friendly but also more cost-effective, as their fuel costs are lower than a conventional vehicle. They bring their own problems to the situation of ride-sharing taxis, however, as they have much longer charge times and a low maximum distance on a full charge, which require modifications to the model to incorporate them in. We sought to eliminate the concern of long charge times from the model, and find a replacement, to make this competitive for a ride sharing based system. We simulated mobile, replaceable batteries to charge the main car battery, and set up a system within the model to simulate this. We set up simulated “depots” across the city model which charge these mobile batteries and exchange them with cars driving to them. We also ensured that the car does not get stranded by making sure it can always access a depot, and discouraging trips when at low charge in the main battery. This model is competitive with the original model with handling requests, not requiring any additional cars and only adding short detours to accommodate switching the batteries. Hence this is a more cost-effective solution to the problem of ride-sharing.

*Principal Investigator:*

*Vaneet Aggarwal, School of Industrial Engineering*

**Sparsity Aware Core Extension Benchmarking in Resource-Limited Microcontroller**

Author:

Ruoyi Chen, Purdue University

Jacob R. Stevens, Purdue

Mark C. Johnson, Purdue

Abstract:

With the introduction of wearable devices and the 5G network, the demand for machine learning workload for edge computing has been increased. The biggest issue for machine learning to be adapted to those devices is high resource usage. This issue attracted many researchers to focus on optimizing from both software and hardware aspect to pack the workload into lower performance devices.

Accelerator, the widely accepted hardware optimization method is not applicable due to size constraints and the lack of development of the internal IP component. This leads us to implement sparsity architecture modification which improvement has not been proved on the device. Therefore, to prove the viability of the sparsity extension, need benchmarking a sparsity extension previously proposed for a microprocessor class device to a RISC-V based microcontroller.

For benchmarking the performance gain achieved by extension, the Bonsai model is translated using SeeDot quantization tools and the compiled codes are implemented into the simulated chip on the DE1-SOC FPGA. Overall performance is determined by the time usage of processing USPS10 testing datasets.

The result can prove that it is valuable to consider widely implement the sparsity extension on a microcontroller device. It would further increase the variety of chip can be chosen for edge computing devices.

*Principal Investigator:*

*Mark Johnson, School of Electrical and Computer Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **A Query Processing Engine for Vehicle Re-Identification: A Clustering Approach**

Author:

Kaiwen Shen, Purdue University

Tiantu Xu, Purdue University

Xiaozhu Lin, Purdue University

Abstract:

The increasing effort in the development of smart cities is leading to a drastic increase in the number of cameras. This calls for a need of automated video analysis in tasks such as matching target vehicle in a system of cameras, or vehicle re-identification, for traffic flow analysis or crime investigation. Previous methods on vehicle re-identification have shown to have good accuracy, but also resulted in high computational cost because of the use of complex neural networks and over analyzing videos due to redundancy in cameras deployment and between camera frames. We hereby propose a query processing engine that identifies specific vehicle by efficiently retrieving the camera (location) and frames (time) that contains the vehicle using a clustering technique with only a small portion of video data. We make the assumption that there exist certain prior knowledge camera locations, or clusters of cameras based on location, and user will provide image of desired vehicle in order to perform the search. We select representative cameras from each location cluster and perform object detection on sampled frames. We then perform clustering algorithm, rank the result from representative cameras, and retrieve the camera and frame information of the desired vehicle. Experiments have been carried out using the CityFlow Dataset, a public surveillance camera dataset, and our approach resulted in fast computing with high re-identification rate.

*Principal Investigator:*

*Felix Lin, School of Electrical and Computer Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Modeling Light Transport in Fog for Computational Imaging**

Author:

Emi Mondragon, Trinity University

Kevin Webb, Purdue University

Brian Bentz, Sandia National Laboratories

Abstract:

Fog is a common degraded visual environment that restricts vital processes and hinders perception of the surroundings. Likewise, absorption and light scatter from the randomly distributed water aerosol can hinder or interfere with optical recording devices that are essential for obtaining sensory or image information. By coupling scattered light measurements with a model for the fog, computational imaging becomes possible. A refinement of the photon diffusion approximation to the Boltzmann equation is investigated to describe the intensity of the scattered light for the important regime where the level of scatter is moderate. To describe the interface between free space and the scattering medium, boundary conditions that incorporate a weak angular dependence approximation is implemented. With this new diffusion representation, analytical results for reflectance and transmittance are compared with published data. This model is shown to capture the measured data accurately for a scattering domain that is less than the transport length, where a standard diffusion model is inaccurate, and the full transport model is computationally burdensome. Beyond application to imaging in fog, this result should prove valuable in biophotonics applications and for other environmental sensing situations where use of light is essential, and scatter is significant.

*Principal Investigator:*

*Kevin Webb, School of Electrical and Computer Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Multi-fidelity Analysis to Study the Emergence of Drug Resistance in Multiple Tuberculosis Granulomas**

Author:

Shaurya Gaur, Purdue University

Alexis Hoerter, Purdue University

Elsje Pienaar, Purdue University

Abstract:

Tuberculosis is caused by *Mycobacterium tuberculosis* and is characterized by the formation of granulomas in patients' lungs. Granulomas are the sites of infection and consist of host cells, dead cell debris and bacteria. *Mycobacterium tuberculosis* can mutate to acquire resistance against several antibiotics such as rifampicin and isoniazid. However, these events are relatively rare and very hard to study experimentally at the single host level. Yet, resistance mutations have major impacts at the population level. Our objective is to quantify these rare events by performing Markov Chain and Monte Carlo analysis on multiple granulomas to predict the probability of emergence of drug resistance in our virtual hosts. We extend the scope of previous research which performed such an analysis on a single granuloma. For our study, we begin with only two granulomas as our base case. We obtain information regarding bacterial population growth trajectories, bacterial deaths, and divisions over time from an existing simulation of granuloma progression (GranSim). GranSim is a hybrid, multiscale, agent-based model describing bacterial growth, division and death during granuloma formation. We then apply Markov Chain and Monte Carlo methods to the two individual granulomas as well as a single combined granuloma formed by the fusion of these two granulomas to predict the probability of drug resistance over time. To address the challenge of understanding the emergence of drug resistance in multiple granulomas, we will apply Markov Chain and Monte Carlo analysis to more than two granulomas and compare the results.

*Principal Investigator:*

*Elsje Pienaar, Weldon School of Biomedical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Computational Investigation of Mechanical Interactions between Cells and Extracellular Matrix**

Author:

Brandon Slater, Purdue University

Jing Li, Purdue University

Taeyoon Kim, Purdue University

Abstract:

Living cells require mechanical forces for many of their physiological functions. Using these forces, cells keep remodeling and interacting with extracellular environments. Such mechanical interactions between the cell and the extracellular environment are critical for many biological processes, such as cell migration, morphogenesis, and wound healing. The actomyosin cortex underlying a cell membrane is one of the main force generators in cells. Via physical links between the cortex and an extracellular matrix (ECM) called focal adhesions, forces generated from the cortex can be transmitted to the ECM, resulting in structural remodeling of the ECM. Due to the importance, matrix remodeling and force transmission induced by force-generating cells have been investigated in several studies. In those previous studies, the ECM was assumed to be an elastic material. However, the ECM is highly viscoelastic and henceforth exhibits a time-dependent response to applied stress and forces. To overcome limits of the previous studies and thus provide more physiological insights, we employed a two-dimensional computational model for investigating how mechanical interactions take place in the ECM with realistic rheological properties. We found that the transient nature of cross-links between matrix fibers and the structural properties of the ECM cooperatively regulate the degree of remodeling and force transmission

*Principal Investigator:*

*Taeyoon Kim, Weldon School of Biomedical Engineering*

**The application of single cell genomics in viral infectious disease**

Author:

Zonghao Zhang, Purdue University

Bingyu Yan, Purdue University

Majid Kazemian, Purdue University

Abstract:

Epstein-Barr virus(EBV), this very virus founded in 1964 infects 95% of adults worldwide. Since EBV could alter the host DNA and DNA structure, those infected might suffer from a series of diseases induced by EBV. The list of disease is getting longer thanks to the virus itself and diligent works done by scientists and medical doctor. This list of disease includes several types of cancer, EBV-associated lymphoproliferative diseases(Rezk et al, 2018), gastric cancer and nasopharyngeal carcinoma. And more than 200,000 cancer cases per year are thought to be the result of EBV(Cancer Research UK, 2014). Moreover, several evidences showed that EBV is responsible for several childhood disorder(Mastria et al, 2016) and autoimmune disease(Toussiro et al, 2008). The vaccine is the ultimate weapon for us to defeat virus, but unfortunately none EBV vaccine has been came out and commercialized. Thus, it is important for us to discover every aspect of EBV and illustrate the regulation of EBV replication in host cells and cellular response to EBV. Single cell RNA sequencingoffers the ability to discover rare features at single cell level and uncover the heterogeneity of the bulk cell population. Moreover, a newly developed genomic method called single cell ATAC sequencing can also offer the ability to detect the chromatin accessibility at single cell level. Here, by building virus-human chimeric reference genomes and mapping the scRNA-seq reads and scATAC-seq reads to the corresponding reference genome, we identified pervasive single cells that are harboring virus fragment in EBV transformed human B-Lymphocyte. This pipeline can be used to dissect the cells with virus load at single-cell level and enables the detailed investigation into the host cell response to virus infection.

*Principal Investigator:*

*Majid Kazemian, Department of Biochemistry*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Effects of Cell-Cell Contact during multicellular migration**

Author:

Anuhya Edupuganti, Purdue University

Hye-ran Moon, Purdue University

Bumsoo Han, Purdue University

Abstract:

Cell migration is essential in the development and maintenance of a multicellular organism and plays a vital role in wound healing, tumor progression and metastasis, and immune response. Understanding the characteristics and mechanisms of cell migration could advance the development of effective therapeutics and innovative biotechnologies. In addition to experimental research, physical and mathematical models have provided valuable insights into cell migration characteristics. However, mechanical interactions among cells and between cells and matrix, especially in collective cell migration, are difficult to quantitatively measure and predict. In this study, collective cell migration in fibroblasts and epithelial cells has been simulated by the Cellular Potts Model using a python/XML-based software package CompuCell3D. Specifically, the effects of cell-cell contact are investigated in the interactions between fibroblasts and between epithelial cells. Fibroblasts and epithelial cells were chosen by virtue of their role in wound healing and cancer metastasis, and the difference in migration pattern demonstrated by them: fibroblasts tend to migrate individually, whereas epithelial cells migrate as collective sheets. The model in this study represents the simplified mechanics of cells' response in migration dependent on the interplay between the strength of cell-cell adhesions and cell-matrix adhesions, and magnitude of protrusion force exerted by the cell. Cell migration is quantified primarily in terms of cell speed, deviation from straight path and number of cells that migrate into the outer matrix past the population baseline, and distance of migration. This model can be adapted to explore the behavior of fibroblasts and epithelial cells in response to external environmental cues and other cell types in the population.

*Principal Investigator:*

*Bumsoo Han, School of Mechanical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

**Noninvasive Measurement and Visualization of Vagus Nerve Activity to Improve the Efficacy of Gastric Electrical Stimulation in Human Subjects with Gastroparesis**

Author:

Rama G. Coimbatore, Purdue University

Matthew Ward, Purdue University

Abstract:

Gastroparesis is a stomach condition that results in abnormal processing of food and delayed gastric emptying without a mechanical obstruction. Symptoms may include nausea, vomiting, early satiety, and bloating. To treat this condition, gastric electrical stimulation (GES) is proposed as an option for patients who do not respond to medication. A GES device is implanted and used to electrically stimulate the stomach wall, which is innervated by the vagus nerve. There is evidence that GES activates the vagus nerve, which is the primary nerve that the stomach uses to communicate sensory information to the brain, including signals that may contribute to nausea and vomiting via the area postrema (“vomiting center of brain”). We hypothesize that GES relieves nausea and vomiting by stimulating the vagus nerve. Vagal nerve recordings were obtained in human subjects receiving GES for gastroparesis using a novel, noninvasive method, consisting of placing a 5x6 multi-electrode array (MEA) on the skin surface overlying the left and right cervical vagus nerves. Demographical data and neck measurements were also collected. A graphical user interface was created as a tool to visualize placement of the MEA and vagal nerve activity. We are determining the limitations of detecting vagal nerve activity through the skin surface, including body mass index and the parameters of the GES device used to stimulate the stomach wall. Visualizing and analyzing the data traveling across the electrodes may provide insight into the typical anatomic course of the vagus nerve. The data will be represented on a virtual person whose neck anatomy is defined by the measurements collected from the subjects. We aim to visually display the vagus nerve activity to decode and analyze its involvement in GES and the treatment of gastroparesis. Another aim of the visualization is to simplify the interpretation of the complex datasets that we collect so that these NIH-funded research studies can be made more accessible to a broad audience with different backgrounds and interests.

*Principal Investigator:*

*Matthew P Ward, Weldon School of Biomedical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

**Novel Ethnographic Investigations of Engineering Workplaces to Advance Theory and Research  
Methods for Preparing the Future Workforce**

Author:

Paige Kadavy, Colorado School of Mines

Swetha Nittala, Purdue University

Tasha Zephirin, Purdue University

Brent Jesiek, Purdue University

Abstract:

Virtual teaming is becoming a more common professional practice used around the world to create more flexible and multifaceted teams and optimize group output. While becoming more commonplace, there remains considerable room for discovery in terms of how team structure, processes, tools, and other factors may contribute differently to virtual team performance, including as compared to more traditional team configurations. In this paper, we review a corpus of literature that analyzes virtual teams and then compare those findings to insights drawn from interviews with technical professionals who engage in virtual work. Our goal is to discover common structures and practices used in virtual teaming within engineering and allied fields. Literature was gathered and chosen systematically from the Engineering Village database based on criteria related to team performance and satisfaction. We additionally conducted semi-structured interviews that explored participants' current and previous experiences working on virtual teams. Based on the literature review and interviews, we compare the findings from each and identify best practices for virtual teaming in engineering disciplines and provide associated guidance moving forward. These findings will guide further research, inform the creation of more effective virtual teams, and help identify avenues in the discipline that are under investigated or require more research. This work will be useful to both members and managers of virtual teams in technical fields, as well as engineering education teachers and researchers who are engaged in preparing students for a rapidly evolving workplace.

*Principal Investigator:*

*Brent Jesiek, School of Engineering Education*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Auto-grading Workflow for College Programming Assignment**

Author:

Swapnil M. Kelkar, Purdue University

Xiao Hu, Purdue University

Milind Kulkarni, Purdue University

Yung-Hsiang Lu, Purdue University

Abstract:

With the recent increase in popularity of Computer Science and programming-based courses at universities, comes the demand for an efficient framework to grade the homework programming assignments which are an integral part of these courses. Currently, the grading systems used at Purdue are time consuming and require significant manual intervention from the teaching assistants. We sought to optimize this by developing a framework which will facilitate not just the submission of the assignment but also the grading and feedback for these assignments. We first interviewed several professors and teaching assistants who had been using auto-graders in the past and listed down their various needs and requirements. Taking these needs into consideration, we made use of one of the most popular online code hosting platforms, GitHub and posted all the assignments on GitHub Classroom, one of GitHub's features tailored specifically for classes with a large enrollment. We then integrated this with another tool called CodePost to receive the code from GitHub and run the necessary tests on it. Through this project, we aim to create an easy to use grading framework for both the students and the teaching assistants. In the past, students would have to wait a minimum of 2 to 3 days to obtain their results, however, with our system, students can get instant feedback on their submissions. We believe that our workflow will not only benefit the students but would definitely help save TA's and professors' time.

*Principal Investigator:*

*Milind Kulkarni, School of Electrical and Computer Engineering*

## **Automated Grading of Programming Assignments**

Author:

Brandon Xu, Purdue University

Swapnil Kelkar, Purdue University

Xiao Hu, Purdue University

Yung-Hsiang Lu, Purdue University

Milind Kulkarni, Purdue University

Abstract:

With the increasing prevalence of online learning platforms and growing sizes of university programming classes, efficient automated grading systems are becoming more and more necessary. Currently, the grading methodologies of programming classes at Purdue University are varied and require time-consuming manual work by teaching assistants. Through various discussions with faculty and past teaching assistants within the Electrical and Computer Engineering Department at Purdue, we formed a list of essential features necessary to create a foundation for our autograding system. In general, an ideal autograder would be easy to set up, provide immediate feedback to students, and grade each assignment automatically. Instead of developing such a system from scratch, we discovered that our needs would be best met by integrating two existing platforms: GitHub Classroom and CodePost. GitHub Classroom is a service that allows class instructors to easily create and distribute individual code repositories for students, and CodePost is a learning platform with autograding capabilities. Utilizing the two services' APIs (Application Programming Interface), we created an intermediate server that allows GitHub to interact with CodePost. By doing so, code that is submitted to GitHub by students will also be sent to CodePost automatically, where test cases will be run to determine grades. This workflow not only saves time during the setup and grading process for instructors and teaching assistants, but also allows students to receive their grades for assignments more quickly.

*Principal Investigator:*

*Milind Kulkarni, School of Electrical and Computer Engineering*

## **Predicting Subsequent Memory From Cognitive States During Learning**

Author:

Gloria Dietz, Purdue University

Yu-Chin Chiu, Purdue University

Abstract:

Learning and memory are such an integral part of life that we often take their relationship for granted: we remember what we have learned. However, this relationship may not be as simple as it seems. This is especially the case when the learning is incidental, rather than the main focus, as we go about fulfilling other behavioral goals. Cognitive control, which is required to produce goal-directed behavior, entails a set of functions that affect learning differently. Some functions (e.g., conflict resolution) appear to help, while others (e.g., motor inhibition, fluctuating attentional states) appear to hurt, resulting in opposite subsequent memory effects (SME). However, the effects of these different aspects of cognitive control have not been assessed jointly to reveal how they interact with each other during learning. It is, therefore, difficult to predict the mnemonic fate of information that is learned under a combination of cognitive controls. In this study, we utilized a cognitive control task that requires both conflict resolution and motor inhibition, along with a surprise memory task to assess the SME of these control functions. We also estimated each trial's attentional state by considering the fluctuation of response times on previous trials. We then built a novel model that combines all three aspects of cognitive control to predict the subsequent memory on a trial-by-trial basis for each of the participants. We found that our model can predict each subject's trial-wise memory, suggesting that different aspects of cognitive control do jointly contribute to how well information is learned.

*Principal Investigator:*

*Yu-Chin Chiu, Department of Psychological Sciences*

## **Automation in Drug Approval Process Information**

Author:

Bobby Putra Santoso, Purdue University

Andrew Strongrich, Purdue University

Alina Alexeenko, Purdue University

Abstract:

Lyophilization has been around since the Incan civilization. In terms of pharmaceuticals, widespread use started in the 1940's. Lyophilization is needed for certain drugs to keep them stable, meant for prolonged use. The lyophilization process involves freezing the drug, then lowering the atmospheric pressure to get sublimation to remove excess water. After the water is removed, the final product can be stored as a preserved drug. The Food and Drug Administration is an organization that approves and regulates lyophilized and non-lyophilized drugs in the United States. Often, information regarding these drugs are kept in a website, and are updated regularly. However, up until now, obtaining information of newly approved drugs requires arduous manual search. This study is to help researchers and health officials better understand drug trends. For instance, researcher can better analyze the trends of lyophilized drugs within the years. We used Python programming language to create an automation algorithm that gather data from the Food and Drug Administration website. Since the drugs information was displayed based on the first letter of the name, the algorithm would loop repeatedly until it reached through every drug. The algorithm would go through every link and save drug labels presented. These drug labels would determine if a drug is lyophilized or not. Supposedly, this automation algorithm should be used every time the FDA approve new drug. We tested this automation algorithm against manual (human checking) in a single drug run. The human individual spends 25.85 seconds to check for a single drug and its label, while the automation algorithm only spends 13.15 seconds. The whole database contains 89 pages, each with around 100 main drugs. An estimate to the run time for the algorithm to run through a page is one hour. A human individual can take up to weeks of data gathering in comparison to just tens of hours using automation. Furthermore, the automation algorithm was evidently more consistent in checking for keywords and saving the drug labels. A possible reason for non-consistency for manual checking factors affecting the human individual, such as fatigue. It was an arduous task for a human to go through pages, all of which have 100 drugs. Based on the findings, we recommend that automation is the key to data mining drug information for analyzing trends. Automation will be needed for researchers and health officials for data gathering regarding new approved drugs.

*Principal Investigator:*

*Alina Alexeenko, Davidson School of Chemical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Bioinformatic Analyses and Synthesis of Natural Product Inspired Cyclic Peptides**

Author:

Chloe Smith, Purdue University

Matthew Hostetler, Purdue University

Elizabeth Parkinson, Purdue University

Abstract:

Antibiotic resistance has created an urgent need for novel therapeutics. Natural products, especially cyclic peptides, have been a fantastic source of antibiotics, including the FDA-approved vancomycin and daptomycin. However, there is great need to find additional molecules with activity against antibiotic resistant infections. Bioinformatics analysis of the natural product biosynthetic gene clusters combined with chemical synthesis of the predicted cyclic peptides will likely allow us to find new non-ribosomal cyclic peptides that could potentially combat antibiotic resistant bacteria. Using BLASTp, we identified 500 biosynthetic gene clusters containing the enzyme responsible for peptide cyclization. Further analysis of the gene clusters using antiSMASH and PRISM allowed us to identify 130 unique cyclic peptides. Cheminformatics combined with gene cluster comparisons have allowed us to prioritize the 50 most diverse compounds. These peptides are currently being synthesized and tested for purity and bioactivity. High pressure liquid chromatography and mass spectrometry are used to determine purity and identity of the synthesized cyclic peptides while standard bioactivity assays are used to determine their antibiotic effects. Bioinformatics combined with chemical synthesis of predicted natural product cyclic peptides will allow us to identify novel antibiotic molecules that will likely help to fill the antibiotic pipeline for the challenging to treat antibiotic-resistant bacteria.

*Principal Investigator:*

*Elizabeth Parkinson, Department of Chemistry*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Expanding a Lipid Fragmentation Database and LIQUID Functionality**

Author:

Chisa Zensho, Purdue University

Daniela Sanchez, Purdue University

Manxi Yang, Purdue University

Miranda Weigand, Purdue University

Julia Laskin, Purdue University

Abstract:

Accurate identification of lipids is key to a better understanding of biological functions as well as the roles of lipids in diseases and drug studies. Lipid Quantification and Identification (LIQUID) is a lipid identification tool that annotates tandem mass spectrometry (MS/MS) data with a customizable target database and scoring function that allows users to distinguish the accuracy of identification. However, since this software was originally developed to analyze samples that were desalted by chromatographic separation, it is limited in its application to samples in which metal adducts are not present. This presents a challenge to mass spectrometry imaging applications, in which lipids are typically observed as alkali metal adducts. We have expanded the target database of LIQUID by adding potassium and sodium adducts for the existing database entries recorded by LIPID MAPS. Furthermore, we have incorporated new fragmentation rules for those adducts to improve the accuracy of lipid identification and scores calculated by the software. The identification ability of the software with the expanded target database and fragmentation rules was compared to the original database with the previous set of fragmentation rules and was found to have a higher rate of detecting and accurately annotating fragments with a higher accuracy of score assignments for data without chromatographic separation. The enhanced LIQUID enables accurate large-scale analysis of a larger variety of lipid species for a broader type of experiments than the previous LIQUID. This work shows the improved annotation capabilities of LIQUID for direct infusion tandem mass spectrometry data.

*Principal Investigator:*

*Julia Laskin, Department of Chemistry*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Applications of Biotechnology in Phage Discovery, Lipidomics, & Proteomics**

Author:

Emma Lietzke, Purdue University

Gillian Smith, Purdue University

Kari Clase, Purdue University

Abstract:

Bacteriophages, or viruses that infect specific bacterial hosts, are essential in understanding evolutionary mechanisms and viral diversity, especially in modeling interactions of phage infection. The application of molecular genetics on phages provides a means to understand their specific gene functions through investigating their proteome and lipidome profiles. Current phage genomic annotation software has many limitations in expanding the understanding of unknown gene functions, as well as structural protein and lipid expressions. Mass spectrometry (MS) in tandem with analysis software, such as MetaboAnalyst, can be used to identify relevant lipids and proteins in phages. Experiments were designed to compare ion intensity outputs from MS from different phages in exponential and stationary phases, and varied time infected by *M. smeg*, with those from a negative control. Statistical and biomarker analyses were utilized to examine the expressions of varying lipids within these samples; the results were then analyzed to determine which lipids were significant and how often. This study compares the results between phages FrenchFry and MrGordo. These phages were chosen to provide the widest range of comparison, as FrenchFry was the most prolific lytic phage and MrGordo, a prolific temperate phage. 509 lipids were identified in MS. From the 9 test variations in MetaboAnalyst, 64 lipids were identified as significant. 11 of these, which appeared 3 or more times across volcano plots and ROC tests, were investigated in metabolite databases and literature. Many came back as toxins or related to inflammatory and anti-viral responses, their potencies dependent on specific chemical structures.

*Principal Investigator:*

*Kari Clase, Department of Agricultural & Biological Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Modeling Ferroelectric Domain Switching Kinetics**

Author:

Minh Tran, Purdue University

Jackson Anderson, Purdue University

Dana Weinstein, Purdue University

Abstract:

In recent years, ferroelectric materials are a rising research topic due to the discovery of a scalable, CMOS compatible ferroelectric phase in thin film HfO<sub>2</sub>. This study presents an open-source implementation of the Du-Chen model of ferroelectric switching, using Python, that has been verified against previously published results. Using experimental data which includes polarization changes with regards to electric field with multiple variations of temperature and signal input, the model computes relevant parameters such as number of domains, time switching, and shortest nucleation time possible as a function of bias voltage and film temperature. This new capability will enable future studies at Purdue of the impact of processing conditions and film composition on the switching kinetics of ferroelectric films, furthering the understanding of this important class of materials.

*Principal Investigator:*

*Dana Weinstein, School of Electrical and Computer Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

**Optimization of Focused Ultrasound Output from Piezoelectric Micromachined Ultrasound Transducers for Neural Stimulation**

Author:

Daria A. Shkel, University of California, Irvine

Imtiaz Ahmed, Purdue University

Dana Weinstein, Purdue University

Abstract:

The search for neural stimulation methods that do not require direct contact between the stimulation device and biological structure (e.g. brain) is of great scientific and practical interest. Pulsed focused ultrasound is one of such non-invasive techniques, in which low-intensity ultrasound is delivered to targeted deep localized regions, resulting in neural activity. Multi-element arrays of hundreds to thousands of ultrasound transducers may enable direction of the outputted ultrasound waves to effectively focus within deep target regions in the brain. We explore the possibility of using custom designed, microfabricated, Piezoelectric Micromachined Ultrasound Transducers (PMUT) and Fresnel Lenses with tuning capabilities, to accomplish this task. The objective of this research was to optimize the design and geometry of PMUT devices. The research aimed to understand how geometric and electrical parameters of devices will affect characteristics of the outputted ultrasound, including the focal point, spot size, and acoustic pressure. For our study, we modeled the device using the COMSOL Multiphysics Finite Element Analysis software and built in Acoustic Module. Our parametric study included variations in geometry of the PMUT device, material layers, material properties, and input actuation voltages. We also investigated the effect of driving different combinations of actuation electrodes on the focal point size and maximum acoustic pressure of the ultrasound. Understanding the effects of these parameters on the generated ultrasound is essential for guiding design and manufacturing of our future PMUT devices.

*Principal Investigator:*

*Dana Weinstein, School of Electrical and Computer Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Finite Element Implementation of Strain Gradient Plasticity for Microscale Amorphous Polymer Structures**

Author:

Fredrik Arentz, Purdue University

Paul Somers, Purdue University

Xianfan Xu, Purdue University

Abstract:

Finite Element Analysis (FEA) has proven to be invaluable in the design of metamaterials – engineered materials with properties not found in nature. Nanomanufacturing techniques such as Two Photon Polymerization have the capability of producing polymer metamaterials, but the classical mechanics approach used in commercially available FEA tools do not accurately predict deformation in polymers on the micro scale. This can make it difficult to predict the precise deformation observed in mechanical metamaterials. It has been shown that strain gradient plasticity models can describe the size-dependent deviations from classical mechanics in microstructures, but the FEA implementations that have been created so far are specialized for metals, whose inelastic deformation differs from polymer structures. In this paper, the mathematical basis for an FEA implementation of strain gradient plasticity for amorphous polymers will be presented. The FEA solver will be based on existing mathematical models and will be implemented in FEniCS, a partial differential equation solver in C++. The study will give the framework for building an FEA solver that can be used to characterize the deformation of metamaterials with a higher level of precision than that offered by current models.

*Principal Investigator:*

*Xianfan Xu, School of Mechanical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Design and simulation of an on-chip LC filter for superconducting quantum circuits**

Author:

Gozde Iloglu, Purdue University

Jeremy Cadiente, Purdue University

Botao Du, Purdue University

Alex Ma, Purdue University

Abstract:

Our motivation behind this study is the search for new and better quantum bits (qubits). In our circuit, the performance will be enhanced with the use of an on-chip low pass filter. An LC low pass filter will be designed and added to our circuit design to prevent qubit excitation by outside sources. The filter will allow the low frequencies to pass but block the high frequencies. This filter will improve the circuit design by protecting the qubit and producing more reliable results. The filter design is constructed in Klayout software using Python. After verifying the design, the filter is simulated in HFSS using ANSYS Electronic Desktop to analyze the performance. Once the design is finalized, it is incorporated into the circuit. From the performance analysis, we saw that the filter does a successful job filtering frequencies until 9 GHz. The filter is most effective at the range of 5-6 GHz. In future work, we will be increasing the frequency range in which the filter is effective.

*Principal Investigator:*

*Ruichao Ma, Department of Physics and Astronomy*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Simulation, Identification, and Application of CMOS inverters using OFETs**

Author:

Walter Kruger, Purdue University

Mohammad Javad Mirshojaeian Hosseini, Purdue University

Robert Nawrocki, Purdue University

Abstract:

Organic Field-Effect Transistors (OFETs) have been fabricated and characterized in laboratories with increasing success. OFETs have been identified as an emerging technology with great potential in the biosensor and bioinspired neuromorphic areas of study. Comprehensive mathematical models of these types of electrical components have also been developed successfully, but as their intrinsic characteristics greatly differ inorganic counterparts, there has been a lack of computational tools that allow for these models to be simulated in complex electrical networks. The goal of this research project is to create the tools necessary for OFET simulation in the Simulink and Simscape platforms. Custom code blocks developed using Marinov and Universal Model and Extraction Method (UMEM) mathematical models for OFET characterization are used to simulate single OFET components and construct a fully functioning virtual Organic Complementary Metal–Oxide–Semiconductor (CMOS) inverter for signal amplification and neuromorphic applications. Through the simulated OFETs and CMOS inverters' I-V output and transfer characteristics, we seek to provide data on the accuracy of the simulated components to those used in a laboratory environment. Additionally, by amplifying low-power signals, we aim to demonstrate the usability of these systems in real world applications. This project seeks to provide researchers with a method for simulating OFETs on a virtual platform capable of integrated network simulation to verify their performance and the feasibility of fabrication and construction for these networks.

*Principal Investigator:*

*Robert Nawrocki, School of Engineering Technology*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Modeling of Mass and Fluid Transfer in Hemodialysis to Maximize Treatment Efficiency**

Author:

Dunya Al Al Marzooqi, Purdue University

Farzad Mohajerani, Purdue University

Vivek Narsimhan, Purdue University

Abstract:

Hemodialysis is a highly regulated and customizable medical treatment used to remove toxins and waste products from the blood stream to a low and safe concentration. This treatment is utilized for patients suffering from advanced kidney disease or end-stage renal disease who have lost the functionality of their kidneys. Over the years, several experimental and modeling efforts have been made in order to find the optimal treatment conditions and newer, more efficient dialyzer designs. This is motivated by the mortality and morbidity rates of these patients, which still remain high. In this study, we will be modeling the hemodialysis process to investigate the ways in which different experimental conditions affect the solute clearance and thus, to increase the efficiency of hemodialysis. MATLAB is used in order to model the hemodialysis system and the command, `bvp5c`, is used to solve its governing differential equations over the length of the dialyzer. This command requires boundary conditions to be set that mimic the treatment conditions. The toxin clearance efficiency of the dialyzer is then calculated at varying treatment conditions. We observe that larger toxins are harder to be filtered out and therefore, cleared from the patient. With this model, we will be able to validate its accuracy by comparing our simulation results to previous experimental data, specifically by comparing the clearance level of toxins achieved to the modeling results. From the results, we can suggest strategies to increase the clearance level of large toxins. Consequently, this study will guide us to the optimum treatment condition which will be tested experimentally in the future.

*Principal Investigator:*

*Vivek Narsimhan, Davidson School of Chemical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Computational modeling of fluid flow through porous media in a cholera enrichment device**

Author:

Julio Rivera, University of Puerto Rico, Mayagüez

Melinda Lake, Purdue University

Jacqueline Linnes, Purdue University

Abstract:

Cholera is an infectious disease that can be contracted by ingesting a substance that contains the bacterium *Vibrio cholera*. Studies have shown that each year there are 1.3 million to 4.0 million cases of cholera and 21,000 to 143,000 deaths worldwide due to this disease<sup>1</sup>. It is most commonly found in the tropics particularly Asia, Africa, Latin America, India, and the Middle East. We propose a cholera filtering device to enrich cholera from one liter of water from an environmental source. Furthermore, we aim to detect cholera at very low concentrations of 1-1000 cells/mL. To understand the pumping mechanism to drive this device, we develop a COMSOL fluid flow model through porous membranes in a cholera enrichment device". This model demonstrates the device functions with the use of different pressure-driven flows through nylon membranes; providing a parametric study that predicts the filtration system's velocity with respect to time providing us with an expected behavior for further design improvements. The model predictions indicate that we can design a device to filter 1L of water to enrich cholera in a time span below 15 minutes, thus making this device suitable for point-of-care applications, particularly in places where cholera is endemic.

*Principal Investigator:*

*Jacqueline Linnes, Weldon School of Biomedical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Mechanobiology Computational Modeling of Healing Following Breast Conserving Surgery**

Author:

Muira Fontaine, Purdue University

Zachary Harbin, Purdue University

David Sohutskey, Purdue University

Adrian Buganza Tepole, Purdue University

Sherry Harbin, Purdue University

Abstract:

Breast conserving surgery (BCS; otherwise known as lumpectomy), in conjunction with radiation therapy, has replaced mastectomy as the standard of care for eradicating breast carcinoma because of its preservation of surrounding tissue. Following lumpectomy, the tissue void heals by wound contraction and scar formation, making it challenging for surgeons to predict cosmetic outcomes. This is further exacerbated by the significant patient-to-patient variation in breast size, composition, and tumor geometry and location. Based on these considerations, surgeons would benefit from new options to optimize oncologic and cosmetic outcomes of BCS. Few computational models of wound healing following lumpectomy have been developed, and there is still a gap in current computational models due the lack of mechano-biological coupling. This project adapts an existing three-dimensional computational mechanobiological model of cutaneous wound healing to the lumpectomy scenario. Breast tissue parameters and properties are modulated to simulate patient-specific conditions and therapeutic interventions, including soft tissue fillers. Preliminary results derived from the coupled mechanobiological model correlated to normal wound closure trends in cell migration and proliferation, causing wound contraction and extracellular matrix (ECM) remodeling. These were consistent with results obtained from the independent biochemical and mechanical models. Studies are ongoing to i) verify model predictability, ii) determine effects of critical parameter modulation (e.g., surgical wound geometry), and iii) simulate applications of collagen-based soft tissue fillers. Computational models quickly inform researchers of new surgical reconstruction strategies or tissue-engineered product design and help clinicians personalize therapies, improving breast wound healing and cosmetic outcomes.

*Principal Investigator:*

*Sherry Voytik-Harbin, Weldon School of Biomedical Engineering*

## **Coarse-graining modeling of proteins**

Author:

Kata Alilovic, University of Florida

Rajat Dandekar, Purdue University

Arezoo Ardekani, Purdue University

Abstract:

Proteins play an important role in metabolism of living organisms. Proteins are built from amino acids that fold into

unique 3D structure that determinates its function. Modeling of proteins is used to understand its physical properties and structure. They are large molecules that are hard to study in simulations with all atom models when

large number of proteins are involved. Therefore, we are looking to develop a coarse-grained model that will be applicable to various proteins and used in simulations to study physical properties like viscosity and diffusivity in a

crowded environment. Coarse-grained models are built in open source molecular visualization program VMD using

the all atom coordinates file from Protein Data Bank. Martini force field is applied to create residue-based coarsegrained models while shape-based coarse-grained models are created using CHARMM force field. Chosen

coarse-grained model will be studied using LAMMPS, open source simulation software.

*Principal Investigator:*

*Arezoo Ardekani, School of Mechanical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Analysis of the Indenoisoquinoline Compound Library for Myc G-Quadruplex Targeting**

Author:

Joshua Kosnoff, Purdue University

Jonathan Dickerhoff, Purdue University

Kaibo Wang, Purdue University

Guanhui Wu, Purdue University

Danzhou Yang, Purdue University

Abstract:

The Myc protein is known as a master regulator of cancer cells, and its suppression greatly diminishes the viability of these cells. Unfortunately, the Myc protein is considered “undruggable.” However, G-quadruplexes (G4) are non-canonical globular DNA structures that can form in the Myc promoter region and downregulate Myc expression. As such, stabilizing the Myc G4 has become a key strategy in cancer therapy. The indenoisoquinoline has previously been identified as a promising scaffold for this purpose, and optimization of this scaffold’s side chains can lead to the achievement of desired activity. With access to over 1000 different indenoisoquinoline-based molecules, we establish a first-of-its-kind compound library and explore the chemical space of indenoisoquinolines to determine the positive Myc G4 hit compounds. The molecules are tested with biophysical and cell-based assays to determine G4 inducing ability, G4 thermal stability, and cytotoxicity. Data from all experiments are compiled into a singular database and filtered bioinformatically. The compiled orthogonal data sets are analyzed together to identify positive hit compounds and provide insights into the side chain structure-activity relationships (SAR). The combined analysis successfully filters the library to identify the top compounds in the library and allows for further hit identification and SAR activity.

*Principal Investigator:*

*Danzhou Yang, Department of Medicinal Chemistry and Molecular Pharmacology*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **The Role of BMAL1 and CLOCK in the Formation of Alveolar Structures in 3D Cultures**

Author:

Jacob T. Larsen, Purdue University

Aridany Suarez-Trujillo, Purdue University

Theresa Casey, Purdue University

Kelsey Teeple, Purdue University

Karen Plaut, Purdue University

Abstract:

Circadian clock disruption during pregnancy is related to impaired lactation in humans and cows. Transcriptional targets of the circadian clock genes, BMAL1 and CLOCK, include epithelial cell junction proteins. The formation of milk-producing alveolar structures is dependent on these cell-cell junctional proteins. We hypothesized that if BMAL1 and CLOCK genes are disrupted, mammary epithelial cells (HC11) will have a reduced ability to form alveoli and produce milk. Our objective was to measure the effect of BMAL1 gene deletion (BMAL1-KO) and CLOCK protein reduction (shCLOCK) in HC11 cells on the formation of alveoli and expression of the cell-cell junction proteins zona-occludins 1 (ZO-1) and e-cadherin (CDH1) in 3D cultures. Cells were plated (13,000 cells/well) on Matrigel and cultured in the presence of lactogenic hormones. On day 7, phase-contrast microscopy was used to capture images of all alveolar structures (n=3 wells/treatment). ImageJ software was used to count the number of alveoli and measure alveolar area, perimeter, minimum diameter, maximum diameter, and circularity. General linear model and post-hoc Tukey analysis indicated that shCLOCK and BMAL1-KO were significantly different in all parameters from HC11 ( $p < 0.05$ ). The total number of alveoli was also reduced in shCLOCK and BMAL1-KO lines relative to HC11 ( $p < 0.05$ ). These results indicate that the BMAL1-KO and shCLOCK cells have a reduced ability to form alveoli in culture, which supports our hypothesis. Evaluation of ZO-1 and CDH1 expression is ongoing, initial staining patterns are consistent with cell-cell junction proteins.

*Principal Investigator:*

*Theresa Casey, Department of Animal Sciences*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Structural Studies of Phospholipase C Epsilon**

Author:

Amanda J. Everly, Purdue University

Elisabeth Garland-Kuntz, Purdue University

Isaac Fisher, Purdue University

Angeline Lyon, Purdue University

Abstract:

Phospholipase Cs (PLCs) are an enzyme family responsible for hydrolyzing phosphatidylinositol lipids at the membrane to produce second messengers, which in turn activate other cellular signaling pathways. This study focuses on PLC epsilon, a subfamily differentiated by several unique regulatory domains. Understanding PLC epsilon's regulation via its structure is important due to its roles in cellular signaling and involvement in heart disease. Our research aims to produce high-resolution structures of truncated PLC epsilon variants to better understand how the structure dictates regulation and activity. Experimental procedures begin with a variety of molecular biology techniques to produce a virus that contains the DNA encoding the target protein, which is then used to infect other cells, allowing them to produce the protein. The target protein is then purified by extracting it from the cells based on the presence of affinity tags on PLC epsilon, along with its charge and size. The purified PLC epsilon can then be imaged by utilizing single-particle cryo-electron microscopy (EM), which uses electron detectors to determine a two-dimensional picture of the protein frozen in non-crystalline ice. Software is then used to process these images and eventually produce a three-dimensional structure from the two-dimensional protein images. This will result in an intermediate to a higher resolution structure (8-15 Å resolution) for the protein compared to what has been determined in the past (20-40 Å). These outcomes will allow for a better understanding of the structure of PLC epsilon and its regulation, which improves understanding of its role in cellular signaling.

*Principal Investigator:*

*Angeline Lyon, Department of Chemistry*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **The Characterization of the Formation of SAGA and CHAT in Drosophila**

Author:

Hannah R. Blum, Purdue University

Eliana Torres-Zelada, Purdue University

Vikki M. Weake, Purdue University

Abstract:

Regulation of genes in eukaryotes often involves large multi-subunit complexes to carry out histone modifications, in order to make chromatin more accessible to the transcriptional machinery. One key histone modification is histone acetylation, and one of the most well-known histone acetyltransferases (HAT) is Gcn5, which works as part of multisubunit complexes. While yeast contains the Spt-Ada-Gcn5 acetyltransferase (SAGA) and Ada2/Gcn5/Ada3 transcription activator (ADA) complexes, metazoans have a third complex: Ada2a-containing (ATAC). It was recently discovered that *Drosophila melanogaster* have two isoforms of Ada2b, a subunit of Gcn5 complexes, and that the Ada2b-PB isoform is in SAGA, while the Ada2b-PA isoform associates with Chiffon, forming a novel complex: the chiffon histone acetyltransferase (CHAT). Unlike their yeast counterpart, metazoan SAGA complexes have not been illustrated to show how each part functions as a whole and neither has CHAT. To expand on the characterization of the formation of these complexes in *Drosophila*, the interactions between different proteins that comprise each complex were tested. A Yeast 2-Hybrid (Y2H) assay was used to test the interactions between the different domains of Spt7 with other SAGA-specific subunits: Spt3, Taf10b, Sf3b3 and Sf3b5, as well as the interactions between the regions of the Ada2b isoforms with Spt7. The results from these two Y2H assays will provide a better understanding of the interactions that drive the separate formations and aid in the eventual illustration of these two complexes.

*Principal Investigator:*

*Vikki Weake, Department of Biochemistry*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **R-loops and DNA Damage in Aging Photoreceptor Neurons**

Author:

Alyssa N. Easston, Purdue University

Hana Hall, Purdue University

Vikki Weake, Purdue University

Abstract:

While it is established that aging increases susceptibility to ocular disease, the biological mechanisms are not fully understood. This study explores the possibility that harmful R-loop (DNA:RNA hybrid structure) accumulation as a result of aging predisposes cells to DNA damage, epigenetic dysregulation, and neurodegeneration. Unscheduled R-loops can have detrimental effects on genome stability and cell survival, as they can block transcription and cause double-stranded breaks (DSBs). Here, we examined R-loop levels and DNA damage levels in aged *Drosophila melanogaster* using DNA dot blots and histone western blots, respectively. Preliminary data suggest that there may be a correlation between age and global R-loop levels, but not global DSB levels in *Drosophila* heads. Now that we have identified a strong signal for R-loops in photoreceptor nuclei, we will repeat the previous experiment with photoreceptor nuclei rather than heads. Beyond this global analysis, genome-wide mapping may reveal trends in R-loop and DNA damage levels and location that are not visible on a global scale. To map localization of R-loops in aged *Drosophila* genome, we will use enzymatically dead human RNase H1 (D210N) mutant expressed specifically in photoreceptor cells using the QF-QUAS systems. We expect that old *Drosophila* photoreceptor nuclei will have higher levels of R-loops and DNA damage than young; this would suggest that unscheduled R-loop formation plays a significant role in neuronal aging.

*Principal Investigator:*

*Vikki Weake, Department of Biochemistry*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

**Marine Renewable Energy: Aligning the Technology, Geography, and Markets**

Author:

Sean P. Murphy, Purdue University

Abhishek Ajmani, Purdue University

Ananya B. Sheth, Purdue University

Dr. Joseph V. Sinfield, Purdue University

Abstract:

The U.S. Department of Energy (DoE) has long recognized the potential for the oceans to provide a sustainable source of energy for society at great scale. However, progress toward this energy ideal has waned due to the technical challenges of effectively harnessing the power of the seas, the community engagement needed to place systems in use, and the financial risks of this endeavor. In this work, through partnerships with the National Renewable Energy Laboratory (NREL), Pacific Northwest National Laboratory (PNNL), and the DoE's Water Power Technologies Office (WPTO), methods of innovation science have been applied to help highlight paths to the development of a sustainable Blue Economy. Specifically, a pattern associated with the successful development of high-impact innovations – termed enabling innovation – has been applied to highlight intersections of purpose and context that may be particularly amenable to adopt marine renewable energy (MRE). Identification of these opportunities has been pursued by combining existing perspectives on ocean conditions along U.S. coastlines, with geo-spatial views of MRE commercial activity, potential application markets, and community amenability to renewable energy projects, yielding a visualization of zones along the coast that likely offer the highest opportunity for marine development. Preliminary findings suggest significant potential for MRE development along the north-west coast, southern Georgia, and North Carolina, with additional, albeit smaller scale opportunity, along the coasts of Maine and Texas.

*Principal Investigator:*

*Joe Sinfield, Lyles School of Civil Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

**Development of a Riverine Energy Harvesting Device: Characterization of Wabash River in Lafayette as a Test Site**

Author:

Zack Zhang, Purdue University

Yijie Wang, Purdue University

Jun Chen, Purdue University

Abstract:

In recent years, there has been a large focus on improving and innovating methods to harness renewable energy. The widespread nature of rivers across the U.S. provides an opportunity to utilize the fast-flowing water current for hydrokinetic electricity generation. The minimal environmental impact and user maintenance regarding hydropower are highly preferable to conventional energy sources. Our research team is partnered with the U.S. Department of Energy (DOE) with the task to design, build, and implement a modular river current energy converter. Before the prototype phase of the device, extensive bathymetric surveying and research on the proposed region of deployment were conducted. The local Wabash River was surveyed remotely using data collected from prior research in the region. Various software allowed visualization of the findings, with primary results including meshgrid surfaces of the riverbed and heat maps indicating average water velocity and water depth. A notable location on the river with exceptional characteristics to house a test-turbine was found. The results of this study highly suggest the suitability of the Wabash River as a test site for our device. Moreover, the recommended location derived from this study has a high probability of being selected as the prototype test site.

*Principal Investigator:*

*Jun Chen, School of Mechanical Engineering*

## **Wind Energy Production and Resource Optimization**

Author:

Abigayle Elaine Moser, Iowa State University

Diego Siguenza, Purdue University

Ali Doosttalab, Purdue University

Luciano Castillo, Purdue University

Abstract:

Power transmission across vast expanses remains a major barrier in providing energy security to underserved regions. Energy isolation remains a challenge for underserved communities. The renewable energy sector has grown substantially in the past decades in terms of industrial expansion and natural resource utilization. Microgrid systems integrating wind, solar, and water are a unique solution to solving imbalances and connectivity in hard to reach areas. This study seeks to outline a framework for resource characterization and subsequent wind farm implementation in isolated regions through meteorological assessment coupled with experimental data, in Peru and Ecuador. Data from meteorological stations were used to assess the wind resource availability coupled with the economic viability of future implementation. In order to examine the effect of the complex terrains, wind tunnel experiments were performed with a 1:950 scaled-down model wind farm. Computational fluid dynamics (CFD) simulations were performed in OpenFOAM software to validate the wind tunnel experimental data with large-scale simulations. The results from the modeled wind farm over the complex terrains indicate greater wind power resources in the mountainous regions than in more flat regions.

*Principal Investigator:*

*Luciano Castillo, School of Mechanical Engineering*

**Development of a More Environmentally Sustainable Machine Tool Through Innovative Design**

Author:

Adriana M. Muñoz-Soto, University of Puerto Rico, Mayaguez Campus

Matthew Triebe, Purdue University

John Sutherland, Purdue University

Abstract:

Machine tools are an essential asset in the infrastructure of the businesses, making it essential to monitor their entire Life Cycle. These machines generate an environmental impact that negatively affects the living creatures nearby emitting large amounts of CO<sub>2</sub> through their energy consumption. There are various ways to redesign the machine to reduce the energy needed, such as light weighting, which consists of reducing the material of certain features of the machine to reduce their energy consumption. However, these design changes may increase their cost due to the greater complexity. In order to implement any design changes, we must primarily understand the features that drive the cost. By strategically researching and redesigning those key components, we will be able to accurately reduce the carbon footprint without increasing the cost dramatically. To better understand the cost drivers, a data sheet is being created with all the key features and prices of various machines, specifically milling machines. This data sheet will be analyzed using a regression model to highlight the features with greater impact. We are able to estimate that features relating to the main table, such as travel and how much weight the table is able to withhold, have the greatest influence in terms of pricing. Having most of our components direct us to the main table, light weighting such component will, in theory, not only reduce the operational cost of the machine, but also reduce carbon footprint since it requires less energy in order to run.

*Principal Investigator:*

*John Sutherland, Environmental and Ecological Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

**An Online Behavioral Experiment on Users-Agency Interactions in the Provision of a Public Service**

Author:

Mauneel M. Amin, Purdue University

Samuel Park, Purdue University

Peyman Yousefi, Purdue University

David Yu, Purdue University

Abstract:

Infrastructure is an important facility that serves people in a specific area or region. These facilities can either be public or private based on exclusivity and competitiveness. Moreover, these resources are often underinvested, exploited, or overused based on its accessibility by the provider or user. A critical challenge of this situation is to evaluate adequate service provision in the face of potential underinvestment to infrastructure by the provider. To solve problems, behavioral experiments on human subjects are performed to understand the real-life crisis. Behavioral experiments can be administered in several ways, including laboratory testing using a paper-pen experiment (in classrooms) or using online testing via various platforms like Amazon mechanical Turk (Mturk), VCWeb, etc. For the Exit-Voice experiment, we will be deploying an online human-subject experimental game on a crowdsourcing platform (e.g. Mturk) to generate a practical insight in the field. Previous studies have shown significant similarities between results collected from lab testing and online platform testing. Using the data collected, we will be testing hypotheses to gain empirical evidence about what kind of policy change is required in terms of infrastructure improvement so that both the user and provider make the best use of the resource.

*Principal Investigator:*

*David J. Yu, Lyles School of Civil Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Exploration of Trust in Automation in Complex, Safety-Critical Systems**

Author:

Jacob W. Evans, Georgia Institute of Technology

Murali Krishnan Rajasekharan Pillai, Purdue University

Ali Baigelenov, Purdue University

Dr. Paul Parsons, Purdue University

Dr. Ilias Bilonis, Purdue University

Abstract:

In 2000 the International Space Station (ISS) began housing astronauts in low-earth orbit for extended periods of time, creating a previously unfathomed sandbox for scientific exploration and discovery. The logical next step beyond earth's orbit is a habitat on an extraterrestrial body (e.g. the moon or Mars). The Resilient Extra-Terrestrial Habitats (RETH) Institute is creating a framework based on resilience to be used in future habitat designs. Any deep-space habitat would require a significant contribution from autonomous systems to assist and aid human decision-making and ensure continued habitation and mission success. These systems would not act independently, but rather would need to interact with trained human agents. Previous autonomy failures across industries highlight the need to explore an explainable relationship between the human agent and the autonomous system. By examining these failures and the literature in human factors and autonomy domains, this work will derive generalizations and identify areas for future study for RETH.

*Principal Investigator:*

*Shirley Dyke, School of Mechanical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Investigating Membrane Material Alternatives for Carbon Dioxide Removal in Space**

Author:

Gabriela Cesar, Purdue University

Debraliz Isaac Aragonés, Purdue University

David Warsinger, Purdue University

Justin Wiebel, Purdue University

Maximillian Cobos, Wabash College

Abstract:

Recently, NASA's ultimate goal has been to launch a crewed Mars mission. However, the current system used for carbon dioxide (CO<sub>2</sub>) removal in air revitalization on the International Space Station (ISS) is not equipped to handle missions beyond low-earth-orbit. The Carbon Dioxide Removal Assembly (CDRA) is a complex system that relies heavily on sorbent materials and faces challenges in reliability, energy, efficiency, and material degradation. Although the CDRA has operated well on the ISS for the past two decades, health effects from high CO<sub>2</sub> levels are amongst the most common complaints and challenges from astronauts. Recent developments in membrane technology prove to be a promising alternative to sorbent-based systems for CO<sub>2</sub>, since they can easily separate gases while being energy efficient. Maintaining high selectivity for CO<sub>2</sub> with a reasonable permeability, at such low partial pressures and in the presence of water, is among the main challenges of using membranes in this application. In this work, we have created a membrane-based model to identify, and optimize, membrane material for effective CO<sub>2</sub> separation in this application. We expect to determine a working range of critical parameters such as permeability, selectivity, membrane area and thickness for successful CO<sub>2</sub> separation. We will also be comparing thermodynamic efficiency of a membrane-based process to that of the CDRA to pinpoint areas of improvement.

*Principal Investigator:*

*David Warsinger, School of Mechanical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

**Thermal Transfer System Development of Cyber-Physical Testbed for Resilient  
Extra-Terrestrial Habitats**

Author:

Jordan Soberg, Purdue University

Yuguang Fu, Purdue University

Davide Ziviani, Purdue University

Amin Maghareh, Purdue University

Shirley Dyke, Purdue University

Abstract:

The future of human spaceflight relies on the development of habitats to house astronauts. Developing and designing these habitats will require a level of resilience that is not currently well understood. To advance knowledge in the field the Resilient Extra-Terrestrial Habitat Institute (RETHi) is taking steps to develop the technology that will enable resilient habitats outside of Earth's atmosphere. To study, demonstrate, and evaluate the technologies developed in pursuit of this mission, a multi-physics cyber-physical test-bed built upon a dome-like structure is being founded at Purdue University. The test-bed must reflect the hazardous conditions of space one of which being extreme temperatures, which is being modeled via a cooling loop on the test-bed exterior. To accurately reflect the cooling loop and its controls computationally, a model is being developed in the Simulink software using the Simscape add-on. The methods of creating this model as well as the effectiveness and accuracy of this software's modeling and controls capabilities will be highlighted in this study. This information will allow for the development of other similar physical models in the Simulink software for further space analogs.

*Principal Investigator:*

*Shirley Dyke, School of Aeronautics and Astronautics*

## **Real Time Occupancy Sensing with a Low-Cost Seat Based Temperature Array**

Author:

Aayush Mathur, Purdue University

Danielle Wagner, Purdue University

Brandon Boor, Purdue University

Abstract:

Humans are active emission sources of carbon dioxide, volatile organic compounds, and bioaerosols. Human-associated emissions can alter the composition of air inside enclosed spaces. Thus, a real-time means of detecting occupancy can be used to determine the quality of air in these spaces, and the corresponding ventilation required to maintain conditions at a safe and comfortable level. Current occupancy detection methods are both inaccurate and wholly unable to determine spatial distributions of occupants. This study aims to develop and evaluate a new means of detecting spatiotemporal seated occupancy patterns in an open-plan office in real time using low-cost Arduino-based temperature sensors. Arduino microcontrollers were coupled with nRF24l01 radio transmitters and K-type thermocouples to develop a low-cost temperature sensor array. These sensors were mounted to chairs, and each chair's surface temperature was transmitted to a receiver microcontroller in real time. The seated occupancy was calculated using two different algorithms, the Peak Temperature Algorithm, and the Delayed Occupancy Algorithm. The Peak Temperature Algorithm calculated occupancy in real time but suffered a delays ranging from 5-15 seconds. The Delayed Occupancy Algorithm calculated occupancy with a 1-minute delay and had errors of 3-5 seconds. This study aims to expand the sensor array, and use it to develop a apical map of seated occupants. This will then be integrated in the Living Laboratories at Purdue University's Herrick Laboratories. The effectiveness of the sensor array will be evaluated against a manual count of actual seated occupancy.

*Principal Investigator:*

*Brandon Boor, Lyles School of Civil Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

**More Olefins: Oxidative Dehydrogenation of Ethane  
in Shale Gas to Ethylene**

Author:

Cristian Oviedo, University of Houston

Zewei Chen, Purdue University

Rakesh Agrawal, Purdue University

Abstract:

In the U.S. the shale gas revolution has resulted in large amounts of shale gas, primarily composed of methane and ethane, to enter the market. Shale gas in remote areas of the U.S. are currently being handled in low value ways such as being flared, re-injected into drilling-wells, and being sold at fuel value prices when it could be used to produce high value olefins such as ethylene and propylene. The demand for these products continues to grow. However the current technology for producing these products is steam cracking, an energy intensive, equipment heavy, and high CO<sub>2</sub> emitting process. To address the growing demand for high olefins and limitations of steam cracking, this study investigates and incorporates existing oxidative dehydrogenation technology into process flow diagrams on a systems level to present a viable alternative to steam cracking. Aspen Plus will be used to create these process flow diagrams, and experimental oxidative dehydrogenation catalytic data will be used to design the chemical reactor. The oligomerization reactor, used to convert compounds like ethylene and propylene to higher weight olefins will be specified downstream. Furthermore, heat integration will be incorporated to maximize energy efficiency and recycle streams will be used to minimize product losses. The results of this study will be used to propose a viable alternative to steam cracking in order to address the growing the demand for high value olefins.

*Principal Investigator:*

*Rakesh Agrawal, Davidson School of Chemical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Consequences of Bronsted Acid Site Proximity and Location in H-MFI Zeolites for Propene Dimerization**

Author:

Lauren Kilburn, University of Florida

Elizabeth Bickel, Purdue University

Mykela Deluca, University of Florida

David Hibbitts, University of Florida

Rajamani Gounder, Purdue University

Abstract:

Shale gas feedstocks contain propane, which can be dehydrogenated to propene and subsequently oligomerized to form transportation fuel-range molecules. Bronsted acidic zeolites can be synthesized with different active site and structural properties, which affects oligomerization rates and product distributions. Zeolite frameworks are composed of silicon tetrahedrally coordinated to oxygen; substitution of Al for framework Si generates a negative lattice charge, which compensates an acid site (H<sup>+</sup>). Al can be substituted in MFI frameworks at 12 crystallographically unique lattice positions (T-sites) with corresponding acid sites oriented in straight and sinusoidal channels (~0.5 nm diameter) or intersections (~0.7 nm diameter). Propene oligomerization rates on MFI have been previously reported to increase with proximal Al content, attributed to steric constraints imposed by proximal adsorbates that facilitate product desorption by destabilizing adsorbed alkyls. This study uses density functional theory (DFT) to calculate relative energies for surface-bound propyl at each T-site in MFI, and activation barriers for propene dimerization at representative isolated and proximal sites. Differences in local Al coordination have a smaller influence on the range of 1-propyl and 2-propyl adsorbate energies (19 kJ/mol and 27 kJ/mol), than differences among O-sites (158 kJ/mol and 136 kJ/mol), because adsorbates bound to different O atoms are confined within different voids. The presence of proximal 2-propyl adsorbates and physisorbed propene increases intrinsic dimerization barriers by 40 kJ/mol and 23 kJ/mol, respectively, suggesting that the extent to which proximal sites influence oligomerization rates depends on the identity of the proximal adsorbate.

*Principal Investigator:*

*Raj Gounder, Davidson School of Chemical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Shale Gas to Oil: Kinetic Model for Oligomerization Reactor**

Author:

Dorinda Y. Ntim, Prairie View A&M University

Zewei Chen, Purdue University

Rakesh Agrawal, Purdue University

Abstract:

Looking at the current state of the energy industry, there seems to be a gradual shift from the use of coal, oil shale and other fossil fuels to the use of renewable sources of energy such as wind and solar energy. In order to bridge the gap between the present dependence on fossil fuels and the transitioning to the future, the energy sector has resorted to using bridge fuels (shale gas).

Converting shale gas to usable oil involves the use of several processes. Since shale gas is mostly composed of lower count alkanes like methane, ethane and propane, the best way to reach the goal of producing these liquid fuels with higher carbon numbers is to produce it by repeating the lower count hydrocarbon chains units through a process called oligomerization which is the heart of the process. This process aids in producing higher carbon number liquid fuels and to reach this goal, kinetic models are being investigated to determine the product distribution from the oligomerization process

After the feed is obtained from a dehydrogenation process, the main component that is oligomerized is ethylene and through the process, heavier carbon chains are formed. These heavier chains are the liquid fuels used in everyday life such as diesel, gasoline and lubricating oils.

The Anderson-Flory-Schulz distribution is analyzed. Using this kinetic model, the product distribution was then determined.

It was observed by the end that, the higher the chain growth probability factor which is dependent on the chosen catalyst, the better the yield for the heavier hydrocarbon liquids.

*Principal Investigator:*

*Rakesh Agrawal, Davidson School of Chemical Engineering*

## **Sensing and Measurement for Controlled Nucleation in Lyophilization**

Author:

Siyue Shen, Purdue University

Andrew Strongrich, Purdue University

Alina Alexeenko, Purdue University

Abstract:

Lyophilization is a technique used for the stabilization of otherwise unstable productions by removing the water from them at low temperatures and pressures. Lyophilization is advantageous in extending shelf lives of pharmaceuticals and foods without damage their active contents, while the prolonged process is the major disadvantage. In modern aseptic cGMP manufacturing environments the nucleation event is homogeneous in nature, often taking hours or days for the entire batch to freeze. The reason why controlled nucleation has gained so much attention is that the whole batch of vials would nucleate. Thus, freezing time for entire batch would reduce remarkably. One of the methods for controlled nucleation is called rapid depressurization, but performing such control need accurate real-time pressure and temperature data inside vials. Developing a sensor, which can take temperature and pressure measurements inside the vials during the process, helps us to analyze the relationship between temperature/pressure and the nucleation time. Also, it is important to have a control portal for the sensor so that it is possible to visualize and record the real-time data easily during lyophilization. Thus, a web application for data visualization would be favorable. On the developed web page, users can visualize the temperature and pressure data as well as performing data recording for selected and enabled devices. The web application runs without crashing. By using the specialized sensor, it is possible to read and record real-time temperature and ambient pressure data in the individual vials. Nucleation is induced uniformly corresponding to the measured pressure drop within the vial headspace due to the adiabatic depressurization.

*Principal Investigator:*

*Alina Alexeenko, Davidson School of Chemical Engineering*

**Progress towards 20% Efficient Flexible Perovskite Solar Cells**

Author:

Yiyuan (Melody) Zhang, Purdue University

Blake Flnkenauer, Purdue University

Letian Dou, Purdue University

Abstract:

Halide perovskites have been considered excellent materials for solar cells because of their long charge carrier lifetimes, high absorption coefficient, defect tolerance, and low-cost fabrications. These properties further allow the fabrication of thin flexible solar cells, which are portable, easier to install, and lower in the fabrication cost compared to the rigid devices. However, traditionally high-performance perovskite solar cells require the use of rigid transition metal oxide. In addition, these materials have different thermal expansion coefficients, which lead to large stresses in the perovskite thin film. Meanwhile, the substrate must be kept flat during fabrication to coat uniform films. To increase the device flexibility, semiconducting polymers and small organic molecules can be used as electrodes and transport layers. However, these materials require sensitive processing and doping to achieve uniform electronic properties. In this work, we use a PET/ITO/PTAA/perovskite/PC61BM/BCP/Ag architecture as a starting point towards an ultra-flexible high-performance perovskite solar cell. We investigate modifying layer thickness, layer interfaces, doping of PTAA, and annealing time for each layer. To assist the analysis of data output from the solar simulator, we developed a code that inputs raw solar simulator data and outputs current-voltage plots with key device parameters for each measurement all together. With these advancements, we expect to quickly improve the flexible device performances and develop a 20% efficient flexible perovskite solar cell. This project provides valuable insight to the study of flexible solar cells.

*Principal Investigator:*

*Letian Dou, Davidson School of Chemical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

**Examining fatigue damage mechanisms in carbon fiber reinforced composite laminates through high resolution X-ray micro computed tomography**

Author:

Javi Solano, University of Houston

Alejandra Ortiz-Morales, Purdue University

Imad Hanhan, Purdue University

(Dr.) Michael Sangid, Purdue University

Abstract:

In aircraft load bearing structures, carbon fiber reinforced polymer (CFRPs) composites have seen increased use due to their lightweight and high strength as compared to traditional titanium and aluminum alloys. The usage of laminate composites into aircraft structures solicits the introduction of new damage mechanisms. Crack growth in such laminate composites is comprised of a complex interaction between microstructural damage mechanisms, which are events that are observed as inter-laminar matrix cracking (delamination), intralaminar matrix cracking, fiber breakage, and fiber-matrix debonding. Although the presence of specific mechanisms has been established, an understanding of the interaction between mechanisms throughout crack growth in CFRPs is necessary to produce optimal damage tolerant designs and reliable predictions for the slow crack growth behavior of structures. Therefore, towards a better understanding of this interaction, a T650/5320 laminate composite with two distinct lay-ups ([+45]6 and [+45/-45/+45]s) was studied under cyclic loading. The local microstructure and the progression of damage was tracked via in-situ synchrotron X-ray micro-computed tomography ( $\mu$ -CT) in order to identify the individual contributions of delamination and intralaminar matrix cracking to the overall crack profile.

*Principal Investigator:*

*Michael Sangid, School of Aeronautics and Astronautics*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Mathematical Modeling of the Anionic Diffusion in Halide Perovskites**

Author:

Alan Pistone, Purdue University

Akriti , Purdue University

Letian Dou, Purdue University

Abstract:

Halide perovskites are novel semiconductor materials that have been shown to have great potential applications in solar panels. Perovskite based solar panels can be made at a much lower cost compared to traditional solar panels while boasting a high efficiency. As an emerging technology, a lot can be explored with the unique properties of these halide perovskites, beyond their solar applications. A halide perovskite crystal structure is generally of the form  $ABX_3$ , where A is an organic or inorganic cation, B is a heavy metal cation, and X is a halogen. Though perovskites have great potential in optoelectronic applications, their commercialization is held back in part due to their inherent instability. Part of this instability stems from the tendency of the halogen anions to diffuse and move around the soft lattice crystal structure of the perovskite. Researchers have designed heterostructure platform to study the halide diffusion process in perovskites. However, the calculations required to mathematically model this phenomenon are cumbersome and can take up hours of research time. In order to streamline the calculation process, we have written several user defined functions in MATLAB to calculate the diffusion coefficient in a few minutes. The codes require minimal user input and is planned to be extended for use in different types of heterostructure platforms. Here, I have successfully utilized the code for calculating bromide-iodide diffusion coefficient in two-dimensional halide perovskite vertical heterostructure.

*Principal Investigator:*

*Letian Dou, Davidson School of Chemical Engineering*

**Discussion Category:** SURF – Summer Undergraduate Research Fellowship

## **Thermodynamic Modeling of Oxidation in Refractory Complex Concentrated Alloys**

Author:

Haydn E. Schroader, Purdue University

Pilsun Yoo, Purdue University

Saswat Mishra, Purdue University

Alejandro Strachan, Purdue University

Michael Titus, Purdue University

Abstract:

Traditional refractory alloys, which comprise a mixture of metals exhibiting melting temperatures above 2000 °C, are often used in state-of-the-art, high temperature technologies such as rocket engines. However, their use is severely limited due to their poor resistance to environmental degradation resulting from reactions with oxygen and nitrogen at elevated temperatures. Recent work has suggested that an emerging class of alloys, denoted as refractory complex concentrated alloys (RCCAs), may exhibit significant improvement in environmental degradation resistance. RCCAs are encompassed by complex concentrated alloys (CCAs), a novel class of materials that lack a single principal component. Due to the nearly limitless combinations of elements and compositions possible in RCCAs, properties of such compounds remain largely unexplored. Thus, this research project aims to provide a method of rapid modeling for the layering of oxides in RCCAs using thermodynamic principles. The model utilizes the Materials Project density functional theory database to calculate grand potentials, which will in turn be used to determine equilibrium phases and compositions. The user-interface is a Jupyter notebook, which calls methods from Python scripts. The model has been validated against phase diagrams in the Materials Project database and verified against experimental results from pure metals, and predictions of oxide formation in select alloys agree well with elevated temperature oxidation testing results. This model provides a novel and rapid method of predicting oxide layering in RCCAs and can be used to guide future RCCA design and development.

*Principal Investigator:*

*Michael S Titus, School of Materials Engineering*

**Discussion Category:** VIP - Vertically Integrated Projects

## **Crowds Detect and Quantify Biased Attributes in Synthetic Face Dataset**

*Mathematical/Computation Sciences*

Author:

Tianhui Chen, Purdue University

Philip Archuleta, Purdue University

Esteban Gorostiaga, Purdue University

Gore Kao, Purdue University

Anirudh Vegesana, Purdue University

Kaiwen Yu, Purdue University

Moya Zhu, Purdue University

Weiyang Hu, Purdue University

Abstract:

The results of computer vision systems may be inaccurate and untrustworthy, stemming from the use of a training image dataset with sampling bias that is unrepresentative of the reality. Bias detection and reduction before model development are thus essential for a “fair vision”. The previous study of our group identified existing bias within an image dataset by leveraging the power of crowdsourcing. Inspired by studies showing that bias in face datasets can be reduced by synthetic data, we are now aiming to explore the possibility of combating dataset bias using images produced by generative neural networks. Currently, we are examining various types of existing Generative Adversarial Networks (GAN) models. A three-step crowdsourcing workflow, taking human vision into account, is developed to analyze and evaluate the results of GANs on creating training face images. Crowd workers are expected to produce a list of potentially biased features they observed in the given image dataset. We are also deploying LIME (short for Local Interpretable Model-agnostic Explanations), an explainable AI (XAI), as ground truth. LIME indicates which parts of the image contribute to the score of evaluation metrics, providing an explanation. Combining these two approaches, our refined network examines system can be applied to real-world model developments, assisting researchers and scientists in establishing fairness and trustworthiness in computer vision.

*Research Mentor:*

*Yung-Hsiang Lu, Purdue University*

**Discussion Category:** VIP - Vertically Integrated Projects

**Disinfecting robot platform software design**

*Innovative Technology/Entrepreneurship/Design*

Author:

Lin Gan, Purdue University

Hojung Ryoo, Purdue University

Abstract:

With the rapidly increasing cases of COVID-19 infection, cleaning viruses in public places became essential. To be effective in addressing medical emergencies, as considering its effect, we are designing a disinfection robot to achieve better and safer zone in public facilities as well as Purdue University. The fundamental part of building a disinfecting robot is its platform. Our part of the project focuses software design that optimize its time and energy use by coverage path planning, while generate maps to help the robot encounter static and dynamic obstacles. In this project we are testing and designing the robot by its specification, including power requirements and UV lamps' wavelength. Optimization will be held to extend its running time to effectively clean the virus. We also come up with assumptions that generating maps for our robot will be using either camera or additional sensor. But we can also utilize Lidar simultaneously while Lidar operates for calculating distance from walls and obstacles. The assumption we made right now is the occupancy grid maps. The algorithm is using the present status to predict the future location and moving estimation. We will also use similar concepts to design the coverage path planning and apply on programming. From this technology, we will be able to utilize this robot to many other places that requires disinfection and prevent human from viruses.

*Research Mentor:*

*Mythra Balakuntala, Purdue University*

**Discussion Category:** VIP - Vertically Integrated Projects

**COVID-19 on surfaces**

*Innovative Technology/Entrepreneurship/Design*

Author:

Ana McArdle, Purdue University

Abstract:

Problem statement: to create hydrophobic surfaces that can be attached to commonly touched areas in schools, hospitals, and other busy areas and will quickly inactivate COVID. The effectiveness of nano porous coatings and soapy residue on surfaces is currently being researched. Effectiveness will be measured with the time it takes for the virus to be inactivated, with how durable the coating is, and with how affordable and practical it will be to apply the coating to a large amount of surfaces.

*Research Mentor:*

*Tanya Purwar, Purdue University*

*Luciano Castillo, Purdue University*

**Discussion Category:** VIP - Vertically Integrated Projects

**Analyzing Worldwide Social Distancing through Large-Scale Computer Vision**

*Social Sciences/Humanities/Education*

Author:

Mohammed Metwaly, Purdue University

Minghao Xue, Purdue University

Abstract:

Abstract withdrawn.

*Research Mentor:*

*Yung-Hsiang Lu, Purdue University*

*George Thiruvathukal, Loyola University Chicago*

*Wei Zakharov, Purdue University*

**Discussion Category:** VIP - Vertically Integrated Projects

## **Automated Behavioral Observations in a Multi-Camera Network**

*Innovative Technology/Entrepreneurship/Design*

Author:

Moiz Rasheed, Purdue University

Siddhartha Kumar, Purdue University

Apoorva Gupta, Purdue University

Colin Witt, Purdue University

Darrell Dai, Purdue University

Russell Kim, Purdue University

Abstract:

Behavioral observations needed to develop accurate human agents in pedestrian simulations is a time consuming and error prone task. Observers must spend many hours tediously tracking the movements of many people in an open space, many of which fall through the cracks as a person can only focus on one thing at a time. This work aims to leverage multi-camera networks to automate this task and capture more complete data on the actions of people within an area. The system consists of two parts: a re-identification (re-id) algorithm and a mapping algorithm. The re-id system is especially tricky since the nature of our problem is inherently open world, where the probe person to ID may not have been seen previously. We alleviate this problem by manually defining known entrances and capturing people as they walk in. Mapping is done by known methods of homography matrices onto a floorplan of the area or integrated into openstreet map data. Datasets were generated in outdoor and indoor spaces to evaluate our methods. The success of the system was determined visually.

*Research Mentor:*

*David Barbarash, Purdue University*

*Yung-Hsiang Lu, Purdue University*

**Discussion Category:** VIP - Vertically Integrated Projects

## **Automated Image Processing in Forest Inventory Works Faster and Better than Humans**

*Innovative Technology/Entrepreneurship/Design*

Author:

Yezhi (Andrew) Shen, Purdue University

Nick Eliopoulos, Purdue University

David Jarufe, Purdue University

YiFang Hsiung, Purdue University

Shreya Misra, Purdue University

Shiqi Wang, Purdue University

Abstract:

Forest inventory analysis is time-consuming and expensive. Recent research involving photogrammetry promises to reduce the cost of inventory analysis. State-of-the-art solutions involving the use of stereo photogrammetry have the advantage of being mobile, relatively low-cost, and require modest expertise. Although published photogrammetry methods require substantial data acquisition time, our aim was to minimize this time while obtaining highly accurate diameter estimates and in-forest positioning. In this study, a stereo camera was carried through a plot to concurrently record video footage and generated a point cloud for all measured trees. Our proposed algorithm identifies a tree and measures its diameter at breast height from the recorded footage. It also allows a tree to be virtually tagged with its information, which enables the relocalization of any measured tree inside a forest plot. Video images for the trees were recorded and saved as rosbag .BAG files, a format that allows the generation of point clouds. Footage acquisition time, diameter at breast height root mean square error, GPS coordinates, and mean absolute error were used as comparison metrics with other methods. By walking 69.2 meters through a plot, a 67.99 meter wide virtual map was obtained, giving an accuracy of 98.25% when compared to real world GPS measurements. Moreover, at one meter, three meters, and five meters from the trunk our diameter at breast height RMSE's were 1.28 cm, 1.47 cm, and 2.57 cm respectively.

*Research Mentor:*

*Keith Woeste, Purdue University*

*Guofan Shao, Purdue University*

**Discussion Category:** VIP - Vertically Integrated Projects

## **Quantum Transport Simulator**

*Mathematical/Computation Sciences*

Author:

Kyeonghoon Son, Purdue University

Abstract:

On account of the scientific enhancements in the fields of semiconductor, the size of transistor has been scaled down to few nanometers. Due to quantum effects, semi-classical transport theory no longer describes the behaviors of carriers. It is necessary to build a quantum transport simulator with a user-friendly graphical user interface (GUI) to easily understand the operating principles of nano-transistors. The purpose of our research is to build and upgrade the simulator that will offer a straightforward way for people to design their own nanowire transistors with different types and investigate the underlying physics. The simulator will be enhanced by constructing a new device structure which will enable the circular nanowire. This improvement will let the users to run the simulator with not only the rectangular nanowire but also with the circular nanowire.

*Research Mentor:*

*Gerhard Klimeck, Purdue University*

*Han-Wei Hsiao, Purdue University*

**Discussion Category:** VIP - Vertically Integrated Projects

**Purdue Solar Sail Team**

*Innovative Technology/Entrepreneurship/Design*

Author:

Naveen Vivek, Purdue University

Abstract:

Abstract withdrawn.

*Research Mentor:*

*Yung-Hsiang Lu, Purdue University*

*Alina Alexeenko, Purdue University*

*Anthony Cofer, Purdue University*

**Discussion Category:** VIP - Vertically Integrated Projects

**Disinfecting Robotics --- Covid-19 Response, Biosensor subteam**

*Innovative Technology/Entrepreneurship/Design*

Author:

Yi Xie, Purdue University

Abstract:

In response to the hazards of covid19, a Disinfecting Robotics team aim to design a robot that utilize network biosensors and UV to quickly sterilize in public places and reduce people's infection by the coronavirus. This environmental biosensor sub-team mainly focused on design a feasible biosensor that can detect coronavirus in the air in the shortest time and send feedback to the robot. Raman Spectroscopy and Bioassays/microfluidic instrumentation were two incredibly promising and developments in both fields of microfluidics and spectroscopy providing a fairly clear outline to rapid detection and subsequent action. The goal was to incorporate biosensing into the Bernoulli section. By comparing to droplet impingement methods, dual cyclone separators, and selective porous membranes for isolating droplets, this team used a Button Sampler filtration as it moves through the Bernoulli section in relative shortest time and low cost. This team continues working on selecting the best method to design the biosensor to filtrate and detect the coronavirus.

*Research Mentor:*

*Moser Abigayle, Purdue University*

**Discussion Category:** College of Education

## **Finding Your Path: An Undecided Student Program's Effect on Academic Success and Decisions**

*Social Sciences/Humanities/Education*

Author:

Joseph Ching, Purdue University

Abstract:

More than 70% of Purdue undergraduates switch majors during their college career. Previous studies suggest that academic and career indecisiveness is associated with lower academic performance and persistence. The Exploratory Studies program at Purdue was designed to address this issue by helping students transition into a major through academic and career planning coursework and one-on-one advising. The study investigates the Exploratory Studies Program's effect on GPAs, graduation rates, and major switching behavior. Propensity score matching was used to control for differences in demographic and academic backgrounds between program and non-program participants who switched majors across colleges. In this retrospective study, six cohorts (Fall 2008 to Fall 2013 beginners) were analyzed over six years. After propensity score matching, Exploratory Studies students had slightly higher GPAs (2.97/4.00) after choosing majors compared to their matched peers (2.95/4.00). Program and non-program participants had similar 4-, 5-, and 6-year graduation rates. However, 46% of Exploratory Studies students switched majors more than once and at greater rates (38%) than their counterparts. These results highlight the importance of controlling for student backgrounds as without matching, Exploratory Studies students had lower average GPAs and graduation rates. Administrators and advisers may consider developing more opportunities for students to be immersed in areas of interest to help students discover and commit to an academic path.

*Research Mentor:*

*David Nelson, Purdue University - Center for Instructional Excellence*

*Yukiko Maeda, Purdue University - College of Education*

*Yumin Zhang, Purdue University - Department of Statistics*

**Discussion Category:** College of Engineering

## **Development of a Smartphone App to Automate the Supine Pressor Test**

*Innovative Technology/Entrepreneurship/Design*

Author:

Aditi Acharya, Purdue University

Abstract:

Preeclampsia is a pregnancy complication characterized by proteinuria, hypertension, and multi-organ failure, causing approximately 76,000 maternal deaths [1] and over 250,000 neonatal premature deaths worldwide [2].

The supine pressor test (SPT) is a non-invasive diagnostic tool for predicting preeclampsia [3]. Here, we automate the SPT to aid pregnant women in assessing their risk for preeclamptic development. The automated device consists of a blood pressure cuff, an inertial measurement unit (IMU), and a smartphone app. The app was written for iOS in Swift, using the Swift for TensorFlow library to receive and process IMU data. The patient was guided through the SPT with the iOS app using images, written instructions, graphs, and alerts. Accelerometer, gyroscope, and magnetometer data from the IMU were processed through an extended Kalman filter based algorithm to track user angular body position in real time. This data was then communicated to the patient through the app using visual feedback, instructing the patient to stay within 15 degrees of the desired body position for the SPT. After each reading, the patient was prompted to enter their results from the blood pressure device into the app. These results were then relayed to a secure database and stored with the patient's encrypted User ID. The patient can then choose to share their results with their clinician. Through automation of the supine pressor test, we hope to standardize the diagnostic process, providing improved prediction of preeclamptic risk during pregnancy, and saving and improving both maternal and infant lives.

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*Research Mentor:*

*Craig Goergen, Purdue University*

*Jennifer Anderson, Purdue University*

**Discussion Category:** College of Engineering

## **Review and Comparison of Gaseous Carbon Dioxide Separating Membranes**

*Physical Sciences*

Author:

Maximilian Cobos, Wabash College

Abstract:

Membranes are an innovative technology used for selective separation of gases in a wide variety of industrial applications. Gaseous separating membranes have the potential to be used in combating climate change, flue gas purification, and even air revitalization in space exploration. Cross-comparisons of membranes are challenging because of wildly different operating conditions and varying thicknesses. The purpose of this study is to review gaseous separating membrane performance data from the literature and incorporate it into a user-friendly database. The specific focus is on gaseous carbon dioxide (CO<sub>2</sub>) separation membranes and their ability to selectively isolate CO<sub>2</sub> under varying operating conditions. The membrane types reviewed include dense, composite, mixed matrix, and multi-permselective. Data relating to the gaseous separating performance, including the operating conditions (e.g., temperature, feed pressure), permeability, permselectivity, and membrane thickness, are recorded and converted to consistent units to facilitate cross-comparison. For cases where some performance data were not reported in the literature, these values were derived from the known parameters using appropriate mass transport equations. The goal of the database is to output membrane types that yield the requisite performance specifications input by the user and compare them graphically. The database may be used to help researchers effectively isolate the best membrane for their application.

*Research Mentor:*

*Debraliz Isaac Aragonés, School of Mechanical Engineering, Purdue University*

*David E. M. Warsinger, School of Mechanical Engineering, Purdue University*

*Justin Weibel, School of Mechanical Engineering, Purdue University*

**Discussion Category:** College of Health & Human Sciences

**Insulin Disparities: Racial and Economic Impacts on the Health of African American and Latino Type 1 and 2 Diabetics**

*Social Sciences/Humanities/Education*

Author:

Mansoorah Kermani, Purdue University

Khunsha Ahmed, Purdue University

Abstract:

The purpose of this interdisciplinary study is to offer a cohesive understanding of racial disparities in insulin access in Chicago, Illinois using a literature review of studies from the fields of medicine, medical sociology, and public policy that assess socioeconomic data from different Chicago neighborhoods, racial disparities in healthcare, and patient and healthcare provider experiences with insulin access issues in order to evaluate possible solutions for addressing this disparity. In recent years, there have been large increases in the cost of insulin, leading many with diabetes to be unable to afford a necessary treatment for their ailment. The increasing costs of insulin are impacting many individuals and families across the United States, including right here in the Midwest, with disparate impacts on marginalized groups: African Americans and Latinos. This study aims to highlight the impact of racial and economic inequality on the health of type 1 and type 2 diabetics, identify the implications for people from marginalized communities in Chicago, Illinois, and propose solutions to insulin access barriers.

*Research Mentor:*

*Lindsay Weinberg, Purdue University*

**Discussion Category:** College of Liberal Arts

## **Historical analysis of social effects of Orientalis and applications to the Coronavirus**

*Social Sciences/Humanities/Education*

Author:

Hetvi Desai, Purdue University

Abstract:

When epidemics strike, they cause significant fear and panic in the hearts of the general public. Such anxiety has many devastating social and cultural consequences. The third bubonic plague epidemic, for example, began in 1855 and caused people to flee their homes due to unreasonable fears. Most people did not have an understanding of how the plague actually spread; thus, they succumbed to. The so-called Orientalis resulted in large scale discrimination against the people of Chinatown in San Francisco, California, because its residents did not realize that the lack of hygiene in the community contributed to the fast-paced spreading of the disease. The people outside of Chinatown began to harbor feelings of resentment towards this community, essentially blaming them for purposefully spreading the plague. The government and media also did not take proper actions to protect its people and the harmful effects lasted for years. With the recent spread of the coronavirus, we see similar xenophobic patterns emerging in modern society. It has been almost 120 years since the Orientalis outbreak and a lot has changed, unfortunately, our behavior in times of crisis have yet to improve. By comparing the outbreak of xenophobic behavior during the bubonic plague and now and understanding what the government and media should be doing, during the coronavirus, we can break the cycle of discrimination and take proper precautions, empowering us to take action to protect ourselves instead of hurting others.

*Research Mentor:*

*Caitlin Fendley, Purdue University*

*Wendy Kline, Purdue University*

**Discussion Category:** College of Science

## **The dependence of a freshwater mussel metapopulation on host fishes**

*Life Sciences*

Author:

Ethan Brady, Purdue University

Abstract:

Freshwater mussels (family Unionidae) are an important species in river ecosystems because they filter nutrient particles not accessible by most other organisms. However, they are highly imperiled across North America due to habitat constriction by dams, habitat degradation from erosion, and invasive species like the Zebra mussel. In addition, their life cycle is complex: adult mussels are sessile and the larvae are parasites on fishes, so a decline in fish populations also affects mussels. We model freshwater mussels for the purpose of theoretically demonstrating the importance of fish populations on mussels. Our modeling scheme is a Levins metapopulation in a spatially-structured environment of a one-dimensional sequence of patches, which represent reaches in a river. Mathematically, we consider a dynamical system of first-order ordinary differential equations in terms of variables for the probabilities of mussel occupancy on river reaches. In a limiting case of exponentially decreasing host fish occupancy, appropriate for the mussel species *Elliptio complanata* and its primary host fish the American eel *Anguilla rostrata*, we show that eel populations might extend twice as far upstream as mussel populations but at lower occupancies than required for mussel persistence. In general, the invasion criterion of the system gives a threshold of fish occupancy required for mussel persistence. Unexpectedly high host fish occupancies, possibly 30% of the river, might not be sufficient to support mussel populations. Therefore, a decline in host fishes that does not imperil the fish population might nevertheless imperil the mussel population.

*Research Mentor:*

*Henriette Jager, University of Tennessee/Oak Ridge National Laboratory*

**Discussion Category:** College of Science

## **The biodiversity of zooplankton communities between permanent and temporary ponds**

*Life Sciences*

Author:

Fabiola Fontan, University of Puerto Rico

Abstract:

Zooplankton are a key component of freshwater food webs and are indicators of ecosystem health. Changes in environmental attributes of aquatic systems, such as water quantity, clarity, temperatures, ice cover, seasonal flow regimes, external loading, and oxygen content, can all affect zooplankton. The objectives of this study were to compare species composition, biodiversity (Shannon-Weiner Index), and species richness between permanent and temporal ponds. The study sampling occurred from May 2016 to October 2018 at three ponds in Purdue Wildlife Area, Indiana; one permanent pond (West), and two ponds that dry half-way through the summer (Orange and Little). During each sampling time, the abundance of three species of zooplankton was quantified: *Daphnia* sp., *Ceriodaphnia reticulata*, and *Simocephalus serrulatus*. In each pond the dominant species was different. The results from the Shannon-Weiner Index were West Pond  $0.55 \pm 0.25$ , Orange Pond  $0.54 \pm 0.25$ , and Little Pond  $0.33 \pm 0.17$ . For richness, the results were West Pond  $2.25 \pm 0.43$ , Orange Pond  $2.78 \pm 0.42$ , and Little Pond  $2.75 \pm 0.66$ . The early findings of the study suggest that throughout the years, the same pattern in the species composition was observed. Also, the richness and Shannon-Weiner Index between the permanent and temporary ponds were not significantly different. Results from this study add to the understanding of zooplankton community composition across permanent and temporary habitats. Likewise, this study presents data that could help further studies of biodiversity and richness of zooplankton.

Keywords: zooplankton, biodiversity, richness, temporary ponds, permanent ponds, species composition

*Research Mentor:*

*Catherine Searle, Purdue University*



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