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PURDUE SUMMER UNDERGRADUATE RESEARCH SYMPOSIUM

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West Lafayette, Indiana

Size Effect on Structural Strength of LEGO Beams

Author(s):

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Abstract:

LEGOs are one of the most popular toys and are known to be useful as instructional tools in STEM education. In this work we used LEGO structures to demonstrate the energetic size effect on structural strength.

Fracture experiments were performed using 3-point bend beams built of 2 X 4 LEGO blocks in a periodic staggered arrangement. LEGO wheels were used as rollers on either ends of the specimens which were weight compensated. Specimens were loaded by hanging weights at their midspan and the maximum sustained load was recorded. Specimens with a built-in defect of half specimen height were considered. Beam height was varied from two to 32 LEGO blocks while keeping the in-plane aspect ratio constant. Thickness was kept constant at one LEGO block. Slow-motion videos were captured to determine how the fracture originated and propagated through the specimen. Flexural stress was calculated based on nominal specimen dimensions and fracture toughness was calculated following ASTM E-399 standard.

The results demonstrate that LEGO beams indeed exhibit a size effect on strength. The dependence of strength on size is similar to that of Bažant's size effect law. Initiation of failure occurs consistently at the built-in defect. The staggered arrangement causes persistent crack branching which is more pronounced in larger specimens. Further ongoing investigations consider the effects of the initial crack length on the size effect and the fracture response.

The present work demonstrates principles of non-linear elastic fracture mechanics and highlights the importance of material microstructure in fracture response.

Mentor(s):

Siegmund Thomas, College of Engineering

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Summer Program: Mechanical Engineering Summer Research Program

Early sleep patterns in two brothers with Duplication 15q11.2-q13.1 Syndrome

Author(s):

Grace Arend,

Abstract:

Sleep problems in Duplication 15q11.2-q13.1 Syndrome (Dup15q) have been present in multiple studies and may be a contributing factor in the developmental progression and behaviors present in diagnosed children. However, previous studies are exclusively cross-sectional and do not consider some of the earliest behaviors of sleep problems in children with Dup15q Syndrome. Sleep behaviors and problems were analyzed in two children (half-brothers) with Dup15q from ages 1-3 years of age using the Children's Sleep Habits Questionnaire (CSHQ; Owens et al., 2000), the sleep problems subscale of the Child Behavior Checklist (CBCL; Achenbach et al., 2000), and actigraphy (coupled with parent-report diaries). Sleep behaviors were then compared to the Sleep Research Society (SRS) age-based recommendations (Hirshkowitz et al., 2015). Child A presented CBCL scores representing clinical and borderline sleep problems scores and consistently slept less than recommended by the SRS. Child B presented inconsistent parent-report sleep problems on the CBCL and did not present low levels of sleep (less than recommended by the SRS) until later in development. Consistent with previous literature, both of the children in this case study series developed sleep problems over the first three years. Notably, these problems were not universally present at all assessment ages but appeared to grow as children matured.

Mentor(s):

Amy Schwichtenberg, College of Health & Human Sciences

Automatic Process Synthesis using a Global Optimization Approach

Author(s):

Arsh Bhatia, College of Engineering

Abstract:

As the world pushes for more sustainable and cost-effective methods of chemical production, there is a greater need for a computational method to generate the best process flowsheet to achieve a required process. Previous work has been done either in creating such models for specific examples, like distillation separation, or in constructing superstructure based on heuristics, but few works have systematically synthesized all possible flowsheets for a general chemical process, which includes reactions, separations, etc. In this project we have created a holistic globally optimized mathematical algorithm that can generate all the possible flowsheets based on their corresponding separation-reaction networks. We developed constraints based on physical and mathematical insights to ensure the feasibility of our solutions. The algorithm is implemented in GAMS with a representative shale gas model case study.

Mentor(s):

Rakesh Agrawal, College of Engineering

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Biofidelity of canine femoral angle measurements using cardan sequences

Author(s):

Katelynn Bopp, Bethany College

Abstract:

Medial patellar luxation (MPL) is one of the most common orthopedic conditions in dogs caused predominantly by anatomical stifle abnormalities that misalign the extensor mechanism. Femoral deformities are more recently being corrected through distal femoral osteotomies however, radiographic preoperational angle measurement techniques lack reliability as they are prone to parallax error. This study will attempt to refine femoral angle measurement practices by utilizing cardan angles and associated anatomical landmarks in the 3D plane.

Three-dimensional digital models of 50 femora from 25 dogs without MPL were converted from CT scans. Each femur model was aligned to the global coordinate system based on the ½ -¼ proximal femoral long axis. Distal local coordinate systems were established based on the radiographic landmark resulting from the intercondylar notch (Blumensaat's line). The distal local coordinate system was rotated around the mediolateral axis, craniocaudal axis, and the longitudinal axis to quantify the procurvatum angle, anatomical lateral distal femoral angle (aLDFA), and anteversion angle, respectively. Three investigators (novice, intermediate, and experienced) measured these angles with the novice and experienced investigators measuring angles twice. The intra- and inter-observer intraclass correlation coefficients (ICC) were evaluated.

The mean values of the groups collective data sets were 94.7° aLDFA, 30.4° anteversion and 11.3° procurvatum. Both intra- and inter-observer ICC were greater than 0.90 demonstrating high reliability associated with angle computation in the 3D plane which holds promise for femoral deformity correction in the future.

Mentor(s):

Dr. Sun Kim Young

Summer Program: Purdue Summer Veterinary Research Scholars Program

Deep-Learning Enhanced Hospital Workload Prediction and Resource Allocation for COVID19

Author(s):

Indira Brown, College of Science

Yuvraj Mundhra, College of Science

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Abstract:

The COVID-19 pandemic amplified the issue of resource distribution among IU Health hospitals. Between five of the main IU Health hospitals- each representing a region of Indiana- there exists a significant gap in nurse allocation resulting in shortages of nurses in several locations and overabundances in others. Thus, the purpose of our project is to accurately predict the number of nurses essential in each region per day. One component of this project is the SIR model which predicts the number of COVID-19 cases each day across different counties in Indiana. The SIR model calculates this value based on the number of susceptible, infected, and recovered individuals in a specific location in addition to a varying infection rate. This estimation aids in hospital arrival predictions. The arrival and discharge predictive models are also included within the project to directly assess the number of nurses that will be needed in the hospital each day. The components of our project are combined into a single website that we created in RStudio. The integration of the website into the IU healthcare system is expected to be completed by the end of August 2021. To meet this goal, we are implementing and refining dynamic features on the website. The completion and incorporation of this website intends to properly allocate resources among IU Health hospitals to further advance the healthcare system and productivity of its employees.

Mentor(s):

Pengyi Shi, School of Management

Jonathan Helm, Indiana University

Summer Program: Discovery Park Undergraduate Research Internship Program (DURI)

Investigating water flow pathways through an artificially-drained agricultural landscape using water stable isotopes and electrical conductivity tracers

Author(s):

Adriana Brown, College of Science

Abstract:

Nutrient discharge from agricultural land management impacts surface and groundwater water quality. This is because of high rates of nutrient application and also potentially changes in hydrologic function like artificial surface drainage by tile networks. Evidence shows that waters flowing from tile drained land have higher nitrate concentrations than non-drained lands. Increased nitrogen loads upset aquatic ecosystems through eutrophication, which causes oxygen-depleted hypoxic zones. To improve water quality in aquatic ecosystems, it is critical to examine the role of agriculture and tile drains to the contribution of nitrate in waterways. In order to investigate nitrate loss pathways and soil biogeochemical processes, we identified soil matrix versus soil macropore flow from tile drain discharge. To examine water flow pathways and nitrate sources during and after a precipitation tile discharge event, we analyzed the relationships between electrical conductivity, oxygen and nitrogen stable isotopes, nitrate-nitrogen concentrations, and tile drain discharge. Here we show nitrate and stable isotope variability across an event hydrograph while inferring contributions from recent rain and waters previously sitting in the soils. Our results also identify nitrate from denitrification and the movement of macropore and matrix water during the precipitation event based on nitrate-nitrogen concentration hysteresis. Identifying the flow paths and nitrate sources in the soil provides insight into how agricultural land management systems transport nitrate in the critical zone. A better understanding of water flow pathways and nitrate transport facilitates revaluation of land management systems and further insight for minimizing hypoxic zones in bodies of water.

Mentor(s):

Lisa Welp, College of Science

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The Legality of Contact Tracing during COVID-19: Its Impact on Student Mental Health at the University Level

Author(s):

Kimberly Cahoon, School of Management

Abstract:

As COVID-19 cases rise, governments are finding new ways to systematically track its spread, but oftentimes, these trackings expose an individual's private information involuntarily. At the university level, student mental health is declining at the same time as forced contact tracing is rising. Electronic data collection, a modern advancement, does not always require, by law, an individual's knowing willingness to participate. Advocates of an opt-out electronic data collection approach believe certain tracking services are necessary to a system's function. Conversely, advocates of an opt-in data collection approach value an individual's choice to share private information with servers. By evaluating precedent and the Fourth Amendment, one can determine the legal basis of forced opt-in data collection as a requirement to attend a university. The connection between the decline in mental health and an increase in involuntary lack of student privacy leads to the conclusion that while not legally obligated, any reasonable university would supply increased mental health services. Any university that does not provide adequate mental health services, yet practices involuntary electronic data collection, does so illegally through the theory of negligence.

Mentor(s):

Cara Putman, School of Management

Psychosocial determinants of intentions to engage in sexual intercourse among Latinx migrant farmworker adolescents

Author(s):

Gustavo Cedeño, College of Health & Human Sciences

Abstract:

Each year, more than 3 million migrants and seasonal farmworkers harvest food across the United States; of which 68% are Latinos. Among Latino migrant farmworkers (LMFW), 60% travel with their minor children when searching for work. Mobility among LMFW families can impact the wellbeing of their children as it exposes these youth to stressors that can lead to risky behaviors such as early sexual debut. The purpose of this study was to identify psychosocial predictors of sexual intentions in Latinx migrant farmworker youth and identify factors that may influence sexual behavior. LMFW youth (ages 10-18) who participated in 2 Migrant Education Programs (MEP) in northern Indiana in the summer of 2016 (N = 53; 55% male; M age = 14; 85% in high school; 66% born in the U.S.; and 90% moved up to twice in the past year) completed online surveys. Specifically, this study examined youth's level of intention to engage in sexual intercourse, communication with caregivers (mothers and fathers) about sexual issues, peer competence, and inhibitory control. Descriptive and inferential statistics were analyzed. Findings suggested that on average, most adolescents reported not intending to engage in sexual intercourse. Regarding parent-child communication about sexual issues, results suggested that on average, parents "somewhat" talk with their children about having sex at this age. Of the predictors analyzed, only peer competence was significantly statistically association with intention to have sex. Overall findings suggests that socialization with peers can play an influential role youth's intention to engage in sexual behavior.

Mentor(s):

Yumary Ruiz, PhD, MPH

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Summer Program: Nexo Huila

Coring vs scrolls: Inclusion of the muscularis layer on tissue scrolls of the urinary bladder leads to inaccurate miRNA expression

Author(s):

Samuel Clark, College of Agriculture

Abstract:

Formalin fixation with paraffin embedding (FFPE) is a method used to preserve tissues. FFPE tissues can be sampled through tissue cores or scrolls. In the study of urothelial carcinomas (UC), the use of a biopsy needle to acquire cores has the advantage of sampling the targeted superficial epithelial cell layer. In contrast, tissue scrolls are collected using a microtome, which includes surrounding tissues such as the muscularis layer. While both methods allow sample collection to extract small molecules, such as miRNAs, there is a lack of literature comparing these methods. MiRNAs are non-coding RNAs responsible for gene regulation, altered in cancer. UC is the most common malignant bladder tumor in dogs and is difficult to diagnosis. This project aimed to compare miRNA expression between the FFPE collection methods in UC (n=3) and healthy bladder (n=1) from dogs to understand the effect of including tissues surrounding a lesion in scrolls. MiRNA was extracted using a commercial kit, and the expression was achieved through RT-qPCR. Cores targeting the epithelia and the muscularis layer were compared to their corresponding scrolls. MiR-214, miR-152, miR-181a, and miR-39 were differentially expressed when comparing cores with scrolls and the muscularis layer, while miR-1842 and miR-143 were not. Comparison between methods within individual samples also showed differential expression for all miRNAs. These results show that the inclusion of the muscularis layer results in misleading miRNA expression and verifies cores as a more accurate technique in miRNA extraction and expression, supporting further miRNA biomarker research.

Mentor(s):

Andrea Pires dos Santos, College of Veterinary Medicine

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Summer Program: Purdue Summer Veterinary Research Scholars Summer Program

{Propellant Management System Design for the Zero-Gravity FEMTA Thruster Experiment

Author(s):

Martin Degener, College of Engineering

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Abstract:

CubeSats are miniature satellites widely used for research in universities for their low cost. Film-evaporating MEMS Tunable Array (FEMTA) is a micro-thruster that offers a compact, low-power alternative to conventional attitude control systems. A propellant management system was designed to provide FEMTA with steady propellant flow at 20-100 kPa of back-pressure. The propellant management system inflates a silicone diaphragm by allowing a hydroflouroether (HFE) compound to evaporate, forcing water out of the tank.

The experiment was designed to be tested on a suborbital flight aboard Blue Origin's New Shepard rocket. During the 160 seconds of microgravity, the flow created by the HFE is sent through an array of sensors that characterize the flow properties. The propellant management system consists of two propellant tanks, one HFE tank, one sensor fixture, and one collection chamber. The goal of the suborbital flight experiment is to test the design and implementation of the system, ensuring that the system works in microgravity and maintains propellant back-pressure. The system has been partially tested in vacuum and will undergo vibration and load tests. Qualification testing is pending the manufacture of final flight hardware.

Mentor(s):

Steven Pugia, Graduate School

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Fourier Transform Fluorescence Recovery After Photobleaching with Diffractive Optical Elements

Author(s):

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Abstract:

Therapeutic macromolecules (such as monoclonal antibodies and mRNA constructs) have enabled the treatment of many conditions. However, broad distribution in resource-limited settings can be limited by stability within final dosage forms (COVID vaccine as an example). Stability within the final dosage form is often dictated by molecular mobility, such that characterization of the mobility of candidate formulations can provide early-stage in vitro assessments of anticipated shelf-life. Conventional "point-bleach" fluorescence recovery after photobleaching (FRAP) is a common benchtop method for measuring molecular mobility and has been demonstrated for monoclonal antibodies and protein aggregates. However, conventional FRAP has many limitations, the most prominent being that the technique is insensitive to anomalous diffusion (diffusion that deviates from Brownian diffusion), due to limitations on photobleaching power and complications from local heating. Fourier-transform FRAP (FT-FRAP) uses patterned illumination for bleaching, in which analysis of the bleach patterns in the spatial Fourier space allows high signal-to-noise (SNR) recovery for both the normal and anomalous diffusion coefficients. In this project, high throughput Fourier transform FRAP (HT-FT-FRAP) was implemented for the first time, where diffractive optical elements (DOEs) were incorporated into a commercial FRAP instrument (Formulatrix), allowing for a point-matrix line bleach pattern with analysis in the Fourier space. The HT-FT-FRAP method combined with robotic low-volume sample preparation (700 nL) was shown to measure diffusion coefficients (4,416 diffusion coefficients over 7 days) over a greater field of view (FoV) than conventional FRAP, reducing noise contributions allowing for analysis for anisotropic/anomalous diffusion.

Mentor(s):

Nita Takanti, College of Science

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Summer Program: Analytical Chemistry REU

Development of hydraulic trainer laboratory for distance learning

Author(s):

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Abstract:

Purdue University has the nation's largest academic hydraulic laboratory and a crucial role to train the best fluid power engineers that are equipped with long-term skills to succeed in their careers. Unfortunately, online students enrolled in hydraulic labs miss the opportunity to gain invaluable hands-on experience. Thus, we are building a controller for hydraulic trainers that would allow students to understand the design of hydraulic circuits and functions.

Creating the hydraulic trainer is a multistage process. This study continues the efforts of researchers from last semester, which focused on a physical attachment that connects to the in-person trainer. During the summer, researchers worked primarily on enhancing the virtual experience by building a Graphical User Interface (GUI) that displays an interactable trainer which users will conduct the labs on and collect data from during the lab. We also integrated another mode that allows professors or TAs the ability to create new labs at a distance as they see fit for their classes with different hydraulic circuits. We also researched and ordered devices (camera and microphone) to best capture lab experiments and display the valuable data on GUI. Finally, the GUI was coded in Processing (Java based coding environment) that connects the software with the hardware components of the hydraulic trainer.

While future development of the GUI will continue to optimize the fully virtual interactions with hydraulic trainers, our team hopes that this study will make hydraulic power more accessible for students of all ages, widening the reach of hydraulic power.

Mentor(s):

Pranav Mohan, Purdue, School of Mechanical Engineering, PhD Student

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Summer Program: Mechanical Engineering Summer Research Program

Semi-regular Scutoids: A Deep Dive Into the Creation of These Two-faced Geometries

Author(s):

Elona Erivona, College of Engineering

Abstract:

Research has shown that stereotomic material systems (SMS) can possess higher strength and higher toughness than their monolithic equivalents. Scutoid shapes are the most energetically efficient shape for packing which makes them particularly attractive for SMS. Thus, this research will focus on creating potential scutoid geometries that may be used in semi-regular tessellations (semi-regular scutoids). To achieve this, data on different pre-existing semi-regular tessellations was gathered. I identified semi-regular tilings of interest and attempted to create a single scutoid geometry, for each semi-regular tiling, with two different polygons for the top and bottom faces. I constructed several iterations of this semi-regular scutoid in a CAD system and assembled them to determine there was no interference or free space between scutoids and that the scutoid faces tessellated as expected. I was able to create a successful potential semi-regular scutoid and will be working to create more using the semi-regular tessellations. The scutoid will be 3D printed and tested to determine if it is truly self-interlocking and load bearing. The results of this research prove that it is possible to create scutoids using two different shapes. It may also serve as a guideline or starting point for the creation of future semi-regular scutoid geometries. These scutoids may be used in the same applications as regular scutoids although they may have the additional benefit of taking up less space making them even more efficient for packing.

Mentor(s):

Thomas Siegmund, College of Engineering

Tanner Ballance, Purdue University

Photocatalytic Inactivation Efficacy of SARS-CoV-2 in HVAC Systems

Author(s):

Andrew Freeman, College of Engineering

Abstract:

The coronavirus pandemic has emphasized a need for robust and reliable air purification systems in buildings; with that comes a need for a standardized testing methodology for air purification technologies in HVAC air circulation systems. One such method of air purification is photocatalytic oxidation (PCO), a mechanism in which a catalyst irradiated by light produces reactive molecules that degrade a wide range of pollutants, including the aerosols that carry COVID. This technology has primarily been used in aqueous applications, but there have recently been developments in air purification that have made it a promising contender to existing technologies. One of the main shortcomings in literature, however, is the lack of to-scale data, particularly in meeting realistic duct air speeds. The present work embodies three main goals. First, the literature validation of SARS-CoV-2 surrogates-- lab-safe MS2 and Phi6-- for aerosolized testing. Second, the establishment and validation of HVAC PCO test operating conditions. The primary conditions include room temperature and humidity, and duct velocities between 0.5 m/s and 2.5 m/s; measurements include pollutant degradation, pressure drop across the purification unit, irradiation of UV light, and ozone production. Third, the development of a robust test schematic procedure. A 2x2x50 foot duct in Herrick Laboratory will allow us to compare viral inactivation efficacy of standard filters, UV light, and PCO filters irradiated by UV light. Performance testing will provide insight into the efficacy of these systems in building-scale applications and allow us to make recommendations for future applications.

Mentor(s):

Sudharshan Anandan, College of Engineering

Summer Program: Discovery Park Undergraduate Research Internship Program (DURI)

VIP: System-on-Chip Extensible Technologies (SoCET)

Author(s):

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Abstract:

SoCET is a team comprised of +50 members, across 10 sub-teams, collectively working to interatively improvement a System-On-Chip (SoC), while faciliating the fabrication efforts of devices designed by collaborating ECE research groups. The Radiation Hardening sub-team is studying 3-D methods for simulating the discharge of trap charges generated by ionizing gamma rays passing through a chip. The Digital Design students are improving a memory controller and the cache's architectures, as well as integrating a power managemnet unit. The Verification team is creating Universal Verification Methodology (UVM) environments for an interrupt controller and two APB peripherals: a SPI and PWM. The Analog members are preparing for the design of a 5G transciever & reciever on a 22nm technolgy node. The PCB sub-team is creating the layout of a board which will host the team's recently fabricated AFTx05 chip, and assembling the devliered components of the AFTx04 system. The Compiler and Software sub-teams are working together to start running RUST based programs on our SoC with the longer-term aim of a being able to run a Real-Time Operating System. The Design Flow team recently succeeded in submiting the latest AFTx06 design iteration for fabrication at SkyWater, and are preparing for two sperate tapeouts, both at the 22nm technology node. The Interposer Component Interconnect (ICI) team is creating a chiplet protocol intended to improve manufacturing yield of systems leveraging an interposer. Finally, the SAFE sub-team is modeling a novel security architecture to demonstrate its' ability to mitigate both supply-chain and spectre-like attacks.

Da Vinci Robot: A tool for Surgical Robotics and Human Factors applications

Author(s):

Daniela Garcia, College of Engineering

Abstract:

The Da Vinci Research Kit (DVRK) is becoming an important tool of application in minimally invasive surgery as laparoscopic robotic operations. Using this technology can minimize patient recovery time, perform faster procedures, and reduce fatigue in surgeons. This study aims at exploring how Robotic Assistive Surgery (RAS) can improve patient outcomes and discussing the gap between when wrong procedures are caused by human error or instruments failures. The future of this technology is creating a safer environment for surgeon - patient implementing robotic surgery.

Multidisciplinary study in robotic surgery is becoming a relevant field, such as the human-robotic interaction. Automatic detection of the current task load of a surgeon in the Operating room in real time could provide helpful information, to be used in supportive systems. This can be achieved by leveraging physiological sensors and Graphical User Interface (GUI) which provides information about position, velocity and effort done by arms, and others features. It can be calibrated to do other activities, for example, the third arm of the robot can be programmed and activated based on surgeon's workload when the performed task becomes difficult due to bleeding. Environmental elements as noise, teamwork, calibration of the robot and proper tools are factors that should be considered when addressing studies related human factors and robotic surgery. Although, future studies are needed to improve surgeon's performance, some advantages of using this technology can change healthcare system by proving feedback to surgeons reducing level of stress and perform better clinical results.

Mentor(s):

Jing yang,

Field Characterization of Agriculatural Aerosols

Author(s):

Matthew Graber, College of Science

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Abstract:

Atmospheric aerosols are particles suspended in a fluid that plays a critical role in the earth's climate system through their interaction with solar radiation and clouds. Quantitative estimation of their impact on climate has continued to be challenging due to the complex nature of these interactions, and limited field observations. These particles act as nuclei for cloud formation by providing a surface for condensation of water vapor in the case of warm clouds, or deposition of ice in the case of cold clouds. The ability of an aerosol to act as a nucleus for cloud formation depends on its physical and chemical characteristics, which depend on its source.

Few field studies have previously focused on the influence of agricultural particulate emissions on clouds. The goal of this project is to characterize particles emitted from various agricultural processes, such as tilling, fertilization, harvest, etc., to explore the influence of agricultural regions on climate. The observations were made at Purdue University Agronomy Center for Research and Education, West Lafayette, IN. The size-segregated number concentrations of cloud condensation nuclei at different humidity conditions were measured using the dual column cloud condensation nuclei spectrometer. On-site observation of weather variables such as temperature, wind speed, and relative humidity was also included in the data analysis. Results from the preliminary analysis of a case study of herbicide application will be presented here. This project will continue into the fall semester until the harvest season to see how agricultural aerosols continue to have effects on cloud formation.

Mentor(s):

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Computer Vision for Forest Inventory Analysis

Author(s):

Dainong Hu, College of Engineering

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Abstract:

Forest inventory is a time consuming and labor-intensive process. In this paper, we utilized computing and camera technology to assist with 3 aspects of forest inventorying: tree species identification, straightness computation, and diameter breast height (DBH) computation. With respect to species identification, we applied a pre-trained convolutional neural network (CNN) to process a dataset containing 302 unique trees and 20 tree species. Our CNN model for species recognition is currently 72% accurate. For straightness calculation, we used depth images to evaluate the area encircled by the centerline, the middle surface line, and the line connecting the centerline's top and bottom. The area now can be steadily finded and computed given a depth image of a tree. Regarding DBH computation, we used output images from a deep convolutional segnet and surface normal analysis of depth images to identify the ground trunk intersection and determine the DBH. This model of DBH computation can currently calculate tree DBH to within approximately 10% of actual DBH, less accurate than a previous implementation.

Mentor(s):

Keith Woeste, Purdue University

Yunmei Huang, Purdue University

Summer Program: USDA Forest Inventory Analysis Hardwood Tree Improvement and Regeneration Center

Designing a Coronavirus Drug using the Online Tool Foldit

Author(s):

Carson Huber, College of Science

Abstract:

The purpose of this research was to design an anti-viral Coronavirus drug to bind to the spike proteins of SARS-Cov-2. The SARS-Cov-2 novel coronavirus that causes Covid-19 binds to the ACE2 receptor on the membrane of human cells which leads to the replication of Covid-19. By designing an antiviral protein that can bind more favorably to the spike proteins on the coronavirus molecule, we can stop the coronavirus molecule from entering the cell virally. To design this alternate binding protein, I used the online protein creation tool Foldit, made by David Baker's lab at the University of Washington. Foldit allows for the manipulation of a simulated protein using commands to change the shape, special position, and makeup of the protein. It then gives you a score based on how well your protein interacts with the binding region of the coronavirus spike, which you can compare to other players using the online database. I focused heavily on packing my protein as tight as I could into the spike protein, while making sure to maximize the number of hydrogen bonds between the two. Using this strategy, I was able to make a high scoring protein design and was ranked 32nd out of 537 people. Even though my design isn't ranked 1st, I still have the chance to get my design created in a lab. Foldit often takes some of the top scored proteins. This means that my design has a chance to be made in a lab to combat the Covid-19 pandemic.

Mentor(s):

Zahara Tehrani, Honors College

Optimization of Conductive Gap Membrane Distillation

Author(s):

Jiyoon Im, College of Engineering

Abstract:

Membrane distillation (MD) is one of the desalination processes that has been developed to obtain clean water from saline solutions. The MD uses a temperature difference across a hydrophobic liquid-blocking membrane to evaporate pure water vapor from saline solutions. This process ensures a high level of purification that cannot be achieved by other processes and has the advantage of utilizing renewable energy. Depending on how the vapor is being recovered from the MD system, different configurations of the MD process can be defined. Air gap MD (AGMD) has an air gap between the membrane and the condenser, permeate gap MD (PGMD) has permeate water filled in the air gap, and conductive gap MD (CGMD) has a conductive condenser in place of the gap.

In this study, the main goal is to increase the flux and energy efficiency of the system by using a carbon nanomaterial condenser. Usage of carbon nanomaterials in CGMD is an emerging novel study as it is extremely thermally conductive and will enhance the thermal conductivity and water production. So far, AGMD and PGMD baseline test has been conducted (without any carbon nanomaterials) to acquire inference points. Based on the validated model results, flux, GOR, and thermal efficiency were compared. In PGMD model, the flux and GOR were improved, but the thermal efficiency was decreased. The later stages of the research will focus on improving thermal efficiency by composing CGMD with added carbon nanomaterials.

Mentor(s):

David Warsinger, College of Engineering

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Hamid Fattahi Juybari, Amirkabir University of Technology

Summer Program: Mechanical Engineering Summer Research Program

An AI Game Agent to Estimate Animal Populations

Author(s):

David Kim, College of Science

Abstract:

The problem of capturing information from a given area of land/space, a goal we dub "Spatial Capture" for the purposes of this project, is a problem that has been researched by statisticians for some time. One of the problems of Spatial Capture is the estimation of animal populations. Indeed, one of the best options available for estimating animal populations, especially populations of endangered species, has been the Spatial Capture-Recapture Method. However, we do not believe sampling and then resampling is the only way to obtain information about an area of land. In this report, we lay out the exploration of the possible utility of AI methods used by scientists to play games in capturing the information of an area of land. To test this, we designed a variant of Whack-a-Mole that we named "Find How Many" that tests these methods' effectiveness in performing spatial capture. We eventually settle on using a reinforcement learning approach to playing the game by learning a policy using a simple neural network composed of one neuron.

Mentor(s):

Fan Ding, Purdue University

Optical Tag Detection to the Design of an Optical Reader

Author(s):

Luna Lugo Leal, Polytechnic Institute

Abstract:

Animal protection has been increasingly important over the years, and various organizations seek animal welfare, for example, some countries have approved the production of cage-free eggs and the rearing of animals such as laying hens, pigs, and even cows without being caged, resulting in difficulties in monitoring their health, feeding, and behavior. The general approach is to cover these problems with the communication between an optical reader and a tag (carried by each animal). The job of the optical reader will be to detect and retrieve data through LEDs placed in the tag using a new technology called Optical Frequency Identification (OFID) created by Walter Daniel Leon-Salas, Ph.D., and his team at Purdue University's TinyLab.

The objective of the research project is the design of the optical reader conformed by a Raspberry Pi 4B and a low-cost camera, the procedure is divided into three parts: first, the detection of an optical tag by means of TensorFlow for which two trainings were performed obtaining better performance in the second model; the second part corresponds to the increase of the frames per second (FPS) using the Google Coral USB accelerator and finally, the reading of each frame to obtain the information of the optical tag. The frames have been obtained by enabling the fast camera on the Raspberry Pi 4B through a graphical interface designed in Python and the reading of the frames using the average RGB through Python is still under development.

Mentor(s):

Walter Daniel Leon-Salas, Purdue University

Summer Program: Nexo Huila

Identification of the nitro functionality in known compounds by using tandem mass spectrometry

Author(s):

Kristine Maxwell, College of Science

Abstract:

Several studies have demonstrated the ability to structurally characterize different compounds via tandem mass spectrometric methods. Mass spectrometry measures the mass-to-charge ratio (m/z) of gas-phase ions derived from analytes. Atmospheric pressure chemical ionization (APCI) is one of the evaporation/ionization techniques used in mass spectrometry to transform neutral analytes in solutions into gas-phase protonated analytes, gas-phase ions. In ion trapping tandem mass spectrometry experiments, the gas-phase ions are transferred into the ion trap, isolated by ejecting all unwanted ions out, allowed to undergo diagnostic reactions, and then all reaction products are separated based on their m/z and detected. In this study, such an instrument, a linear quadrupole ion trap (LQIT), was used to develop a method for the identification of the nitro functionality, which is known to be present in potentially mutagenic drug impurities. Both monofunctional and polyfunctional analytes with nitro groups were examined to demonstrate the performance of the method.

Mentor(s):

Judy Kuan-Yu Liu, College of Science

Victoria Boulos, Purdue University

Hilkka Kenttamaa, Purdue University

Summer Program: Analytical Chemistry REU

Determining Effective Ion Temperatures and Arrhenius Parameters for Protonated Leucine-Enkephalin (YGGFL) Using DDC Kinetics

Author(s):

Monica McDaniel,

Abstract:

Thermometer ions, such as protonated leucine-enkephalin (YGGFL), have well-established dissociation kinetics derived from techniques such as blackbody infrared radiative dissociation (BIRD). They can therefore be used to study novel dissociation methods as well as the models derived to describe them. BIRD can be used to generate the highly informative Arrhenius parameters (i.e., activation energy (E_a) and log(A) values), under appropriate conditions, but such measurements are restricted to a narrow temperature range. We seek to develop a collision-based approach for measuring Arrhenius parameters for ion dissociation in tandem mass spectrometry that can be implemented on readily available quadrupole ion traps over a wider temperature range. An approach for increasing the internal energy of an ion in a quadrupole ion trap is to apply a dipolar DC (DDC) potential across opposing electrodes. However, there must be a means for correlating the amplitude of the DDC voltage to ion temperature in order to extract Arrhenius parameters from kinetics data generated by DDC. Tolmachev, et al. have described a model that relates DDC conditions to an "effective temperature", T_{eff}. We have evaluated the accuracy of this model using thermometer ions and DDC kinetics generated on a Sciex Triple TOF 5600 mass spectrometer. We found that the Tolmachev model works well for protonated YGGFL but becomes less accurate for the b4+ fragment ion of YGGFL at lower bath gas pressures and high dissociation rates. This work will lay the groundwork for our use of DDC kinetics to understand fundamental aspects of bio-ion dissociation.

Mentor(s):

Samantha Mehnert, College of Science

Joshua Fischer, Purdue University

Scott McLuckey, Purdue University

Novel COVID-19 Anti-viral Protein Design Study

Author(s):

Victoria Mier, College of Science

Abstract:

This study aims to predict the structure of a novel anti-viral protein that can be used in the treatment of COVID-19. The COVID-19 virus is able to enter into human cells by the binding of the COVID-19 surface spike proteins to the ACE2 receptor found on the outside of human cells. The idea behind this study is the novel binder protein will bind to the COVID-19 spike protein and competitively inhibit the COVID-19 virus from binding to the ACE2 receptor. The approach used to identify the structure of the novel protein was a computer game called FoldIt. FoldIt provides players with introductory puzzles that introduce the tools of the game and the protein folding science behind them. Then, players may begin working on a novel protein predicted by a computational modeling software to bind to the COVID-19 spike protein. The goal of this study was to use FoldIt tools and protein folding concepts to identify the most favorable 3D structure of the novel binder protein. Modifications that led to a more favorable 3D structure increased the score of the protein. Proteins with the highest score and stability will be synthesized in a lab and tested for binding to the spike protein for competitive inhibition. The highest level of protein stability was obtained by burying hydrophobic sidechains in the interior of the protein, aligning beta sheets in a parallel fashion, and avoiding sidechain clashes and voids. This study revealed how online protein folding software can save scientists both time and money. In future novel-protein design studies should consider the effects of hydrophobic and hydrophilic interactions, the alignment of beta sheets and the arrangement of sidechains within the protein. Additionally, future studies should evaluate the benefits of using a virtual design software to aid in the process of designing novel proteins.

Mentor(s):

Zahra Tehrani, Honors College

Organ-specific impact of PRRSV infection on the regulation of cell division in the late gestation fetus

Author(s):

Margaret Mulligan, College of Agriculture

Jocelyn Kleiman, College of Agriculture

Andrew Caldemeyer, College of Agriculture

Abstract:

Porcine reproductive and respiratory syndrome virus (PRRSV) infection during late gestation negatively affects fetal cell division. The objective of this study was to identify the organs most severely impacted following infection and evaluate the relationship between this response and fetal phenotypes. RNA was extracted from fetal tissues including heart, liver, lung, thymus, kidney, spleen, and loin muscle, all previously collected following late gestation viral challenge of pregnant gilts. Initially, gene expression for three cell cycle promoters (CDK1, CDK2, CDK4) and one inhibitor (CDKN1A) were evaluated in a previously established model of biologically extreme phenotypic subsets including gestational age matched controls (n=10), uninfected (n=10), high-viral load viable (n=10) and high-viral load meconium-stained (n=10) fetuses. An additional 90 heart and 84 kidney samples were added to evaluate expression relative to viral load and thyroid hormones (T3 & T4). There were no differences between controls and uninfected groups for any gene, demonstrating no impact of maternal infection alone. Relative to controls, high-viral load fetuses showed a significant down-regulation of at least one CDK gene in all tissues except liver, while CDKN1A was upregulated in all tissues except muscle. While some degree of disruption was identified in all tissues, heart and kidney were most severely impacted. Expression of CDKN1A was highly correlated with serum and thymic viral load as well as fetal T4, but there was no significant relationship with T3. Further research is required to determine if viral load or T4 are directly responsible for suppressed cell division in the PRRSV infected fetus.

Mentor(s):

Jonathan (Alex) Pasternak, College of Agriculture

John Harding, University of Saskatchewan

Summer Program: Molecular Agriculture Summer Institute (MASI)

Understanding Conformational Dynamics of Phospholipase C β3 and its regulation by Gβγ

Author(s):

Kennedy Outlaw, College of Science

Abstract:

Phospholipase C β (PLCβ) plays an important role in cardiovascular diseases and opioid analgesia. PLCβ catalyzes the hydrolysis of the inner membrane lipid phosphatidylinositol-4,5-bisphosphate (PIP2) to inositol-1,4,5-triphosphate (IP3) and diacylglycerol (DAG). IP3 and DAG are crucial secondary messengers that activate multiple signaling pathways and modulate gene expression to control cellular function and behavior. PLCβ is a downstream effector of G-protein coupled receptors (GPCRs) and is activated by both the Gαq and Gβγ subunits. Here we focus on PLCβ conformational dynamics and Gβγ activation. In order to investigate this, we mutated residues on PLCβ predicted to break intramolecular interactions between the PH domain and the first EF hand repeat then measured changes in PLCβ activity. We hypothesized that these mutations would alter Gβγ dependent activity of PLCβ by either decreasing the ability of PLCβ to bind to Gβγ or by altering the conformation of PLCβ such that it can interact with Gβγ more readily. Mutational analysis done in the PH-EF domain interface revealed an increase in basal activity; however, there was a loss in activity upon Gβγ activation when compared to wild type PLCβ. Currently we are characterizing more mutations to analyze the interaction between Gβγ and PLCβ. Future work will focus on solving the structure of PLCβ bound to Gβγ which will provide structural insights on conformations of PLCβ as well as regulation by Gβγ.

Mentor(s):

Isaac Fisher, College of Science

Kaushik Muralidharan, Purdue University

Angeline Lyon, Purdue University

Summer Program: Biochemistry REU

AI for Small Unit Manuever

Author(s):

Kartik Pattaswamy, College of Engineering

Fares AlQassim, College of Engineering

Suood Alshehhi, College of Engineering

Aditya Ray, College of Engineering

Shllok Gupta, College of Engineering

Aref Malek, College of Science

Alfaaz Gouse, College of Engineering

Abstract:

The main focus of this project is to assist the U.S Navy with beta testing for the challenge they are hosting on autonomous robotic systems – AI for Small Unit Maneuver (AISUM). The challenge is to build software that would allow a drone to autonomously maneuver its way through a building to allow them to access complex and congested areas. Our research aims to build an algorithm that will enable the drone to autonomously explore a building and perform object detection within it in real-time. To test our code, we are using Microsoft's Airsim as the simulation environment. The environment for initial testing contains a hospital building with objects laid throughout it. Accurately labeling objects seen by the drone is challenging and the methods for labeling are rapidly improving. Our current approach for object detection is using the YOLOv5 computer vision algorithm. We are creating our own dataset consisting of frames captured from the simulation environment and annotating these frames so that we can train our own model with this dataset that will allow it to accurately predict the objects it sees in the hospital building. Although we are focused on developing code in a simulation environment, the future of this research will be directed towards transitioning from a simulation environment to a real life drone as well as improving the object detection algorithm. Improving the YOLOv5 model in the future will involve collecting better processed data and implementing reinforcement learning for better object predictions.

Mentor(s):

Aly El Gamal, College of Engineering

Shreya Ghosh, Purdue University

Summer Program: Vertically Integrated Projects (VIP)

Design of a novel COVID-19 binder protein using the game Foldit

Author(s):

Rowan Peijs, College of Science

Abstract:

In finding effective proteins to fight against diseases, the most significant trouble results from the absence of knowing how a protein will configure itself in a 3D space. Therefore, the David Baker lab at the University of Washington has created the online citizen science game "Foldit". Here, the general population solves protein structure puzzles and receives a score on how energetically stable their design would be in real life. The highest scoring design will then be tested in the David Baker Lab on binding strength to the designated protein. For this project, my research question was "What is the most optimal 3D structure for a coronavirus binder protein?". This way, I hoped to help find effective medication against the illness that has influenced people's lives all around the globe. First, biochemical concepts were introduced and explained in intro puzzles. After this, the tools explained in the intro puzzles were provided to design your tertiary structure. What I found was that most of the energy reduction comes from the creation of hydrogen bonds, finding the ideal distance between amino acid side chains and taking note of the biochemical properties of hydrophilic and hydrophobic sidechains. While this 3D modelling provides a reasonable estimate of the given protein, this does not mean that the actual tertiary structure will look exactly like my design or that the given protein will work as a reliable blocker of the Covid-19 spike protein. Also, a lower-scoring design will not even be considered for protein production and testing.

Mentor(s):

Zahra Tehrani, Honors College

Design, synthesis and characterization of carbonic anhydrase inhibitors with potential antibacterial activity

Author(s):

German Jesid Peralta Camacho, College of Pharmacy

Abstract:

Bacterial resistance to antibiotics is a worldwide concern threatening human health and food security. Regarding clinical environments, infections caused by resistant bacteria are difficult to treat and have a high death ratio. In this context, Enterococcus bacteria and Neisseria gonorrhoeae are of special interest since they cause serious nosocomial infections and, therefore, effective treatments are needed. It has been reported that FDA approved drugs Acetazolamide (AZM) and Ethoxzolamide (EZM) have antibacterial activity against those bacteria. The objective of this work was designing, synthesizing and characterizing new AZM and EZM analogs with improved antibacterial activity and enhanced inhibition towards bacterial carbonic anhydrase enzymes. First, computational tools such as "molecular docking" were used to optimize and look for chemical modifications that can improve the activity of AZM and EZM by simulating the molecular binding between the compound and its target. Based on this information, some promissory analogs were obtained by chemical synthesis, then purified and characterized by 1H and 13C NMR, mass spectrometry and RP-HPLC. Synthesized compounds were determined to interact with carbonic anhydrase enzyme by florescence polarization assay and CO_2 hydration catalytic assay. Remarkably, it is proposed to carry microbiological assays to determine the activity of these compounds against the studied bacterial strains. At the end, it is expected to obtain some active analogs which, due to the fact of being similar to FDA approved drugs, can be promissory candidates to be accepted as antibiotics.

Mentor(s):

Daniel Flaherty, Purdue University

Summer Program: Undergraduate Research Experience Purdue - Colombia (UREP-C)

The association between parent-child relationship and communication on academic competence in Latino youth

Author(s):

Amanda Puente, College of Health & Human Sciences

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Abstract:

Of the 54 million school-aged youth in the U.S., 25% are Latino youth (1). Compared to other major ethnic groups in the U.S., Latino youth are at 7.7% greater risk of dropping out of high school (2). Low academic competence has been linked to poor academic performance due to a lack of resources and engagement (3). Studies reveal that parents can positively influence their children's academic competence by helping them with coursework or being involved in school activities. Additionally, communication among Latino parents and their children about their educational aspirations has been positively associated with youths' grade point average (4). This study examined if academic competence was correlated to parent-child relationship and communication among young Latino adolescents.

Fifteen Latino youth ages 12-15 completed an online survey that was part of a baseline data collection for Juntos, an academic success program. Descriptive and correlation analysis were completed using SPSS.

Participants were 8th grade (N = 15) youth ages 12-15 (Mage = 13.25, SD = 0.68, 43.8% male). Correlation analysis revealed a statistically significant relationship between academic competence and parent-child communication (r = 0.687, p = 0.005) and parent-child relationship (r = 0.725, p = 0.002).

Results revealed parent-child relationship and communication are positively related to academic competence which is linked to academic competence among Latino youth. Thus, building these skills among Latino parents may contribute to decreased high school dropout rates among Latino youth. To enhance academic competence among Latino, programs could provide opportunities for social skills and engagement for youth and their families.

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Mentor(s):

Yumary Ruiz, College of Health & Human Sciences

Carlyn Kimiecik, Purdue University

Summer Program: Children, Youth and Families at Risk (CYFAR)

Use of Direct Simulation Monte Carlo for measurements of FEMTA micro-thruster's exhaust characteristics

Author(s):

Daniel Qi, College of Engineering

Abstract:

There is an increasing need for a power-efficient and compact propulsion or attitude control method for small satellites. Film-Evaporation MEMS Tunable Array (FEMTA) presents itself as a promising solution as it only utilizes water to produce thrust. Furthermore, this propulsion method requires a lower power supply and is relatively small compared to its competitors. The FEMTA suborbital experiment is aimed at testing the performance of this propulsion device in microgravity. In the physical experiment, a FEMTA is fired into a cathode tube so that the exhaust can be ionized for further analysis. To further understand experimental outcomes and FEMTA's performance, a Direct Simulation Monte Carlo (DSMC) simulation is employed to measure generated thrust, pressure, temperature, and other flow characteristics by processing each simulated particles' physical state. DSMC is a probabilistic model for fluid flows; this method can be advantageous for rarefied gas simulations, such as in FEMTA's case, as traditional computational fluid dynamics methods no longer apply in non-continuum flows. The current DSMC model is able to vary experimental parameters to measure its effects on the plume characteristic. Exhaust characteristics for FEMTA thrusts between 25-120 µN and FEMTA-cathode distances between 2.5-10 mm have been studied. The model is also capable of simulating the cathode's plasma generation, ambient back pressure, and other physical phenomena. Overall, building a DSMC model of the FEMTA thruster experiment would not only help validate the experimental results, but also provide an estimation of FEMTA's performance for different experimental setups without conducting the physical test itself.

Mentor(s):

Katherine Gasaway, College of Engineering

Steven Pugia, Purdue University

Alina Alexeenko, Purdue University

Summer Program: Vertically Integrated Projects (VIP)

Autonomous Drone

Author(s):

Hongjiao Qiang, College of Engineering

Advait Mallela, College of Science

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Seejay Patel, College of Engineering

Avi Patel, College of Science

Alex Isahc, College of Engineering

David Fitzgerald, College of Engineering

Ethan Lu, College of Engineering

Abstract:

The purpose of this project is to create a competition where teams will design a fully autonomous drone that follows a ground robot throughout a set course. The drone must avoid obstacles whilst tracking the ground robot around the course. Common object tracking challenges like crossover and obstruction of target will need to be considered. This competition will facilitate the development of low-power computer vision algorithms that can be run from a drone. This will allow for more reliable autonomous piloting systems in drones that do not rely on connections to outside hardware. Competitors will be scored based on how close their drone tracks the ground robot. Scoring will be done through the use of the motion capture system in Purdue UAS Research & Test Facility. This system can track and position objects up to a millimeter of accuracy. We will design, build, and test a sample solution to this competition to serve as an example for what competitors will need to accomplish. Moving forward, our team will complete a working sample solution for this competition and have the referee system ready for accurate scoring of competitors.

Mentor(s):

Yung-hsiang Lu, College of Engineering

James Goppert, Purdue University

Summer Program: Vertically Integrated Projects (VIP)

Macroscopic Resistance Measurement Of Vanadium Dioxide During Metal Insulator Phase Transition

Author(s):

Amit Rohan Rajapurohita, College of Science

Abstract:

Vanadium Dioxide (VO_2) exhibits unique pattern formation while it undergoes a temperature-driven Metal-Insulator (MI) phase transition. We use optical microscopy techniques to image the surface of a VO_2 thin film, simultaneously measuring the macropscopic resistance. Patches of metal and insulator form while undergoing the MI phase transition and display hysteresis. We model the observed resistance by converting each pixel of the recorded images into an insulating node or a metallic node with four terminals. The resulting two-dimensional resistor grid was generated by connecting each node with its four neighbors, with equal temperature-dependent insulating resistors or saturated metallic resistors. The resistance values connecting the nodes with their four terminals were based on the temperature and macropscopic resistance measurements taken during the saturation of each phase. I used a time and memory-efficient Bond Propagation Algorithm mediated by Y-Delta/Delta-Y transformations in JAVA, which reduces the 2D resistor grid into a single equivalent resistance. Comparison between computationally simulated and experimental resistance measurements sheds light on a shortcoming of the model. The modeled resistance curve was sharper, opened later, and closed earlier than the measured resistance curve, implying intricate pattern formation beyond the microscope's resolution. Equipped with the idea of a more delicate sub-pixel structure, the grayscale intensities of each pixel are now modeled using patterns from the Random-Field Ising model. This model has the potential of capturing the entire macroscopic resistance measurements. This study would further our understanding of temperature-driven phase transition in VO_2 and open new avenues in nanoelectronics and neuromorphic computing.

Mentor(s):

Erica Carlson, College of Science

Sayan Basak, Purdue University

Robust Data Submission Pipeline For AgMIP Global Economics Modelers

Author(s):

Raziq Ramli, College of Science

Abstract:

Agricultural Model Intercomparison and Improvement Project (AgMIP) is an international effort to improve agricultural models and scientific and technological capabilities for assessing the impacts of climate variability and other driving factors on agriculture, food security, and poverty. The Global Economics (GlobalEcon) team in AgMIP conducts extensive model intercomparison to assess the agricultural effects of climate change, bioenergy policies, and socioeconomic factors. Currently, the preparation and sharing of GlobalEcon model data are done manually, which is time-consuming and error-prone. This project aims to address this problem by designing a robust data submission pipeline capable of harmonizing data from diverse modeling groups within the team. The result is a web application implemented with Jupyter Notebook and hosted on MyGeoHub that can accept, validate, and clean up model data from the GlobalEcon modelers, diagnose the data for errors, and visualize potential outliers in the data. The created tool performs data sanitization and diagnosis based on data format protocols agreed by the modeling team. It also lets individual users request a protocol update should the need arise. In addition, for protocol violations that are easy to fix, the application allows users to correct them on the go. Upon successful submission, the tool stores the uploaded data in a shared repository on MyGeoHub, which an existing data exploration tool can query and access. The creation of this feature-rich data submission tool helps the GlobalEcon team build an accessible and interoperable data repository and streamline their ensemble modeling activities.

Mentor(s):

Rob Campbell, Information Technology

Lan Zhao, ITaP Research Computing

Summer Program: Discovery Park Undergraduate Research Internship Program (DURI)

Radiation Effects on Space Solar Cells at Various Earth and Jupiter Orbital Altitudes

Author(s):

Naazneen Rana, College of Engineering

Abstract:

Solar cells are used as the primary power source for earth-orbiting satellites and as a primary/secondary source for various missions within the solar system. However, high energy particles from the sun, planetary magnetospheres, and the galaxy can impact solar cells in outer space. This can affect the performance and life expectancy of the space solar cell and associated power systems. Therefore, this study will analyze the performance of space solar cells, particularly the SolAero IMM-α, at various Earth and Jupiter circular orbits. This is done by using the Naval Research Lab Displacement Damage Dose (DDD) methodology by (1) obtaining particle fluence data and calculating the DDD of a specific orbit using SPENVIS; and (2) analyzing the solar cell's performance/degradation with the given DDD. We find that for various circular Earth orbits, the most degradation for the IMM-α occurs at Low Earth Orbits (LEO) of altitudes of approximately 3000-20000 km due to a high concentration of high-energy protons in the region. Similarly, the IMM-α undergoes the most degradation in the lower orbits of Jupiter, despite higher fluences of electrons as compared to Earth. These results reveal that with suitable shielding techniques, appropriately designed solar cells resistant to proton displacement damage can support long-term missions to Jupiter.

Mentor(s):

Muhammad Alam, College of Engineering

Peter Bermel, Purdue University

Summer Program: Discovery Park Undergraduate Research Internship Program (DURI)

Horizontal gene transfer in microbial eukaryote Prymnesium parvum

Author(s):

Olivia Riedling, College of Agriculture

Abstract:

Prymnesium parvum (Golden alga) is a toxic and invasive algal species. They cause massive deviation to fish populations in many fisheries and wildlife areas. A unique trait of P. parvum is that they are mixotrophic meaning they can utilize photosynthesis and consume prey for nutrition. They are a member of the haptophyte lineage of microbial eukaryotes. The Wisecaver lab has recently sequenced the genomes of two P. parvum strains (12B1 and UTEX2797), and we hypothesized that because P. parvum is mixotrophic the species would have genes acquired from prey by horizontal gene transfer (HGT). We performed a comparative genomic analysis consisting of P. parvum and seven other haptophyte genomes to analyze HGT in P. parvum. There was a large amount variation in gene content across all the haptophyte genomes. An ancestral gene content analysis revealed that 9,053 genes families were gained in P. parvum, which was the most of any species in the analysis. Phylogenetic analysis found one gene family with strong evidence of HGT. The HGT gene family in P. parvum was horizontally acquired from stramenopiles and functionally annotated as tyrosinases. The two HGT-derived tyrosinases (UTEX2797g6779, UTEX2797g3537) are paralogous and a result of a duplication event after the initial transfer from stramenopiles. These paralogous genes are likely to be involved in tyrosine metabolism and eumelanin biosynthesis pathways. We observed a large amount of genetic variation in the entire haptophyte lineage and especially in P. parvum, supporting our hypothesis that P. parvum had genes acquired horizontally from prey.

Mentor(s):

Jennifer Wisecaver, College of Agriculture

Robert Auber, Purdue University

Summer Program: Molecular Agriculture Summer Institute (MASI)

Elastic modulus assessment of particle-reinforced elastomers

Author(s):

Angie Daniela Rojas Cardenas,

Abstract:

For numerous applications in the automotive, aerospace, and maritime industries, light-weight materials with high mechanical stiffness are essential. Although elastomeric materials have outstanding chemical resistance and are electrically insulating, they typically have very low materials stiffnesses or moduli. Therefore, particle reinforcement is used to increase the modulus. Silicone elastomers like poly(dimethyl siloxane) (PDMS) employ silica as the predominant particulate filler for reinforcement. The objective of this project is to measure the elastic modulus of particle-reinforced silicones via indentation and tensile testing to determine how various formulations impact the modulus and demonstrate the utility of indentation. Two grades of sand ("play sand" and "lab sand") were incorporated at several loadings (0%, 30%, 60% and 90% by weight). We studied two commercially available types of PDMS (Smooth-On Solaris and Dow Sylgard 184) cured at 25 °C and 70 °C. To determine the modulus, we performed indentation and tensile tests on each formulation. As expected, we showed that a higher particle loading increased the composite modulus. More importantly for this study, indentation was the simpler method for quantifying the modulus in terms of sample preparation and handling as well as performing the experiment. The measured modulus values were in good agreement between the two methods, but the indentation technique was sensitive to local heterogeneities and resulted in lower standard error.

Mentor(s):

Chelsea S. Davis, College of Engineering

Anne E. Serban, Purdue University

Summer Program: Undergraduate Research Experience Purdue - Colombia (UREP-C)

Level of colostrum intake affects vaginal lipidome of gilts at weaning

Author(s):

Jocelyn Sheets, College of Agriculture

Adrianna Mann, College of Agriculture

Abstract:

Colostrum is the first milk available to neonatal pigs in the first 24-36 h after birth. Colostrum provides immunity, nutrients, essential fatty acids, and bioactive factors. Colostrum consumption is related to long-term fertility. Previously, vaginal lipidome of female piglets (gilts) on d 21 postnatal (PN) was found different between animals that became highly fertile production sows versus infertile animals. Arachidonic acid, a derivative of essential fatty acids was lower in infertile animals. We hypothesized that differences in vaginal lipidome profiles of gilts were due to differing levels of colostrum intake, thus we hypothesized gilts with higher immunocrit ratios, and higher 24-hour weight gain (measures of colostrum intake) will have higher levels of essential fatty acids and derivatives. Here we determined the relationship of immunocrit (IM) and 24 h gain to vaginal lipids on d21 PN. Gilts (n=60) were weighed at birth and 24 h postnatal (PN), and blood sampled to measure immunocrit. On d21 PN vaginal swabs were taken from surviving gilts (n=53). Lipids were extracted from swabs using the Bligh-Dyer method and measured using multiple reaction monitoring profiling). MetaboAnalyst 5.0 was used for statistical analysis. Phosphatidyl choline (PC) (36:3), PC(36:2), and arachidonic acid positively ($P<0.05$) correlated with immunocrit. PCo(38:6) and cholesterol ethers negatively ($P<0.05$) correlated with immunocrit and 24 h gain. Overall, our hypothesis was supported as higher colostrum intake is related to higher levels of essential fatty acids and derivatives in vaginal lipids at 21d PN.

Mentor(s):

Theresa Casey, College of Agriculture

Kayla Mills, Purdue University

Christina Ferreira, Purdue University

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Summer Program: Molecular Agriculture Summer Institute (MASI)

Observing Fracture and Mechanics of CNC Thin Films

Author(s):

Dawson Smith, College of Engineering

Abstract:

Cellulose Nanocrystals (CNC's) are sustainable, cheap, and strong bundles of cellulose fibers. CNC's are anisotropic - covalent bonding makes the rod-shaped crystals stronger along their length, while weaker hydrogen bonding spans their diameter. CNC thin films are promising replacements for polymers as transparent, flexible packaging and share the crystals' anisotropy, exaggerated by how many crystals face the same direction (order), and the angle between applied stress and CNC orientation. Previous researchers[1] simulated CNC films under tension to understand their fracture and estimated both moduli (resistance to deformation) and fracture strengths (stress at which the film breaks) at different alignments. At low alignment angles, crystals slide past one another until fracture, at high alignment angles, the interface between crystals breaks, and in between, the modes mix. These modes were indeed experimentally observed by tensile testing polydimethylsiloxane (PDMS)/CNC/PDMS composites, however, their mechanical properties were skewed due to flawed composites. We improve the composite by attaching a plastic frame to prevent premature cracking and use oxygen plasma to restrict the composite's size. The films will be loaded at variable orders with tension parallel to CNC length (0°), rotated 45°, and perpendicular to the length (90°) and the simulated fracture modes will be verified by imaging the composite with a microscope. We expect the modulus and fracture strength of the films to decrease with rotation as the weak interface between CNC's is subjected to greater force. Observing the thin films' fracture will determine their suitability for oxygen barriers and packaging for electronics and food.

Mentor(s):

Chelsea Davis, College of Engineering

Hyeyoung Son, Purdue University

Flood Mapping Using Satellite Images and GIS Tools: A case study of Indiana, USA

Author(s):

Isabela Suaza Sierra, College of Engineering

Abstract:

In the U.S., the Midwest is the center of agriculture and biofuel production. However, it is also the region often subject to record flood damages. In central Indiana, for example, four 100-yearflood events have occurred over the last 15 years (http://in.water.usgs.gov/flood/). And according to the National Weather Service (NWS) of United States, floods are typical in Indiana and have been caused by conditions such as excessive rain, rapid snowmelt, and frozen ground that prevent the upper soil surfaces from allowing water to percolate downward as groundwater and increase surface runoff. Moreover, approximately 24 percent of the state was historically covered by wetlands which makes Indiana more susceptible to severe flooding.

Knowing the hazard (In this case, flooding) allows people to take decisions in meeting mission requirements related to flood hazard mitigation, planning, and response. For this reason, this work is going to focus on mapping the 2018 flood event in Indiana, showing two methods. One of them is manual digitalization looking at the flood extent, and the other is using some automatic tools to delineate flood extent. The last one is going to be compared with the manual digitization to find out which automatic tool is most accurate. On the other hand, it is going to show how to better understand the hazard of flooding in the studied area.

Mentor(s):

Venkatesh Mohan Merwade, College of Engineering

Sayan Dey, Purdue University

Summer Program: Undergraduate Research Experience Purdue - Colombia (UREP-C)

A Musical and Historical Analysis of the Slave Spiritual "Wade in the Water"

Author(s):

William Taylor, College of Engineering

Abstract:

The purpose of this study is to understand the influence of the spiritual "Wade in the Water" on modern and contemporary music through analyzing specific renditions and samples of the song in 19th and 20th century sacred and secular genres. This study focuses on the musical forms of the songs and techniques employed by musicians. The selected songs are analyzed using three factors: tempo, instrumentation, and phrasing. To provide a historical context for slave songs and spirituals, the study looks to the origins and environments in which they first appeared, as well as the creative process and inspiration involved in their creation. The improvisational nature of slave songs serves as a basis for an entire tradition of musical experimentation, from jazz and bebop to rhythm and blues and hip hop. Rather than disrespecting the origins of the song, these renditions and samples pay tribute to its fluid nature. In addition to the historical and musical analysis completed, the study concludes with an arrangement of the chorus of the song. The form of the arrangement is a trio for alto saxophone.

Mentor(s):

J. Peter Moore, Honors College

Interposer Component Interconnect (ICI)

Author(s):

Minh Tran, College of Engineering

Priebe Christopher, College of Engineering

Abstract:

The interposer component interconnect (ICI) is a standard physical, electrical, and logical protocol that runs the integration of multiple silicon dies into an integrated system using 2.5D die-stacking (chip-stacking) technique that is slowly becoming an industry standard for fabricating ASICS. The interposer enables many different components (mainly memory systems) stacks on processor chip. ICI system is unique in that once the chip is packaged, the system will be permanently integrated. Therefore, the ICI system must have great fault-tolerance and continues to operate even when component failure occurs. As the system is more condensed due to system integration and has more effective self-maintenance, the cost of producing and maintaining chiplets that use ICI will be decreased significantly. Since the interposer has a fall in place interface that helps the chip functions even in a degraded state, communication and network between nodes of the chiplet is extremely important.

The end goal of the project is to implement an ICI protocol as an improvement to Purdue SoCET team SoC. During this summer, the main goal is to be able to create a good simulation for the node communication network on C so that the project can be continued to be physically implemented on an FPGA using SystemVerilog in future semesters.

Mentor(s):

Mark Johnson, College of Engineering

John Martinuk, Purdue University

Summer Program: Vertically Integrated Projects (VIP)

LC/MS coupled to PODIUM establishes the amino acid metabolomes of Sorghum bicolor

Author(s):

Caden Tuinstra, College of Agriculture

Abstract:

Untargeted metabolomics is a well-known and reliable method to globally profile small molecules. A number of analytical tools can be used to accomplish this goal, but liquid chromatography mass spectrometry (LC/MS) is most often used due to its precision and sensitivity. Although the use of LC/MS results in large amounts of data, much of it is difficult and time consuming to analyze. Most importantly, LC/MS cannot conclusively identify small molecules; additional analytical tools are needed to address these limitations. Effort has been put into streamlining the analysis of data from LC/MS in untargeted metabolomics with recently created analytical pipelines like XCMS, CAMERA, and PODIUM. The advent of these technologies makes it possible to efficiently analyze large amounts of data and conclusively identify small molecules, thus expanding our knowledge of metabolites and their role in various biochemical pathways. In this research, we attempted to use PODIUM to analyze the data from an untargeted metabolomics experiment in order to identify metabolites derived from amino acids. The aim of the experiment had two parts: (1) to feed Sorghum bicolor seedlings with isotopically labeled amino acids and analyze them using PODIUM and (2) to tentatively identify small molecules derived from the amino acids. Overall, this research will utilize PODIUM to identify metabolites and will determine the relationship between metabolites and the amino acids responsible for their synthesis.

Mentor(s):

Clint Chapple, College of Agriculture

Jeffrey Simpson, Department of Biochemistry, Purdue University

Zhiwei Luo, Department of Biochemistry, Purdue University

Summer Program: Molecular Agriculture Summer Institute (MASI)

Particle Size Distribution and Chemical Composition of Aerosols in Coastal Peru

Author(s):

Alyssa Van Fossen,

Abstract:

This study investigated the size dependent, chemical composition of aerosols collected along the coast of Peru. Anions (Cl^-, NO_3^-, and SO_4^{2-}) were analyzed the data showed that different anions were largely grouped in different aerosol sizes. Cl^- was mostly found in large aerosols [diameters 3.0-10.2um] which we concluded was mostly derived from sea salt. NO_3^- was mostly found in 1.5-7.2um diameter aerosols. We concluded that this was mostly due to the large surface area of this sized aerosol and the high reactivity of HNO_3 on surfaces. SO_4^{2-} was mostly found in aerosols <0.95um with up to three times as much relative to larger particles. A majority of this was attributed to non sea salt sulfate, which we assumed to originate from the oxidation of sulfur derived from either Dimethyl sulfide or SO_2 emitted by a nearby copper smelter. The results indicate that there is a variety of chemical compositions within various size ranges of aerosols because of the different processes that lead to their formation.

Mentor(s):

Greg Michalski, College of Science

Ilayda Kelley, Purdue University

Summer Program: Analytical Chemistry REU

Groundwater Flow Processes in the Colca Canyon, Peru

Author(s):

Andrew Wanstall, College of Science

Abstract:

Groundwater flow processes in the upper and middle reaches of the Colca Canyon, Peru remain poorly quantified, yet this information is critical. Towns such as Yanque, Maca, and Callalli depend upon surface flow from the Rio Colca and groundwater from springs to support their needs. Colca Canyon is the third most popular spot for ecotourism in Peru and home to Quechua people, who retain many of their traditions including stepped-terrace irrigation which route groundwater from springs for agriculture. This region is semi-arid and does not receive large amounts of rainfall. Locals noted that springs north of the river are desiccating compared to the southern springs and understanding the reason for this is important. Purdue University students sampled 15 springs in Maca and Yanque (southwestern portion) and Callalli (northeastern portion) during June 2019. We seek to use this data to understand the rock units which host groundwater flow and circulation depths. Silica geothermometry was used to estimate circulation depths since there was a linear relationship between temperature and silica. Our data shows that the springs in the south are supported by deeper groundwater flow. This can be explained by the active fault network that cuts through Maca, which is expressed by near-surface earthquakes which may be increasing permeability in rocks, allowing groundwater to flow deeper and be less susceptible to changes in recharge. Higher equilibration temperatures in the southern springs also support the locations of geothermal centers in those areas hypothesized during the field study due to clusters of hot springs.

Mentor(s):

Marty Frisbee, College of Science

Jack Fekete, University of Arkansas

Lisa Welp, Purdue University

Elizabeth Olson, Purdue University

CubeSat reliability estimation

Author(s):

Ricardo Xie, College of Engineering

Abstract:

CubeSats are miniature satellites first designed in 1999, to help democratize access to space through a standardized, low-cost form factor using commercial-off-the-shelf (COTS) parts. While they soon became popular platform among universities and other stakeholders, they pose a unique challenge: they use parts that may be more susceptible to the space radiation. Therefore, the purpose of this project is to estimate the reliability of CubeSats in their missions. To analyze the hardness assurance in space, one popular methodology is using goal structuring notation (GSN). It is a graphical notation standard that helps document the assurance cases and visually organize the arguments. Developed around 1990s at the University of York, it is now a widely used standard in many agencies, including NASA. At the end of this study, a CubeSat system-level reliability assurance case using GSN is presented. For future work to quantify the expected lifetimes of the parts, using methodologies such as accelerated lifetime modeling and testing, are described.

Mentor(s):

Peter Bermel, Discovery Park

Summer Program: Summer Stay

Machine learned synthetic feasibility estimation from a computer-assisted synthesis planning tool

Author(s):

Kevin Yu,

Abstract:

De novo molecular generation and optimization can often lead to chemical structures that are synthetically infeasible. Thus, chemically accurate synthesizability metrics are important for filtering out such synthetically infeasible molecules in virtual screening workflows. Computer-aided synthesis planning (CASP) tools are capable of proposing synthetic routes for a wide range of molecules but currently are prohibitively slow for the analysis of large molecular sets. We have developed a neural network-based regression method that approximates the output of the CASP tool ASKCOS. Trained on tens of thousands of compounds from the ChEMBL database, the ASKCOS approximation model can estimate the height of the corresponding retrosynthetic tree (which we posit to correlate with synthetic difficulty) for any given molecule at a significantly higher speed than ASKCOS itself. Thus, this model can be useful in rank-ordering the synthetic feasibility of large molecular sets either proposed by generative models or contained in a database.

Mentor(s):

Matthew Muhoberac, Purdue University

Prageeth Wijewardhane, Purdue University

Summer Program: Analytical Chemistry REU

Experimental and Design effort to understand a wider sense of memeory application

Author(s):

Nicholas Zogbi, College of Engineering

Abstract:

Magnetic Random-Access Memory (mRAM) is a more efficient, smaller, and less power-hungry memory device that can be implemented into computers. Using Magnetic Tunnel Junctions (MTJ) we store memory in devices that are far less complex than other types of memory with just the use of currents and magnetic fields changing the data.

In collaboration with the System-on-Chip Extension Technologies (SoCET) and Computing Advances by Probabilistic Spin Logic (CAPSL) groups, we have been working on using the characteristics of MTJs to characterize available commercial mRAM devices so we can have a better understanding of the thresholds of the MTJs. The SoCET teams develops chips using elements of the basic architecture and machine learning optimization. The CAPSL team creates probabilistic bits (p-bits) for probabilistic computing using MTJs and the Boltzmann Machine. Combining these two teams together I can work with mRAM to take the knowledge of computer architecture and knowledge of MTJ to better characterize and test the mRAM. To conduct the testing of commercial mRAM devices, a System Verilog code for a memory controller is being developed to input the data into the mRAM and read the data. To characterize mRAM we will test it by straining it multiple ways such as heat, high magnetic fields, and varying magnetic fields. We will be able to characterize it by comparing the data written into the device to the data read from the device after it has been strained.

Mentor(s):

Joerg Appenzeller, College of Engineering

Mark Johnson, Purdue University

John Martinuk, Purdue University

Summer Program: Discovery Park Undergraduate Research Internship Program (DURI)

Effects of a High Fat Diet on Stress and Circadian Rhythms

Author(s):

Michael Anderson, College of Agriculture

Abstract:

Diet influences physiology including circadian rhythms, stress, and overall mood. The purpose of this study is to determine the effects of four weeks of feeding a high-fat diet on hair corticosterone levels, as an indicator of stress, circadian rhythms of melatonin, and corticosterone in female mice. Four-week-old ICR mice (n=42) were weighed and assigned to a high-fat diet (HFD; 60% kcal fat; n=24) or control diet (CD; 10% kcal fat; n=18). Mice were weighed weekly and exposed to 12 h of light and 12 h dark with ad libitum access to food. Weekly diurnal and nocturnal feed intake was determined by weighing feed every 12 h. On d 28 of feeding, crown-rump length was measured to calculate body mass index (BMI), and hair was shaved to extract and measure corticosterone levels using liquid chromatography-tandem mass spectrometry (LC-MS/MS). Fecal samples were collected every 4 h from d 23-25, and melatonin and corticosterone were extracted and measured with (LC-MS/MS) to capture circadian rhythms. Mice on HFD weighed more ($P<0.05$; 23.62 ± 28.44 vs 25.9 ± 35.1 g) and had higher BMI ($P<0.05$; 3.22 ± 3.84 vs 3.55 ± 4.59) on d 28 than CD. HFD mice had a higher feed intake ($P<0.05$) during the day than CD mice during weeks 2-4, indicating diet disrupted circadian behaviors.

Mentor(s):

Theresa Casey, College of Agriculture

Karen Plaut, Purdue University

Kelsey Teeple, Purdue University

Summer Program: Molecular Agriculture Summer Institute (MASI)

The Impact of Drainage Water Recycling on Downstream Water Quality

Author(s):

Emily Burns, College of Agriculture

Abstract:

The size of the hypoxic zone in the Gulf of Mexico has been linked to the high nitrate loads associated with subsurface drainage of agricultural land in the Midwest. New methods to reduce the rate of nitrate loss from these systems are necessary to minimize negative impacts to the water quality in the Gulf of Mexico and local water sources. Research in the past has identified sources of the problem, but innovative ideas for sustainably feeding a growing world population are still needed. This project makes use of drainage water recycling which is one innovative practice that takes nitrate-rich drainage water and stores it for reuse as irrigation rather than releasing that nitrate-rich water downstream. The Drainage Water Recycling 2021 (DWR 2021) project takes place at a wetland located at the Agronomy Center for Research and Education (ACRE) at Purdue University in West Lafayette, IN. The wetland has two inlets that drain from 175 acres of agricultural land, and they flow through the wetland to the control structure placed at the outlet. The control structure stores the water in the wetland to be recycled as irrigation in the neighboring soybean field. The goal of this project is to evaluate the increase in downstream water quality once drainage water is recycled. A weir was placed on the control structure in July 2021 to measure outflow from the wetland. The recorded outflow is then multiplied by nitrate concentration, found by taking weekly water samples at the inlets and the outlet, to determine the weekly nitrate load. Annual nitrate load from 2009 to 2020, before the drainage recycling project, was calculated using the same method. The reduction in discharge due to DWR 2021 is estimated by subtracting inlet discharge from outlet discharge. With this information, the outflow load is simulated for the years 2009 to 2020 as if the outflow had been as reduced as DWR 2021. The simulated and observed annual nitrate load will then be compared to reveal how much drainage water recycling could reduce nitrate loads leading into waterways. This research will quantify the potential positive impact drainage water recycling can have on water quality, and it can be used to further research into more environmentally friendly agricultural practices.

Mentor(s):

Katy Mazer, Purdue University

Summer Program: PHIG

User-Friendly Biosensors for Bovine Respiratory Disease

Author(s):

Andres Dextre, College of Engineering

Abstract:

This work focuses of the development of a Loop-mediated isothermal amplification assay for 3 of the main Bovine Respiratory Disease (BRD) associated bacteria: Pasteurella multocida, Mannheimia haemolyitca and Histophilus somni. BRD is one of the most prevalent and costliest diseases currently affecting the United States feedlot industry. While BRD is a complex, multi-factorial disease; there are certain pathogens that have been found to be causative of BRD. Current diagnostic practices are mainly reliant on visual inspection which is not specific as it does not indicate the causative pathogen(s). More specific diagnostics such as Polymerase chain reaction tests; require long waiting times, specialized equipment and highly trained personnel which delays diagnosis and therefore treatment. The assay developed overcomes these challenges by allowing multiplexed detection from a single sample, requires minimal instrumentation, user-friendly readout, and fast turnaround times. In a liquid format the assay has a limit of detection of approximately 1000 copies/reaction and can be easily expanded to include other pathogens/targets of interest.

Mentor(s):

Mohit Verma, College of Agriculture

Summer Program: Molecular Agriculture Summer Institute (MASI)

What makes a nurse bee? Identifying genes associated with behavioral states in honey bees.

Author(s):

Anna Donnelly, College of Agriculture

Abstract:

The ability to adapt behavioral responses to external or internal cues—behavioral plasticity—is critical to the success of social organisms and for agricultural security. Honey bee workers provide a useful model as they reversibly transition between two strikingly different roles over their lifespan: nurses and foragers. As workers age, they transition from nurses to foragers but the transition can be accelerated or reversed if the population of available nurses or foragers is lost to disease or pesticide exposure. The proximate mechanisms underpinning this plasticity are relatively unknown but the 'genetic toolkit hypothesis' posits that plasticity results from the differential regulation of highly conserved genes. There are hundreds of differentially regulated genes between nurse and forager brains and many of them are highly conserved within Drosophila. However, the largest regulatory changes in a worker's brain occur in genes unique to the honey bees. Remarkably, we know very little about the role that novel genes play in behavioral plasticity and phenotypic diversity more broadly and we lack many of the tools to explore these questions in honey bees, specifically. We propose developing an ectopic expression system in Drosophila to functionally characterize novel honey bee genes underpinning the transition from nursing to foraging. Our proposed system can be adapted to explore the function of any novel honey bee gene and provides a leaping off point for our labs to test cause-and-effect effect hypotheses between genes and phenotypes in honey bees more broadly.

Mentor(s):

Brock Harpur, College of Agriculture

Vikki Weake, Purdue University

Stephanie Hathaway, Purdue University

Summer Program: Molecular Agricultural Summer Institute (MASI)

Determining the Contribution of the Mediator Complex to the Repressive Chromatin Modification H3K27me3 in Arabidopsis thaliana

Author(s):

Ogechukwu Ezenwa, College of Agriculture

Abstract:

Abstract redacted.

Mentor(s):

Joseph Ogas, College of Agriculture

Jiaxin Long, Purdue University

Summer Program: Molecular Agriculture Summer Institute (MASI)

Investigating loss of PKL in isw1 isw2 plants

Author(s):

Jacob Fawley, College of Agriculture

Abstract:

Abstract redacted.

Mentor(s):

Joseph Ogas, College of Agriculture

Jiaxin Long, Purdue University

Summer Program: Molecular Agriculture Summer Institute (MASI)

The Localization of Cdc14 in Tetrahymena thermophila

Author(s):

Cody Goode, College of Agriculture

Abstract:

Abstract redacted.

Mentor(s):

James Forney, College of Agriculture

Mark Hall, Purdue University

Kedric Milholland, Purdue University

Summer Program: Molecular Agriculture Summer Institute (MASI)

Heat Stress, Labor Capacity, Climate Change

Author(s):

Gozde Iloglu, College of Science

Abstract:

Heat stress is caused by exposure to intense heat and humidity for long periods of time. It can cause serious health conditions that can lead to death. There are several factors affecting the intensity of such conditions such as the time being exposed to the said conditions or access to resources like water, shade, air conditioning, etcetera. While the effect of heat stress on human health is a crucial problem to consider, we need to look beyond the effects of heat stress on individuals and consider its effect on society. On a larger scale, added contributions of heat stress can present complications on the labor capacity of future generations. This can have huge ramifications on the economy as entire populations will be forced to relocate due to rising temperatures in primarily the mid-latitude regions. There is current scientific literature on the adverse effects of rising temperatures. In this presentation, we analyze the heat stress in the Middle Eastern-North Africa (MENA) region as measured by Wet-Bulb Globe Temperature (WBGT), a metric that combines the effects of temperature and humidity using historical and modern-day data from 5 different climate models. Then, we calculate the decrease in labor capacity due to the rising temperatures. This framework is useful in helping us better understand the future costs of climate change, hedging practices, and mitigation strategies.

Mentor(s):

Matthew Huber, College of Science

Qinqin Kong, Purdue University

Summer Program: Discovery Park Undergraduate Research Internship Program (DURI)

SARS-CoV-2 Spike Protein as a Therapeutic Target for Antiviral Treatment of COVID-19

Author(s):

Mansoorah Kermani, College of Health & Human Sciences

Abstract:

The Coronavirus Disease 2019 (COVID-19) infection is caused by viral infection of SARS-CoV-2 in humans. It has been shown to result in pneumonia and upper/lower respiratory tract infections. The SARS-CoV-2 spike protein is involved in receptor recognition and the cell membrane fusion process between the spike protein and SARS-CoV-2. The virus binds to host cells via this trimeric spike glycoprotein, which makes it a key target for potential therapies and diagnostics. Fever and shortness of breath are two hallmark symptoms of COVID-19, but others include shortness of breath, myalgias/fatigue, confusion, headache, sore throat, and even acute severe respiratory syndrome which can lead to respiratory or multi-organ failure. For patients, particularly elderly ones, with comorbidities such as diabetes, hypertension, and cardiovascular disease, their mortality rates are higher if they acquire COVID-19, and could result in severe and fatal respiratory distress. Using FoldIt, a protein-folding computer game, I have designed a protein which acts as an antiviral drug that binds to the coronavirus spike protein, which could be used to block interaction with human cells and thereby halt infectious processes.

Mentor(s):

Zahra Tehrani, Honors College

Tulip tree (*Liriodendron tulipifera* L.) responds to drought but does not remember past drought events

Author(s):

Jaden King, College of Agriculture

Abstract:

Abstract redacted.

Mentor(s):

Michael Mickelbart, College of Agriculture

Michael Gosney, Purdue University

Summer Program: Molecular Agriculture Summer Institute (MASI)

2021 Summer CAM2 Drone Video Team: A Low-Power Computer Vision Competition for Evaluating Multi-Class, Multi-Object Tracking

Author(s):

Ayden Kocher, College of Engineering

Ajay Dev, College of Science

Pume Tuchinda, College of Engineering

Bhavey Jain, College of Science

Haoyuan Chen, College of Engineering

Michael Scirocco, College of Engineering

Jun Young Choi, College of Science

Tao Sun, College of Science

Sriram Anasuri, College of Science

Uday Chaudhary, College of Engineering

Abstract:

Drone technology can be applied to a variety of problems, especially situations that demand a portable, vision based solution. We propose a competition with emphasis on low power computer vision solutions for these drone applications. Low power is emphasized as drones and similar camera equipped tools are primarily limited by their battery lives.The needs of a competition infrastructure to accelerate progress have been proven by the strong interests and large participation in online computer vision competitions. That is why we are creating a competition and dataset that asks competitors to perform multi-object, multi-class tracking of objects in UAV video. Our provided sample solution generates detections from YOLOv5 and passes them to DeepSORT for tracking. YOLOv5 and DeepSORT were chosen due to their efficient operation and accuracy. To optimize our model for low power and speed on the Raspberry Pi and drones, we utilize small models and perform quantization, frame skipping with optical flow, and pruning to decrease CPU operations and memory requirements. Competitor's submissions are evaluated online where their solution's accuracy and power consumption is calculated. The initial accuracy is calculated through the F1 scoring system, which is then divided by the energy used to give the final result. The final results will be posted to the competition's website and a formal presentation of the winning solutions will be developed for others to understand and build upon.

Mentor(s):

Yung-Hsiang Lu, College of Engineering

Qiang Qiu, Purdue University

Wei Zakharov, Purdue University

Xiao Hu, Purdue University

Summer Program: Vertically Integrated Projects (VIP)

Identification of Metabolic Products of Amino Acid Precursors in Arabidopsis

Author(s):

Lydia Kowalskyj, College of Agriculture

Abstract:

In this project, we investigated the metabolism of phenylalanine, tyrosine, and tryptophan in Arabidopsis thaliana. Our goal was to determine if using Liquid Chromatography-Mass Spectrometry (LC-MS) and the Pathway of Origin Determination in Untargeted Metabolomics (PODIUM) XCMS-based analytical program method was able to identify metabolomes from labeled (13C) and unlabeled (12C) amino acid isotope precursors.

We grew wild-type Arabidopsis plants in funnels, using three replicates of plant samples per isotope precursor to reduce variation. Once harvested and extracted with 70% methanol, samples from phenylalanine, tyrosine, and tryptophan were run through negative ion LC-MS and the PODIUM program to identify metabolites that have been synthesized from the administered amino acids.

Metabolites were identified by comparing mass to charge ratios, ion counts, retention time, and chemical structures to previously known metabolites in Arabidopsis. When comparing fed samples, all amino acids showed an increase in the 13C labeled isotope in the samples fed with labeled precursors than in unlabeled fed samples (figure 1). The same pattern is shown in Coniferyl alcohol + O-Hex, a metabolite we identified from phenylalanine (figure 2). Detection of the isotopes was higher in rosettes than in stems across all three amino acids (figure 3).

In conclusion, PODIUM can identify metabolites from exogenous amino acids. We determined that phenylalanine had a large number of products when compared to the others. Identification of metabolites in this model suggests our method could identify products derived from a broader range of amino acids.

Mentor(s):

Clint Chapple, College of Agriculture

Jeffrey Simpson, Purdue University

Zhiwei Luo, Purdue University

Brian Dilkes, Purdue University

Summer Program: Molecular Agriculture Summer Institute (MASI)

Microfluidic Argonaute Mediated COVID-19 Point of Care Diagnostic Device

Author(s):

Jieun Lee, College of Engineering

Madhumitha Prakash, College of Engineering

Hailey Szadowski, College of Engineering

Manu Correa, College of Science

Grace Cook, College of Engineering

Victor Pacheco, College of Liberal Arts

Miles Thompson, College of Engineering

Andres Dextre, College of Engineering

Matthew Chan, College of Engineering

Karthik Ravichandran, College of Science

Abstract:

Abstract redacted.

Mentor(s):

Ethan Hillman, University of Michigan Medical School

Kok Zhi Lee, Washington University at St. Louis Energy, Environmental & Chemical Engineering

Mrugesh Parasa, Purdue University

Summer Program: Molecular Agriculture Summer Institute (MASI) & Summer Undergraduate Research Fellowship Program (SURF)

Developing Quantification Methods for N-Terminal Acetylation of Proteins

Author(s):

Micah Lehe, College of Agriculture

Abstract:

N-terminal acetylation is a form of protein modification that is known to be associated with biological regulation, signaling pathways, and certain diseases. For example, a notable increase in N-terminal acetylated proteins is observed in patients with cancer. Therefore, accurate methods of quantifying peptides with acetylated N-termini via proteomic approaches are highly valuable to the study of multiple diseases. Through our research, we have tested a range of methods for isolating N-terminal acetylated peptides in cell lysates, followed by quantification with mass spectrometry. This includes protein labeling with acetic anhydride isotopes and strong cation exchange (SCX)-based isolation. We are aiming to devise a set of methods that will allow us to comprehensively analyze N-terminal acetylation in the brain cells and extracellular vesicles (EVs) of model organisms. Our ultimate goal is to better characterize the abundance of N-terminal acetylated proteins associated with diseases like cancer. We are also interested in determining any differences in acetylation level between brain cells and their EVs.

Mentor(s):

W. Andy Tao, College of Agriculture

Michelle Lihon, Purdue University

Summer Program: Molecular Agriculture Summer Institute (MASI)

Uncovering Vanillin Biosynthetic Precursors in Petunia hybrida with CRISPR-Cas9

Author(s):

Renqiuguo Li, College of Agriculture

Abstract:

Vanillin is one of the most popular flavoring agents in the world, however the plant metabolic pathway leading to vanillin formation remains still unknown. Cured pod extracts from the orchid Vanilla planifolia are considered the only natural source of vanillin; but these extracts make up less than 1% of industrially produced vanillin (Walton et al., 2003). Challenges in microbial production techniques include expensive bioreactors, costly extraction methods, and environmental concerns associated with wood-derived carbon sources. Similarly, seasonal production, the need for a tropical climate, and labor-intensive harvesting/curing methods all contribute to the high cost of vanillin produced from V. planifolia (Dixon, 2010). Thus, vanillin production necessitates alternative synthetic strategies, but an unclear biosynthetic pathway and lack of characterized plant enzymes represent severe limitations (Yang et al., 2017; Kundu, 2017; Gallage et al., 2014). The objective of my research project is to identify genes and enzymes contributing to vanillin biosynthesis in Petunia hybrida, a solanaceae plant which also contains a large number of vanillin emissions.

Multiple studies indicate that the plant precursors of vanillin are phenylpropanoids, compounds derived from phenylalanine (Kundu, 2017). Synthesis of vanillin requires the removal of two carbon units from the side chain of the aromatic ring of these precursors. Vanillin could be the result of ferulic acid side chain shortening, catalyzed by enzyme similar to 4-hydroxybenzaldehyde synthase (Podstolski et al., 2002) or by a dioxygenase with specific vanillin synthase activity (Negishi and Negishi, 2017).

Mentor(s):

Natalia Dudareva, College of Agriculture

Summer Program: Molecular Agriculture Summer Institute (MASI)

Program Analysis as a Service

Author(s):

Kaden Merrill, College of Engineering

Andrew Lynn, College of Engineering

Daniyaal Rasheed, College of Engineering

Allison Hill, College of Engineering

Sabrina Chang, College of Engineering

Leila Yanni, College of Engineering

Jack Myers, College of Engineering

Abstract:

The program analysis team as a whole strives to create an advanced grading and feedback system for students studying at purdue. This involves revamping the current system to be more streamlined and natural to use for both students and professors. The class we are building for currently is: Advanced C Programming.

Our grading script makes use of valgrind to detect problems in a student's code; the professor can deduct points based on information from these memory leaks and assign weights to each test case. Our plans for analysis involve AFL++, an advanced debugging tool. AFL presents a future grading script that could generate an exhaustive test corpus to efficiently test each student's code, support differential fuzzing to test a student's code in parallel with a professor's code, error corpus expansion to find many test cases that result in a certain bug, and more advanced metrics to aid a student with their development.

The frontend of our team aims to create an efficient web interface for students and professors to view assignment data and code metrics, create assignments and more. The majority of the web development is done using the django python library that facilitates advanced database structures, and fluid web pages.

Our current implementation uses github as our main submission stream for students. Github provides classroom tools, a robust API and shell commands that allow us to automate the grading process for a class and provide thorough feedback directly in the student's repository.

High-Yield Synthesis Using Accelerated Micro-droplet Reactions involving Recycling in a Semi-Closed System

Author(s):

Berket Mesele, College of Engineering

Abstract:

A closed system for microdroplet/thin film reactions with the capacity to dispatch high-yield microdroplet reactions and be capable of recycling the solvent that was produced for gram-scale chemical synthesis. The original design produced satisfactory results pertaining to the recycling yield and in increasing the acceleration factors of the microdroplet spray system due to the Claisen-Schmidt, Schiff base, the Katrizky and Suzuki coupling reactions. As the solutions are confined and spritzed onto a surface, their resulting vapor flows into the condenser due to the negative pressure provided by the system's pump. Resulting in returning the reagent solution. While it resulted in satisfactory results, it produced issues that could not be ignored. All these issues stemmed from the yield and scale of the sprayer. To address this, a new system was designed in an attempt to prevent significant loss of solution and a threatening buildup of pressure. This design involved in reiterating the collection chambers involved and being capable of separating the most critical points in the system.

Blessing or Burden? The Impact of PTSD Service Dogs on Military Families

Author(s):

Elise Miller, College of Science

Abstract:

While PTSD service dogs are specifically trained to interact with their veterans, emerging evidence suggests that service dogs may also have an impact on other members of veteran households. To our knowledge, only one study quantifies these effects focused on veteran spouses (McCall et al., 2020). Our study aimed to quantitatively measure the impact of PTSD service dogs on military family wellbeing. Data was collected from survey responses of 88 veteran spouses who rated their experiences on standardized outcome measures. Each spouse answered the surveys at two time points: (1) baseline, and (2) three months post-baseline (follow-up). Spouses in the control group (n=40) were on the waitlist for a service dog for both baseline and follow-up, while the service dog group (n=48) received a service dog after baseline. Multiple regression analysis yielded statistically significant differences between the waitlist and service dog groups which suggested that service dogs may increase caregiver burden and decrease caregiver satisfaction, but potentially encourage increased participation in activities for veteran spouses. Small effect sizes suggested service dogs may also foster increased companionship and positive affect in veteran spouses. Analyses indicated no notable impact on veteran children. These findings suggest that the impact of PTSD service dogs may extend to veteran spouses, potentially encouraging interest and investment in this complementary intervention option. Two statistically significant negative effects emphasize the need to inform the military family of practical strategies to minimize possible detrimental effects, which would likely lead to an improved family experience with the service dog.

Mentor(s):

Marguerite O'Haire, College of Veterinary Medicine

Leanne Nieforth, Purdue University

Summer Program: Discovery Park Undergraduate Research Internship Program (DURI)

Generation of Maize Dwarfing Mutants with Mutagenesis

Author(s):

Cooper Nevitt, College of Agriculture

Abstract:

The gene of interest for our research is a mutant gene in corn that causes the expression of dwarfism. This gene is known as brachytic-2 (br2). The expression of dwarfism can be potentially advantageous due to increased resistance to weather conditions that would otherwise harm corn of standard height, as well as decreased need for input. In this study, we sought to use PCR in order to ascertain the genotype of plants with the br2 gene. There are two factors at play in the gene of interest: SNPs and insertion of a transposon. Both of these lend themselves to the use of CAPS markers. We used primers in order to amplify DNA fragments of interest. The mutation of interest causing dwarfism in our corn samples is a recessive gene. Our PCR tells us which samples do and do not possess the mutant gene. Our results provide evidence of the feasibility of our mutant corn plants for use in large-scale agriculture. Due to the recessive nature of the gene, multiple back-crosses would be necessary in order to introgress the gene into normal lines.

Mentor(s):

Gurmukh Johal, College of Agriculture

Summer Program: Molecular Agriculture Summer Institute (MASI)

Determination of DMP9 Functional Domains through Molecular and Genetic Analysis

Author(s):

Mario Perez-Ahuatl, College of Agriculture

Lauren Gartenhaus, College of Science

Abstract:

In flowering plants, seeds are the direct products of sexual reproduction. The interaction between proteins localized at the gametes cell surface (plasma membrane) - the two sperm cells and each of the female gametes, the egg and central cell - result in a double gamete fusion event called double fertilization.

In Arabidopsis thaliana, two plant-specific proteins, DMP8/9 exclusively expressed in sperm cells are required for sperm-egg fusion and double fertilization. However, the molecular function of DMP8/9 is unknown. In this study we used molecular complementation studies to investigate regions in the DMP9 protein required for function and sperm cell specificity. Our results indicate that DMP9 have unique functions that cannot be replaced by any other DMP member. We also determined that the N- and C-terminus of DMP9 protein is necessary for its function.

Effects of Facility Dogs on Emotional Wellbeing of Pediatric Hospital Personnel

Author(s):

Abhinav Ramesh, College of Science

Abstract:

Healthcare is one of the most demanding professions, and approximately 45% of physicians experience job-related burnout (Dyrbye et al., 2018). While previous research has shown that working with facility dogs in hospitals may improve job satisfaction (Jensen et al., 2021), little research has been done on specific observed factors related to emotional wellbeing. The purpose of this study was to examine effects of working with facility dogs on emotions using ecological momentary assessment (EMA). One advantage of EMA over traditional assessments is the elimination of temporal bias, by asking participants about their current state rather than asking them to recollect something from weeks ago (Kashdan & Collins, 2010). EMA data was collected from a group of hospital personnel who worked with facility dogs (handlers; n=61) and a control group who did not (n=61). Multiple daily check-ins throughout a 2-week period included questions about what emotions they were feeling, rated on a scale from 1, "not at all," to 7, "an extreme amount." On average, each participant completed 27.6 daily check-ins. As per the Discrete Emotions Questionnaire, emotion scores were calculated as the average of four related items each. In a t-test comparison, we found no significant difference in anxiety scores between handlers and controls; however, sadness, relaxation, and happiness scores were all statistically significantly better in the handler group. These findings supported our hypothesis that facility dogs would have a positive effect on emotional states of hospital employees. Further directions may include studying specific attributes of facility dogs contributing to results in handlers.

Mentor(s):

Clare Jensen, College of Veterinary Medicine

Marguerite O'Haire, Purdue University

Effects of Novel Tumbling Application and Postmortem Aging on Cull Cow Beef Loin Tenderness

Author(s):

Madison Romanyk, College of Agriculture

Abstract:

Cull cows comprise 19.7% of all cattle slaughtered in the U.S., however their meat is under-utilized due to it being tougher. Research shows that tumbling fresh beef, without a brine, can improve tenderness of fresh meat products without adversely affecting other quality attributes. The objective of this study was to investigate the effect of different tumbling methods and postmortem aging on the tenderness and proteolysis of cull cow beef loins. Loin muscles (Longissimus lumborum) from twelve Holstein cows over 30 months of age were divided into three tumbling treatments: no tumbling control (NT), tumbling normal (T), and tumbling with spiked liner (TS). These sections were separated into two aging treatments: no further aging (NA) and 2 weeks of further aging after tumbling (A). Meat quality and proteolysis were measured. The Warner-Bratzler shear force values showed no significant differences between tumbling treatments ($P > 0.05$), however, there was a downward trend. The aging effect was not significant ($P > 0.05$), but the shear force values of A samples had decreased, compared to NA. The instrumental tenderness of cull cow beef loin was slightly improved with the addition of the spike mat in the tumbler. Western blot analysis showed no significant differences in amount of proteolysis that occurred between tumbling treatments ($P > 0.05$). There were no negative effects on WHC, color, or pH ($P > 0.05$). Fresh beef tumbling coupled with aging could potentially improve tenderness of cull cow beef loins. Further trials with different tumbling conditions (e.g. tumbling speed, time etc.) could maximize tenderization of under-utilized beef products.

Mentor(s):

Mariah Nondorf, Purdue University

Summer Program: Molecular Agriculture Summer Institute (MASI)

Effects of the Inclusion of Dry-Aged Beef Trimming as a Flavor Enhancer

Author(s):

Katie Schmucker, College of Agriculture

Abstract:

The objective of this study was to determine the potential of using dry-aged beef trimmings as a novel ingredient to enhance meat quality and flavor. Beef lean and fat trimming from different aging methods (Wet-aging [WA], Conventional dry-aging [DA], Dry-aging in a water permeable bag [DWA] and UV-light dry-aging [UDA]) were collected. Patties (n=3 batches) were manufactured by combining the treated lean and fat trim with fresh ground beef, creating an 80:20 lean to fat ratio with 6 treatments (control [CON], DA-FAT, WA, DA, DWA and UDA). The patties collected were then subjected to meat quality and flavor analysis. CON patties had a lower pH compared to other treatments ($P<0.05$), except for DA-FAT ($P>0.05$). No significant impact was observed on the cook loss across all treatments. The addition of the trimmings significantly affected the chewiness of the patties, while hardness, adhesiveness, resilience, cohesion, springiness, and gumminess were not influenced ($P>0.05$). Color analysis showed that DWA patties had the least color stability, exhibiting decrease in redness by 4d of display ($P<0.05$) and highest discoloration by 5d of display ($P<0.05$) compared to all other treatments. The TBARS value increase significantly across display period, however no treatment and interaction effect were observed ($P>0.05$). The current results indicated that addition of dry-aged trimming will not negatively impact ground beef patties quality. Analysis to identify flavor differences are currently on going.

THE ROLE OF DIMERIZATION IN CDC14 PHOSPHATASES

Author(s):

Jack Schwartz, College of Agriculture

Abstract:

Cdc14 is a family of protein phosphatase enzymes found in many eukaryotes, which dephosphorylate specific substrates of cyclin-dependent kinase (Cdk) and/or MAP kinases. While Cdc14 phosphatases are highly conserved in animals and fungi, the CDC14 gene was lost among a common ancestor of angiosperm plants causing them to lack this gene altogether. In fungi, Cdc14 has been shown to be integrally important in mitotic exit, response to cell wall stress, and fungal pathogenesis. Due to the fact that Cdc14 is required for infection by fungal pathogens, it has been proposed as a promising, novel antifungal target. With this in mind, it is important that we fully understand the mechanism by which Cdc14 enzymes work and characterize differences between fungal and animal orthologs that could be used to selectively target the fungal enzymes. One unique feature of Cdc14 enzymes is that they appear to always exist as dimers, and the dimer interface is poorly conserved between yeast and animal orthologs, suggesting it could be a useful target for inhibitor development. However, it is still unknown how this dimerization affects enzyme activity. Our lab has also identified a conserved, functional motif in the C-terminus of fungal Cdc14 enzymes which may be mechanistically linked to dimerization. Our hypothesis is that this motif stimulates enzyme activity by interacting with the catalytic site of the opposite subunit. I will test this hypothesis using site-directed mutagenesis, a two-step affinity purification to isolate heterodimers, and enzyme kinetic assays.

Mentor(s):

Mark Hall, Purdue University

Summer Program: Molecular Agriculture Summer Institute (MASI)

Non-Toxic Corn Protein Adhesives

Author(s):

Kylie Smith, College of Science

Logan Miles, College of Science

Abstract:

We are developing non-toxic, plant-based adhesives from corn zein protein as alternatives to some commercial adhesives that emit formaldehyde. Qualitative tack testing was used first to evaluate the potential of our adhesive solutions to be used as pressure sensitive adhesives. Preliminary testing showed that the as-prepared solutions (zein - tannic acid), were not viscous enough for sticking together any substrate other than paper. The solutions were applied to substrates, then air dried at room temperature to increase viscosity. Then adherend pairs were pressed together and kept hanging to determine their ability to resist separation and sliding. If the adhesive solution was not strong enough to prevent sliding, the viscosity was increased by air-drying the glue until it stuck. We present qualitative tack testing and our "hanging experiments" using six substrates. To evaluate potential for different applications, we choose metal substrates such as aluminum, stainless steel, and bronze. Polytetrafluoroethylene (Teflon) and polypropylene (PP) are chosen for their hydrophobic polymer surfaces, and wood is the plant-derived renewable material. The zein-tannic acid adhesive solutions performed very well on all substrates and the higher the viscosity, the stronger the adhesion.

To quantify the above observations, we used lap-shear testing to compare bond strength of dried adhesive solutions. Since wood is the only substrate capable of absorbing the solvent within the adhesive, the adhesion strength using this substrate is strongest. The metal substrates performed slightly better than the polymer surfaces. Surprisingly, the adhesive solutions stick well to Teflon surfaces, even when diluted with ethanol and water.

Mentor(s):

Gudrun Schmidt, College of Science

An Inquisition into Biothiols: Synthesizing a Molecular Probe Capable of Reversibility, Prime Selectivity, and Fast Rate Kinetics

Author(s):

Crystal Vega,

Abstract:

Biothiols (or biological thiols), are a type of biological molecule that play a key role in regulating the intracellular environment. Three frequently studied biothiols are cysteine (Cys), homocysteine (Hcy), and glutathione (GSH). Irregular concentrations of these biothiols are correlated to serious pathological diseases. In order to better understand how irregular concentrations of thiols can affect or trigger certain diseases, molecular probes have been synthesized in order to study thiol concentrations. However, these current probes have encountered caveats that limit our understanding of thiols. These probes are challenged with limitations of irreversibility, unfavorable selectivity, and slow rate kinetics. This poses a difficulty as the concentration of thiols are ever-changing and are present in small amounts as low as nM. To further investigate thiols, a novel probe was synthesized in order to surpass these limitations with desired characteristics such as reversibility, prime selectivity, and fast rate kinetics.

Mentor(s):

Caitlin Randolph, Purdue University

Gaurav Chopra, Purdue University

Summer Program: Analytical Chemistry REU

Development of Rust Based Low-Level Virtual Machine for AFTx06 chip for development of sample applications

Author(s):

Nicholas Verastegui, College of Engineering

Abstract:

Microchips are the foundation for a multitude of various electrical devices from smartphones to medical diagnostic devices. These microchips require programs that can translate instructions into machine code to be interpreted by the chip itself. To develop more efficient systems, the programs that translate these instructions need to be able to work faster and run efficiently on their respective chips. Rust is a more reliable and safe programming language compared to other available languages. Rust's memory guarantees such as no buffer overflows or dangling pointers make it an ideal language to be integrated into LLVM systems.

This project aims to develop a Rust-based LLVM that works with the AFTx06 chip developed by Purdue's System-on-Chip team. This LLVM will interface with the chip and bridge the disconnect between hardware and software. This will be accomplished with efficient instruction set architecture (ISA), and software that utilizes sparsity. This research will run sample tests of the LLVM, attempting to demonstrate that it could run basic machine learning tests as well as linear algebra. The successful test runs of sample applications on this chip would indicate the possibility of uploading an operating system onto the chip.

Mentor(s):

Mark Johnson, College of Engineering

Cole Nelson, Purdue University

John Martinuk, Purdue University

Structure-Activity relationship of Indenoisoquinoline on G-Quadruplex

Author(s):

Adan Villeda, Temporary

Abstract:

DNA G-quadruplexes are non-canonical secondary structures often formed in the promoter region of many genes and act as a transcriptional "on-off switch." c-MYC is one of the most commonly deregulated oncogenes implicated in human cancers, and its transcriptional activity is repressed through the formation of a DNA G-quadruplex in its proximal promoter. The c-MYC G-quadruplex is an attractive biological target for cancer therapeutics. It has been found that compounds that bind and stabilize the formation of the G-quadruplex can downregulate c-Myc protein expression. Indenoisoquinolines are topoisomerase I inhibitors that strongly bind to c-MYC G-quadruplex to and downregulate c-MYC activity. Binding affinity measures how strong a ligand (Indenoisoquinoline drugs) binds to a biomolecule (G-quadruplex). One method to test Indenoisoquinoline binding affinity is through fluorescence. Fluorescence is a highly sensitive observable by which binding affinity can be measured. Using a fluorescent-labeled MYC G-quadruplex, we measure changes in fluorophore emission upon drug titration to determine dissociation constant (Kd). Comparison of Kd amongst indenoisoquinoline analogs reveals a structure-activity relationship for drug binding.

Mentor(s):

Adam Joseph Buric, College of Pharmacy

Summer Program: Research Experience for Undergraduate (REU)

Video Analytics for Understanding Human Behavior

Author(s):

Tong Wang, College of Engineering

Apoorva Gupta, College of Science

Moiz Rasheed, College of Engineering

Edmund Chau, College of Engineering

Vincent Vu, College of Science

Elizabeth Thomas, College of Engineering

Abstract:

Our research team is developing a camera-vision-based human identification system that tracks and analyses human movement within a multi-camera system's field of view. The team works in subteams: Re-Identification and 2D-mapping.

The Re-ID portion of the pipeline handles detection of humans in the camera's field of vision. It creates bounding boxes around detected humans, and assigns them a unique identifier based on their visual attributes. An image of this human is stored in a dynamic gallery to assign new IDs to those who are not in the gallery and maintain the unique human and ID pair. This system is tested by different data with variable parameters like the distance from camera and size of person detected in the video to identify constraints and limitations and check the accuracy of the gallery.

The 2D-mapping pipeline converts coordinates from a multi-camera network to latitude and longitude and plots the position on a satellite image generated by Google Maps API. The mapping contains two linear steps, perspective transformation and unit conversion. Perspective transformation converts a point on the three-dimensional camera view to a point on the satellite image. Unit conversion converts the mapped pixel coordinate on the image to latitude and longitude. The output of the 2D-mapping varies among the number of cameras. Tests were performed with various permutations of camera configurations to benchmark system performance.

A functional system will provide current and robust patterns of human behavior in the monitored space, which improve efficiencies in movement and flow in other open spaces.

Mentor(s):

David Barbarash, College of Agriculture

Summer Program: Vertically Integrated Projects (VIP)

Metrology study of End Ring Metallic Insert M16 holes for CMS experiment at LHC

Author(s):

Jack Wheeler, College of Science

Abstract:

The Large Hadron Collider (LHC) at CERN is a high energy particle physics experiment with the purpose of answering questions of paramount importance about our universe such as the fundamental forces that govern all matter and the nature of space and time. The High-Luminosity upgrade currently underway at LHC is set to increase the luminosity (the number of collisions per second) by an order of magnitude. The Compact Muon Solenoid (CMS) detector is currently being reconditioned at LHC in order to function at the higher energy levels associated with the HL upgrade. One of these components is the Boundary Tracker Support Tube (BTST), which houses detector components towards the center of the detector. The BTST has carbon fiber plates on the outer and inner surfaces with a paper honeycomb sandwiched in-between. This tube is extremely heavy when fully loaded with detector components, and accurate positioning is critical in order to minimize uncertainty. Mispositioning by just 0.2 mm could cause a cascade of alignment issues for other components, and could potentially invalidate results. End Ring Metallic M16 inserts were designed to mount and support the tube, and fiducial markers are integrated into the part in order to accurately and reliably measure the position of these inserts. Prototypes of these metallic inserts were designed at the Composites Manufacturing and Simulation Center at Purdue University. The goal of this research is to determine the repeatability of each measurement system and to identify the challenges associated with validating accurate positioning.

Mentor(s):

Benjamin Denos, College of Engineering

Andreas Jung, Purdue University

Sushrut Karmarkar, Purdue University

Data Analytics for Humanities and Historical Analysis

Author(s):

Henry Wu, College of Science

Abstract:

Historical text and images feed the complex narrative we view history with today. In some cases, references to recurring situations in the form of a diary or a series of maps can become quantifiable data in the form of a visual record. Analytics can be performed on maps of military campaigns tracking the movement of troops over time, a form of time series data, and on casualty lists recording the when, where and from which individual soldiers fell in battle. Our project utilizes primary data from maps and casualty reports concerning World War II battles, specifically from the Eastern Front, to reconstruct one of the largest military clashes recorded in human history: 1941 Operation Barbarossa. We transformed multiple maps into one central database recording the place and time of troops as well as their losses. The data set was not only checked for accuracy and completeness, but also interpreted for various military postures such as: attack, defense, movement, or reserve. Finally the data was mapped into an animated environment. The team created a new type of "weather" map displaying the movement of troops as if they were a weather front. Graphic representation using mathematical modeling allowed for detailed accounts of areas with concentrated troops and the direction of movement. A demo of the work can be found at URL http://visiblepast.org/apps/OPMAPS/OPMAPS_FINAL_DEMO/OPMAPS_BETA.ipynb?appmode_scroll=0

Mentor(s):

Sorin Matei, College of Liberal Arts

Summer Program: Discovery Park Undergraduate Research Internship Program (DURI)

Sleep Problems for Children with Autism: Associations with Grey and White Matter Brain Volumes

Author(s):

Sarah Zhang, College of Health & Human Sciences

Abstract:

Autism spectrum disorder (ASD) is a neurodevelopmental disorder that affects roughly 2% of adults in the U.S. (Dietz et al., 2020). Previous studies document that children with ASD have more sleep problems than their typically developing (TD) peers (Cortesi et al., 2010). Moreover, sleep disturbances are associated with smaller grey matter volumes in children two and older (Kocevska et al., 2017). The current study explores the relationship between sleep disturbances with grey and white matter volumes in children with ASD and TD children using the Children's Sleep Habits Questionnaire and structural MRI scans. 21 children diagnosed with ASD and 20 TD children between 9 and 14 years of age participated in this study. Within this study, and consistent with previous research, children diagnosed with ASD had significantly more parent-reported sleep problems than the TD comparison group, $F (1, 39) = 4.89$, $p < .05$. However, grey and white matter volumes were not associated with sleep problems for the children with ASD. The relations between sleep and brain development in autism are complex and may not be well captured by global measures of grey and white matter volume. Future studies could be well served to look at more nuanced elements of brain development.

Mentor(s):

A.J. Schwichtenberg, College of Health & Human Sciences

Brandon Keehn, Purdue University

Pearlynne Chong, Purdue University

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