

SCHEDULE OF EVENTS

JULY 30, 2025 PMU BALLROOMS

10:30AM-11:30AM Poster Session 1

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1:30PM-2:30PM Poster Session 3

GRISSOM HALL

9:00AM-4:00PM Research Talks

JULY 28-AUG. 1, 2025 SYMPOSIUM WEBSITE

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Presentation Time: Session 1: 10:30-11:30am

Investigating metabolic alterations in PFOS-exposed rat: Implications for neurotoxicity and potential link to neurodegeneration.

STEM

Authors(s): Ximena Cortes Vergara†

Abstract:

Perfluorooctane Sulfonate (PFOS) belongs to a class of chemicals known as Per- and polyfluoroalkyl substances (PFAS) which are highly abundant in the environment due to their prevalence in various industrial products. Studies have reported numerous lipid metabolites such as glycerophospholipids, fatty acids and carnitines associated with PFAS exposure. In this study we hypothesize that lipid metabolism is affected by PFAS exposure, and we will investigate changes at transcriptome and metabolite level. We will employ computational approaches to generate genome-scale metabolic networks of rat brain to investigate tissuespecific metabolic signatures associated with the exposure to PFOS. We have collected 91 microarray transcriptomic datasets for Rattus norvegicus from GEO public database and used it for metabolic network construction. Our analysis approach includes use of Limma for normalization of expression datasets and use of Recon3 genome-scale model of human as a template to generate tissue-specific metabolic networks using mCADRE. Using experimental data from rats, we will be able to investigate gene and metabolite changes in the brain under control and PFOS-exposed conditions. Transcriptomics and metabolomics data will be integrated with the metabolic networks to identify changes in levels of cholesterol, primary and secondary bile acids associated with PFOS-exposure and linking to neurotoxicity.

We aim to analyze the genes and metabolites in lipid pathways from our study, with the intention of translating our findings to human. We will use the data from AD Knowledge portal and correlate our findings in cognitively normal and Alzheimer's disease (AD) patients' data.

Keywords:

PFOS; iRatBrain; Lipid Metabolism

Mentor(s):

Priyanka Baloni (HHS)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Esraa Abdelmonem Gabal (HHS)

Presentation Time: Session 1: 10:30-11:30am

Impact of Porcine Reproductive and Respiratory Syndrome on reproductive performance of sows born on different outbreak phases

STEM

Authors(s):

Miguel Angel Cuervo Espinosa†

Abstract:

Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) is a major pathogen affecting swine reproduction worldwide. Understanding how reproductive performance is altered during different phases of PRSSV outbreak is critical for improving herd resilience and management strategies. This study analyzed phenotypic reproductive performance from sows born before, during, and after a natural PRRSV outbreak on commercial multiplication farm. The dataset included 4,313 purebred Large White sows from four farms. The traits evaluated were total number born (TNB), number born alive (NBA), number weaned (NW), and age at first insemination (AFI). Using R, we performed data cleaning and exploratory data analysis across outbreak phases. We calculated the mean per trait before, during and after the outbreak. Sows born before the outbreak presented mean of 15.76 ± 3.03 , 14.86 ± 3.04 , 12.23 ± 2.89 and 249.73 ± 21.82 for NTB, NBA, NW and AFI, respectively. Sows born during the outbreak presented mean for NTB, NBA, NW and AFI of 17.40 \pm 1.34, 16.80 \pm 1.30, 14.60 \pm 1.14 and 253.60 ± 6.54, respectively. And finally, sows born after the outbreak had mean of 17.68 ± 1.67 , 16.84 ± 1.77 , 14.84 ± 1.21 and 226.79 ± 6.52 for NTB, NBA, NW and AFI, respectively. The results suggest changes in some reproductive traits during the outbreak period, particularly for AFI. Our results reveal notable shifts in reproductive performance, particularly in gilts first inseminated after being born during the outbreak. Specifically, gilts born during the outbreak exhibited higher age at first insemination (AFI), suggesting delayed sexual maturity, possibly due to reduced growth performance associated with early-life exposure to PRRSV.

Keywords:

Swine Reproduction; R; Large White; Disease Resilience

Mentor(s):

Luiz Fernando Brito (Agriculture); Leticia Fernanda de Oliveira (Agriculture)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

MAGIC-Derived Genotyping and QTL Mapping in Vigna unguiculata: Enhancing Quality Traits and Tannin Characterization

STEM

Authors(s):
Maria Paula Garcia Molina†

Abstract:

Genetics play a fundamental role in the life of an organism, influencing its traits, functions, and even its potential to improve food sources. Genetic variations and interactions among genes influence phenotypic expression and protein production, making genetics a tool for real solutions the world needs. My research focuses on Vigna unguiculata (Cowpea), a vital protein source in Africa that contributes to food security and livestock feed. Despite its importance, cowpea yield is still very limited as a result of biotic and abiotic stresses such as pests, pathogens, heat, and drought (Huynh et al., 2018).

To address these challenges, the Multi-parent Advanced Generation Intercrossing (MAGIC) technique is applied to cross eight genetically distinct lines that carry traits such as higher yield and stress resistance. From this, Rrecombinant linbred Llines (RILs) are developed through self-fertilization, ensuring stable genetic lines for further analysis. Genotyping with Single Nucleotide Polymorphism (SNP) markers and Quantitative Trait Loci (QTL) mapping will help identify genomic regions associated with desired traits. Additionally, Near Infrared Spectroscopy (NIR)will be used to assess protein and amino acid content, correlating genetic variations with nutritional improvements.

Beyond genetic enhancement, my research also explores the biological activity of tannins extracted from cowpea leaves. Tannins, which are water-soluble polyphenols, act as natural defenses in plants and have diverse applications in human and animal health. Their protein-binding ability influences digestion in ruminants, potentially improving amino acid availability while reducing feed efficiency (Durgawale et al., 2016; Wina et al., 2010). The extraction process will be optimized using aqueous solvents (Wina et al., 2010). Quantification will be performed using spectrophotometry at 550 nm, measuring the presence of tannins through their reaction with hydrochloric acid and butanol.

This research aims to enhance the resilience of cowpea to environmental stressors while exploring its potential for sustainable agricultural and nutritional applications.

Keywords:

QTL Mapping; Protein Content; Tannins; Crop Resilience; Vigna unguiculata (Cowpea)

Mentor(s):

Jeneen S Fields (Agriculture); Jean Paul lyakaremye (Agriculture)

Other Acknowledgement(s):

Lore N Sebata (Agriculture); Sarah Janelle Abrams (Agriculture)

Presentation Time: Session 1: 10:30-11:30am

Development of a multiantigenic vaccine against Clostridioides difficile

STEM

Authors(s):

Etna Sofia Gonzalez Granados†

Abstract:

Clostridioides difficile infection (CDI) remains an urgent public health threat. Current antibiotic therapies are limited by high recurrence rates, microbiome disruption, and emerging antibiotic resistance. To address this, we pursued a protein-based vaccine targeting four key virulence factors: The toxins Toxin A (TcdA) and Toxin B (TcdB) (mediating epithelial damage), the exosporium protein CdeM (critical for spore persistence and recurrence), and the flagellin FliC (essential for mucosal adhesion). In this study, we successfully expressed, purified, and validated all four antigens. However, conjugation with an adjuvant revealed a critical barrier: in PBS, adjuvant-antigen complexes stayed in the insoluble form, while in HEPES buffer, antigens remained soluble but failed to conjugate efficiently. Further challenges included persistent precipitation and ineffective interactions, suggesting suboptimal buffer conditions and plasmid design. These results highlighted the need for a new approach, including buffer formulation, plasmid redesign for proper tag placement, and evaluation of alternative adjuvants or linker strategies, before advancing to immunogenicity and animal studies. Despite these technical barriers, our work establishes a foundation for a multi-antigen vaccine targeting both toxin-mediated pathology and sporedriven recurrence. Resolving these challenges could enable a novel therapeutic approach to CDI, overcoming the limitations of current antibiotics.

Keywords:

Clostridioides difficile; Vaccine; Molecular Biology; Treatment

Mentor(s):

Ahmed Abdelkhale Hassan (Vet Med)

Other Acknowledgement(s): Lijia Zhang (Vet Med)

Presentation Time: Session 1: 10:30-11:30am

Construction of a Weak KAM Solution for the Overdamped Langevin Dynamics HJE

STEM

Authors(s):

Thomas Martinod Saldarriaga†

Abstract:

It is known that classical solutions to the Hamilton—Jacobi equation (HJE) do not exist in general settings, as is the case for the HJE arising from overdamped Langevin dynamics. To address this, in this work we present a rigorous and explicit variational construction of weak KAM solutions for the HJE associated with overdamped Langevin dynamics on the one-dimensional torus. We begin by deriving the HJE corresponding to this specific stochastic system. Then, under the assumption that the external drift field has at least one root, we prove that the Mañé critical value is zero and compute the Aubry set. We proceed to explicitly compute the Peierls barrier and describe the global energy landscape in the one-dimensional conservative case, while discussing extensions to higher dimensions. Finally, we show that the dynamic solution to the HJE is given by the global energy landscape, which remains invariant under the Lax—Oleinik semigroup and thus provides a viscosity solution to the PDE.

Keywords:

Weak KAM Theory; Overdamped Langevin Dynamics; Global Energy Landscape

Mentor(s):

Yuan Gao (Science)

Other Acknowledgement(s):

Yuxi Han (Science)

Presentation Time: Session 1: 10:30-11:30am

Evaluation of Bokashi as a Suppressive Strategy Against Botrytis cinerea in Tomato (Solanum lycopersicum) and Validation of Its Effectiveness Using Multispectral Sensors STEM

Authors(s):

Maria Fernan Moreno de la Espriella†

Abstract:

Intensive tomato production is significantly impacted by fungal diseases, with Botrytis cinerea being one of the most prevalent and aggressive pathogens. This study evaluates the application of Bokashi, an anaerobically fermented organic amendment, as a strategy to reduce plant susceptibility to this disease and supply key nutrients. It also proposes a low-cost early detection approach using multispectral imaging to identify signs of infection before visible symptoms appear.

Four Bokashi formulations (B1, B2, B3, and BC) were prepared using different substrates and fermentation conditions. The resulting leachates were applied to tomato plants (Solanum lycopersicum) three times per week for two weeks. Additionally, half of the plants in each treatment group received Hoagland solution to evaluate the combined effect of Bokashi and nutrient supplementation on growth and disease resistance.

Detached leaflets were inoculated with B. cinerea (5×10? conidia/mL) and incubated under high humidity to promote infection. A low-cost multispectral imaging prototype, developed using a Raspberry Pi 4 and multispectral LEDs, was used to capture images over three days post-infection. Data were compared with results from a Plant Explorer Pro+standardized photosynthesis sensor.

Preliminary findings show that disease severity decreased considerably in plants treated with B1, B2, and B3. Plants supplemented with Hoagland solution exhibited similar resistance to the disease but developed greater leaf area compared to non-supplemented plants. This work supports the potential of Bokashi as a sustainable strategy to reduce susceptibility to B. cinerea and highlights the promise of affordable multispectral imaging tools for early disease detection in tomato production.

Keywords:

Bokashi; Botrytis cinerea; Tomato (Solanum lycopersicum); Disease Resistance; Multispectral Imaging

Mentor(s):

Lori Hoagland (Agriculture)

Other Acknowledgement(s):

Henrique Petry Feiler (Agriculture); Cristian Andres Salinas Castillo (Interdisciplinary & Special Programs)

Presentation Time: Session 1: 10:30-11:30am

Determinants of Physical Activity in Latino Men in the U.S.: A Systematic Review

Social Science

Authors(s):

Andrea Yuliana Ramirez Prieto†

Abstract:

Background: Physical activity (PA) promotes physical and mental health, and prevents and manages chronic diseases(1). Latino men in the U.S. are significantly less likely to meet PA guidelines compared to other demographic groups(2). Despite high rates of physical inactivity and related chronic diseases among Latino men, the factors influencing PA adoption and maintenance in this group are understudied(3,4). This systematic review examines PA determinants among Latino men in the U.S. through the social ecological model. Methods: The protocol was registered in PROSPERO. A systematic search of PubMed, PsycINFO, CINAHL, and Web of Science (through January 2025) was conducted using keywords related to PA, barriers, facilitators, Hispanic/Latino, and men. Included studies sampled at least 50% Latino men, studied PA determinants, were US-based, and were published in Spanish or English. PRISMA guidelines were followed. Results: Sixteen articles met inclusion criteria(5-20), most were qualitative studies (n=10, 62.5%).

Organizational-level barriers predominated, particularly job-related time constraints (n=9, 56%) and job-related fatigue (n=7, 44%). Community-level barriers included the built environment (n=3, 19%) and neighborhood safety (n=2, 13%). Interpersonal facilitators included support from wives (n=4, 25%). The influence of acculturation on PA behavior was inconsistent across studies. At the individual level, perceived health benefits (n=3, 19%), PA self-efficacy (n=2, 13%), and strong willpower (n=2, 13%) facilitated PA engagement, while chronic health conditions were cited as barriers (n=2, 13%). Conclusions: Understanding which PA determinants most influence Latino men's behaviors is essential to guide culturally responsive multilevel interventions to reduce chronic disease burden.

Keywords:

Physical Activity; Barriers; Facilitators; Hispanic/Latino; Men

Mentor(s):

Elizabeth A Richards (HHS)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Valentina Santoyo-Angulo (HHS)

Presentation Time: Session 1: 10:30-11:30am

Self-pumping Membranes STEM

Authors(s):

Lily Dawn Farmer† (Engineering)

Abstract:

The physics of nanofiltration is not well understood, as many types of membranes and filters exist, but they all interact very differently with the substance they are filtering. This research investigates membranes that can autonomously pump fluid through catalytic reactions. The first set of experiments was to collect zeta potential measurements as zeta potential is a critical property that directly affects fluid transport. Zeta potential was measured using the Anton Parr SURPASS 3, which measures the sample by streaming a given solution through a channel of membranes and uses the Smoluchowski equation to return the zeta potential value. Measurements were performed across varying pH values and salt concentrations to assess ionic effects. The results show zeta potential tends to be higher when in a lower pH and a lower salt concentration for the given membranes. The next part of the research observes the movement of particles through the membrane in the presence of ultraviolet light and different salt solutions. In microscale systems, sensors struggle to record accurate fluid flows, so as a solution, the measurements were taken from tracking the particles for better accuracy using a method called 'particle tracking velocimetry.' To do this, a microscope slide is prepared with fluorescent particles suspended in various solutions surrounding the membrane. A channel exists within the slide where an inverted microscope camera is used to take images of the particles. The images are collected, then used to find the various speeds of the particles with or without light present. This method will be utilized in the next part of the project's work. It is expected that there will be an increase in particle movement in the presence of ultraviolet light in each salt solution. In conclusion, nanofiltration is dependent on many factors due to the sensitive nature of the membranes. Future work in this project will involve replicating the previous work with new membranes to verify results.

Keywords:

Membranes; Catalytic Reactions; Zeta Potential; Particle Tracking

Velocimetry; Micropumps

Mentor(s): Sudharshan Anandan (Engineering)

Presentation Time: Session 1: 10:30-11:30am

A Deep Learning Framework with XAI for Atmospheric Blocking Detection and Interpretation

STEM

Authors(s):

Devansh Khandelwal† (Science|Graduate)

Abstract:

Atmospheric blocking is a large-scale quasi-stationary phenomenon in mid-latitude circulation, characterized by persistent high-pressure systems that disrupt the typical west-to-east flow of the jet stream. These systems can cause extreme weather events—such as heatwaves, cold spells, or droughts—that persist for days or even weeks. This study proposes a deep learning framework to predict and interpret the occurrence of atmospheric blocking by integrating geophysical precursors such as geopotential height (Z500), stream function (SF200), and potential vorticity. These features, which are dynamically linked to blocking onset and persistence, serve as inputs to a Convolutional Neural Network model trained on the CESM Large Ensemble (LENS) dataset. After initial training, we apply transfer learning to adapt the model to the ERA5 reanalysis dataset, preserving the feature extractor while retraining the classifier to improve generalization on real-world atmospheric data. To improve model transparency and interpretability, we apply eXplainable AI techniques. These tools provide spatial insights into the CNN's decision-making process, highlighting which atmospheric features are most important for the model's blocking predictions. By advancing the understanding of mechanisms and indicators of blocking through deep learning and XAI, this work contributes toward more accurate and interpretable weather forecasting models—vital for anticipating and mitigating the societal impacts of extreme weather events.

Keywords:

Deep Learning; Atmospheric Blocking; Explainable AI; Climatology

Mentor(s):

Lei Wang (Science); William Henry Stevens (Science); Yanjun Hu (Science)

Presentation Time: Session 1: 10:30-11:30am

Building a Digital Library of 3D Point Cloud for Deep **Learning-based Tree Species Identification** STEM

Authors(s):

Yuexin Jiang† (Engineering)

Abstract:

Light Detection and Ranging (LiDAR) technology has become an essential tool for forest inventory, enabling high-efficiency and wall-towall measurements of forest structure at the individual tree level. Recent advances in deep learning have demonstrated strong potential in analyzing 3D point cloud data for tasks such as tree segmentation and identification. However, accurate tree species classification with deep learning on 3D point cloud data remains a major challenge, primarily due to the lack of large, annotated point cloud datasets. This project aims to address this gap by creating a digital library of point clouds at individual tree level. We focus on refining individual tree segmentation, creating species labels, and matching stem locations with field inventory data collected from Martell Forest, Indiana, using backpack mobile LiDAR systems. The dataset covers a 2-hectare area and consists of approximately 410 million points representing around 20 tree species. The resulting library will provide structured, georeferenced point cloud data paired with species annotations, serving as a foundational dataset for training and evaluating deep learning models in future ecological and forestry studies.

Keywords:

LiDAR; Deep Learning; Tree Species Identification; 3D Point Cloud; Individual Tree Segmentation

Mentor(s):

Jinyuan Shao (Agriculture); Songlin Fei (Agriculture)

Presentation Time: Session 1: 10:30-11:30am

Modular Pipeline for Terrain Classification in LiDAR Point Clouds

STEM

Authors(s):
Anna Ospina Bedova†

Abstract:

Ground filtering is an essential preprocessing task in digital forestry and other geospatial applications involving 3D point cloud data. Accurate identification of ground points improves terrain modeling and is critical for downstream tasks such as vegetation analysis and the detection of manmade objects like solar panels. Misclassified ground points can significantly distort these results, highlighting the need for robust filtering strategies. This project presents a modular workflow for ground filtering in LiDAR point clouds, aimed at enhancing terrain classification and enriching publicly available datasets hosted at https://lidar.digitalforestry.org. The main goal is to generate an additional label that distinguishes ground from non-ground points. The method divides large LiDAR scenes into overlapping patches (e.g., 625) using a regular grid. Each patch is processed using local geometric filters based on hyperbolic distance metrics, and a custom classification pipeline assigns binary labels. The patches are then merged to reconstruct the full scene, allowing for visual validation and refinement. Initial results show high accuracy in separating terrain from vegetation and built structures, particularly in forested regions. In Wildland-Urban Interface (WUI) zones, some buildings were misclassified as ground. To address this, we added a correction step using regression and clustering techniques, which improved results in these complex areas. The workflow is designed to be modular, enabling testing of alternative approaches such as hierarchical or sequential clustering, Progressive Morphological Filters, Cloth Simulation Filtering, and Multiscale Curvature Classification. Our approach consistently exceeds baseline methods in challenging environments.

Keywords:

LiDAR Point Clouds; Ground Filtering; Point Cloud Classification; Hyperbolic Distance

Mentor(s):

Baijian Yang (Polytechnic); Tonglin Zhang (Science)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Hong Zhao (Polytechnic)

Presentation Time: Session 1: 10:30-11:30am

A Model for Extragalactic Supernovae Candidates Utilizing Spectral Decomposition and Principal Component Analysis STEM

Authors(s): Zachary Pleska†

Abstract:

Core collapse supernovae (CCSN) are energetic explosions initiated by the gravitational collapse of a massive star's core. These events produce heavy elements and dust that provide the foundation for new stars and planets, making them crucial for the evolution of galaxies. Investigating the nucleosynthetic yields of these explosions and the physical characteristics of the produced dust grains (size, composition, distribution) improves our understanding of CCSN explosion dynamics. However, because CCSN are not abundant in the Milky Way Galaxy, the number of observations with high resolution is limited, becoming a leading factor for the poor dust and elemental constraints using current models. We present an analysis of high-resolution images of the supernova remnant Cassiopeia A made by the James Webb Space Telescope that attempts to address this uncertainty. Using images obtained with the NIRCam and MIRI instruments, we measure the spectral energy distribution of gas and dust between 5 and 25 microns and attempt to identify the dominant components of emission. We aim to model these dominant emission features in order to make estimates about dust properties and correlations between the dust and chemical abundances of the supernova ejecta. Our work on this resolved supernova debris field can inform analyses about unresolved extragalactic supernovae. Z.P. acknowledges NSF support from grants PHY-2244297, PHY-2209451 and AST-2206532, and NASA

Keywords:

Supernovae; Spectroscopy; Digital Imaging; Stellar Evolution; Data Analysis

Mentor(s):

Danny Milisavljevic (Science)

Other Acknowledgement(s): Noah William Zimmer (Science)

Presentation Time: Session 1: 10:30-11:30am

Simulating Wave Propagation in Fractured Media STEM

Authors(s):
Jordan Sexton†

Abstract:

Enhanced Geothermal Systems (EGS) represent the future of geothermal energy production because of the potential to harvest geothermal energy in more regions and generate electricity at greater rates than traditional geothermal systems. EGS differentiates itself from traditional systems by utilizing fractures within underground rocks to provide the necessary flow paths to transfer heat to fluids to generate electricity. The geometry and connectivity of the fractures directly correlate to the electrical generation capacity of EGS.

The Center for Understanding Subsurface Signals and Permeability (CUSSP) group aims to characterize fractures found in EGS for predicting the behavior of subsurface fractures under varying conditions. CUSSP is currently analyzing experiments (EGS Collab) run at Sanford Underground Research Facility (SURF) where geophysical monitoring was used to characterize the geometry and changes in subsurface fractures. CUSSP aims to utilize simulation software, such as Seismic Waves, 4th Edition (SW4), to generate synthetic seismic data to compare to data collected at SURF to verify the spatial distribution of fractures interpreted from the field data.

This project aims to explore the applications of SW4 within CUSSP's goals by testing various simulations representing the EGS Collab experiments. Simulations were conducted with SW4 using material and water interfaces and fractures with geometries and materials representative of the SURF site.

After matching the seismic data, CUSSP plans to use SW4's fracture manipulation capabilities to predict the seismic signals of the fractures at SURF for various physical conditions, such as high and low fluid pressures, changing interface geometry, and thermal gradients.

Keywords:

Geophysics; Simulation; Fractures

Mentor(s):

Laura J Pyrak-Nolte (Science); David D Nolte (Science)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Alexandra Blair Clark (Science)

Presentation Time: Session 1: 10:30-11:30am

Classifying Hamiltonians by time evolution of slater states STEM

Authors(s): Grayson Welch†

Abstract:

Entanglement entropy is a measure of how correlated one part of a quantum system is with another, possibly providing clues on why macroscopic phenomena are emergent from quantum mechanics. In fermionic systems, M-body entanglement entropy measures these correlations between M particles and the remainder of the system. All Nfermion systems have a theoretical upper bound to the entropy defined by a maximally mixed M-body density matrix. We developed software to simulate the Hubbard and t-V models and to track changes in M-body entanglement entropy under time evolution. To observe these changes, we evolved single slater determinant states, which have initially zero entropy, until entropic saturation was reached. In the case of the Hubbard model, the total spin of the initial slater determinant provides a refined upper bound which is less than the absolute upper bound. The arrangement of particles and strength of their interaction energies further contributes to the rate of change of entanglement entropy. The number of neighboring fermions in the t-V model are hypothesized to exhibit similar behavior during evolution of single slater states. There is strong evidence that conserved quantities within a system, such as spin, refine the upper bound of M-body entanglement.

Keywords:

Entanglement; Hamiltonian; Time Evolution; Quantum Mechanics; Software

Mentor(s):

Jukka Ilmari Vayrynen (Science)

Other Acknowledgement(s):

Irakli Giorgadze (Science); Haixuan Huang (Science)

Presentation Time: Session 1: 10:30-11:30am

Identification of HIF1a interacting proteins STEM

Authors(s):

Anya Jolee Piarowski† (Agriculture)

Abstract:

As a heterodimeric transcription factor in charge of keeping cells healthy in hypoxic conditions, Hypoxia inducible factor 1 (HIF1) is critical for many processes within the cell. HIF1a is the alpha subunit of the HIF1 and is degraded when oxygen levels are normal to regulate HIF1 activity, as overactive or underactive HIF1 protein is linked to cardiovascular diseases, cancer, and diabetes. This degradation under normoxic conditions is through a ubiquitination process involving CRL2VHL ubiquitin ligase. Previous works have reported HIF1a can be degraded when CRL2s are inhibited, suggesting a CRL2VHL-independent mechanism for its degradation. In my project, I am using TurbolD, a proximity labeling technique, to find protein candidates for this pathway by biotinylating proteins nearby HIF1a. The Oxygen-Dependent Domain (ODD) isolated from HIF1a has been known to be primarily degraded through the CRL2VHL-dependent degradation pathway. Therefore, we can use a cell line that expresses ODD only as a negative control, and ODD will capture proteins responsible for CRL2VHL-dependent pathway or unrelated background proteins. Through comparing results from HIF1a and ODD, I am expecting to get candidate proteins for the CRL2VHL-independent degradation pathway. Later, further experiments can be performed to confirm each protein's role in the CRL2VHLindependent HIF1a degradation.

Keywords:

HIF1a; ODD; TurboID; Ubiquitination; Degradation

Mentor(s):

Xing Liu (Agriculture)

Other Acknowledgement(s):

Emily Spray (Agriculture); Rajasi Somesh Dravid (Agriculture)

Presentation Time: Session 1: 10:30-11:30am

Engineering flux through the MVA Pathway to Enhance Terpenoid Synthesis in Tomato

STEM

Authors(s):

Justin Ray Walder† (Agriculture)

Abstract:

Terpenoids are a large class of secondary metabolites with important roles in plant defense, growth, and development. These compounds are responsible for pigment formation, flavor development, aroma, and nutritional value in crops. Most tomato varieties have been traditionally bred for traits improving size, pest resistance, and storage, yet have

decreased terpenoid levels. Terpenoids are synthesized from the mevalonic acid (MVA) and methylerythritol phosphate (MEP) pathways. Exchanges of pathway intermediates occur to control flux toward different terpenoids such as lycopene, carotenoids, sterols, ubiquinone, phylloquinone, etc. We hypothesized that targeted over-expression of rate-limiting pathway enzymes could increase levels of terpenoids by increasing the pool size of pathway intermediates. We used transient Agro-infiltration in tomato fruits to over-express key enzymes (AtHMGR-2A-PMK, AtIPK, and RcGFPPS1) of the MVA pathway. We tested our strategy of over-expressing these genes individually and in combination to observe potential additive effects on terpenoid biosynthesis. Since there is crosstalk between the pathways, we measured metabolites, which are predominantly derived from one pathway or the other, such as lycopene, ?-carotene, and phytoene from the MEP pathway, and sterols and ubiquinone from the MVA pathway. Upon analysis, we observed a significant increase in the levels of lycopene, sterols, and ubiquinone in tomato fruits at Br+10 stages. These observations suggest that overexpression of the above genes is responsible for increased levels of MVA intermediate pools and their effective shuttling across the MEP pathway. Based on our transient transformation results in tomato fruit, we expect to see increased terpenoid production in transformed stable lines.

Keywords:

Terpenoids; MVA Pathway; Agro-Infiltration; Tomato; Over-Expression

Mentor(s): Joshua R Widhalm (Agriculture); Mearaj Ahmed Abdul Jabb Shaikh (Agriculture)

Other Acknowledgement(s): Emily Spray (Agriculture); Manuel Bellucci (Agriculture)

Presentation Time: Session 1: 10:30-11:30am

Role of DDX5 Protein Domains in Unfolding the MYC Promoter G-quadruplex

STEM

Auth	ors(s):
Nikki	Chun+

Abstract:

MYC is a highly deregulated oncogene in many human cancers but is hard to directly target at the protein level due to its intrinsically disordered structure. An alternative strategy to target MYC is to lower its cellular levels by reducing its expression. The proximal promoter region of MYC contains a guanine-rich sequence that forms a G-quadruplex (G4) under physiologically relevant conditions. The highly stable MYC promoter Gquadruplex (MycG4) acts as a transcriptional silencer and needs to be actively resolved in cells, DDX5, a DEAD-box helicase protein, can unfold the MycG4 and transactivate MYC transcription. Therefore, the DDX5-MycG4 interaction presents a promising molecular target for downregulating MYC and anti-cancer therapy. However, little is known about how DDX5 binds and unfolds the MycG4. DDX5 is comprised of two main helicase core domains which are flanked by several N and Cterminal disordered domains. Through characterizing the role of each DDX5 domain in MycG4 unfolding, we can understand how DDX5 recognizes and unfolds the MycG4. We have designed, expressed, and purified different truncations of DDX5 protein and tested their activity using a FRET-based G4 unfolding assay to examine the role of each protein domain in G4 unfolding. The results of this study provide a basis for understanding the mechanism of DDX5 unfolding the MycG4 and will guide the design of DDX5 truncation proteins as ideal candidates for future structure determination of the DDX5-MycG4 complex.

Keywords:

[no keywords provided]

Mentor(s):

Danzhou Yang (Pharmacy); Sarah Dagher (Pharmacy)

Presentation Time: Session 1: 10:30-11:30am

Inflammation Pathway: Interactions of Granzyme A (GrA) with Bacterial Lipopolysaccharide (LPS)

STEM

Authors(s): Nyla Gillus†

Abstract:

Granzyme A (GrA) is a serine protease that promotes intestinal inflammation and induces apoptosis-like cell death in bacteria-infected cells. Increased levels of GrA have been found in patients with severe infections caused by gram-negative bacteria. Lipopolysaccharide (LPS), an endotoxin located on the outer membrane of Gram-negative bacteria, triggers the production of pro-inflammatory cytokines such as interleukins (ILs) in the presence of GrA. Previous studies have shown that this GrAand LPS-induced cytokine response is dependent on CD14, suggesting that GrA may be involved in the LPS/Toll-Like Receptor 4 (TLR4) signaling pathway. In this pathway, LPS is first transferred to CD14, which facilitates its recognition by TLR4 and subsequently activates the immune response. However, the mechanism of how GrA interacts with LPS and participates in this signaling transduction remains unclear. The goal of this project is to investigate the binding interaction between GrA and LPS. GrA was cloned into the pET28a plasmid and expressed in E. coli BL21(DE3) cells. The protein was refolded from inclusion bodies and purified via immobilized metal affinity chromatography (IMAC) using a Ni-NTA column. Circular dichroism (CD) spectroscopy was used to assess the secondary structure of GrA, and purified protein was used for crystallization screening. To explore the GrA/LPS interaction, native crystals of GrA will be soaked with bacterial LPS and we will also perform co-crystallization. This study aims to provide structural and mechanistic insights into the role of GrA in modulating the LPS/TLR4 signaling pathway.

Keywords:

Granzyme A; Lipopolysaccharide

Mentor(s):

Nicholas Noinaj (Science); Yi Lien (Science)

Presentation Time: Session 1: 10:30-11:30am

Developing an understanding of the structural basis of VceC induced UPR via the analysis of the VceC-HYPE complex STEM

Authors(s):

Nathalia Liu De Restrepo†

Abstract:

Brucella spp. are Gram-negative coccobacilli that cause brucellosis, a zoonotic disease that significantly impacts livestock in lower-income countries. Infected livestock result in economic losses and pose a public health risk, as contact with infected animals can cause chronic disease in humans. During infection, Brucella enters host cells and utilizes secreted effectors to hijack cellular processes, forming a replication niche within the host endoplasmic reticulum (ER). ER stress occurs during infection and is hypothesized to benefit Brucella's intracellular survival. The Brucella effector VirB-coregulated effector C (VceC) is sufficient to induce the unfolded protein response (UPR) in host cells, though the mechanisms remain poorly understood. Structural studies using X-ray crystallography and AlphaFold modeling suggest that VceC assembles into an octameric beta-propeller structure, with a transmembrane domain that potentially facilitates pore formation in the ER membrane. Despite these insights, VceC demonstrates significant oligomeric conformational flexibility, complicating high-resolution structural characterization. To address this, we aim to generate a stable complex between VceC and HYPE, a human Fic domain-containing protein that regulates ER stress via AMPylation and that has been shown to interact with VceC in vitro. The goal of this project is to produce high quality samples of the VceC-HYPE complex for strucutral analysis via X-Ray crystalography and Cryo-Electron Microscopy. Elucidating the structural basis of VceCmediated UPR activation will enhance our understanding of Brucella pathogenesis and may inform the development of targeted strategies to mitigate the burden of brucellosis in vulnerable populations.

Kevwords:

VceC; HYPE; Unfolded Protein Response; Brucella spp.; Endoplasmic Reticulum

Mentor(s):

Reed Michael Smith (Agriculture); Seema Mattoo (Science)

Other Acknowledgement(s): Nicholas Noinaj (Science)

Presentation Time: Session 1: 10:30-11:30am

F3 Nanobody Purification STEM

Authors(s):
Jasmine McKinnie†

Abstract:

Sialic acids, such as N-Acetylneuraminic acid (Neu5Ac), are widespread nine-carbon sugars typically found at the terminal positions of human glycoconjugates. These molecules play essential roles in host-pathogen interactions, aiding pathogenic bacteria in immune evasion through molecular mimicry. Many bacteria acquire Neu5Ac from host tissues and import it using tripartite ATP-independent periplasmic (TRAP) transporters, which consist of a periplasmic binding protein alongside membrane-spanning components. This study explored protein purification strategies for an engineered F3 nanobody designed to target a Neu5Ac-binding periplasmic protein. A key focus was optimizing buffer conditions to maximize nanobody yield and purity, specifically comparing phosphate-buffered saline (PBS) at pH 8.0 to the standard pH 7.4. Our results indicated that raising the buffer pH led to improved purification outcomes.

Keywords: [no keywords provided]

Mentor(s):

Ramaswamy Subramanian (Science)

Other Acknowledgement(s): Yiyang Cheng (Science)

Presentation Time: Session 1: 10:30-11:30am

Structural Insights into the TIdR-Mediated Transcriptional Repression

STEM

Authors(s): Naomi Nunez†

Abstract:

Transposon associated protein B (TnpB) is a transposon-associated, RNA guided endonuclease regarded as an evolutionary ancestor of the type V CRISPR-Cas family of effectors. These enzymes, like Cas12s, are part of Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR–Cas) systems, a natural adaptive immune system in bacteria. Cas12 proteins use a guide RNA to recognize a matching DNA sequence next to a Protospacer Adjacent Motif (PAM) and cleave it causing a double-stranded DNA break. Similarly, TnpB proteins recognize Transposon Adjacent Motif (TAM) sequence via their REC lobe and cleave DNA using their NUC lobe.

Recent studies have identified a class of protein that evolved from TnpB, known as TnpB-like nuclease-dead repressors (TldRs). Together with their associated ?RNA, these proteins form an ancient RNA-guided system that regulates gene expression, not destroy DNA. The guide sequence of ?RNA pairs with the promoter regions probably inhibits transcription. We've obtained a cryo-EM structure of TldR-?RNA-target DNA ternary complex. With this structure, we hypothesized that by binding to the promoter region, TldR could block the binding of RNA polymerase competitively, interrupting transcription. This project aims to understand the mechanism of TldR-mediated inhibition of transcription using cryo-EM and T7 transcription assay. Additionally, we identified the interaction between TAM sequence and TldR-?RNA complex besed on the structure. Therefore, site-directed mutagenesis will be employed to understand the binding mechanism of TldRs-?RNA and target DNA.

Keywords:

Structural Biology; TldR; Protein; Transcription Inhibition

Mentor(s):

Dan Xie (Science)

Presentation Time: Session 1: 10:30-11:30am

Investigating the Constituently Active Effect of the D-to-Y Mutation in Phospholipase C?

STEM

Authors(s):

Victoria Isabella Porter† (Science)

Abstract:

Phospholipase C (PLC) is a family of enzymes that hydrolyzes phosphatidylinositol 4,5-bisphosphate (PIP2) at the plasma membrane. When a ligand binds to a G protein-coupled receptors (GPCR), G?g/11 disassociates from G?? then binds and activates PLCs causing the hydrolysis of PIP2 into diacylglycerol and inositol triphosphate (IP3). In mammalian PLCs, there is a subfamily called PLC? which includes PLC?1-4, all of which are activated by G?q/11 but only PLC?1-3 are activated by G??. It was unknown if PLC?4 interacted with G??. however, the constituently active D-to-Y mutation at position 630 is potentially inhibited by G??, showing that PLC?4 may interact with G??. To see if the effect of G?? is specific to PLC?4 or specific to the mutation, we are introducing the D-to-Y mutation to PLC?1-3 and performing an in cellulo assay to determine the activity with and without G?q/11 and G??. We expect to see an increase in basal activity in PLC?1-3 with the D-to-Y mutation compared to wild-type. However, we don't expect to see further increase nor decrease in activity when adding either G?q/11 or G??, thus rendering the mutated PLC?1-3 isoforms maximally active. This would show that the effect of G?? is specific to PLC?4 and not specific to the D-to-Y mutation.

Keywords:

Phospholipase C; Inositol Triphosphate; Heterotrimeric G Protein; GPCR; PIP2

Mentor(s):

Angeline M Lyon (Science); Leon Filip Laskowski (Science)

Presentation Time: Session 1: 10:30-11:30am

FLORA: Field and Landscape Observation via Robotic Automation

STEM

Authors(s):

Muhammad Zohaib Ali† (Engineering); Mirza Orunav Shahper‡ (Engineering); Qinjia Xu* (Engineering)

Abstract:

Static sensors and manual surveys lack the spatial flexibility and realtime responsiveness needed for field-scale environmental monitoring. and most commercial UAV kits hide the full hardware-software autonomy pipeline required for repeatable, research-grade data collection. Moreover, many research prototypes rely on manual piloting or semi-autonomous modes, limiting reproducibility and scalability for missions requiring waypoint-based navigation across challenging terrains. In this paper we introduce FLORA (Field and Landscape Observation via Robotic Automation) which addresses these gaps by delivering a fully custom UAV built from the ground up, guided by a systematic literature review of remote-sensing platforms, sensor fusion, swarm coordination, and ecological monitoring needs to enable autonomous, repeatable field observation. The UAV was custom designed from a carbon-fiber airframe paired with brushless motors. ESCs, and a LiPo battery accommodating for 20 min endurance. A SIYI N7 autopilot (ArduPilot) integrates GPS, IMU, barometer, and telemetry. allowing navigation and autonomy. Mission Planner was applied for mission upload, HIL simulation, and real-time telemetry monitoring. Bench tests demonstrated successful hardware integration and reliable calibration and navigation. Indoor flight testing indicated a stable flight for up to 5 minutes. Outdoor missions are being conducted for 10-20 min flight time (to mimic real field navigation). This ground-up autonomy stack validates that a custom UAV can reliably perform waypoint navigation, establishing a modular platform for robot-driven environmental monitoring. Future research areas include integrating multispectral and LiDAR sensors, extending flight endurance, and scaling to multi-UAV cooperative coverage for high-resolution, alongside developing the computer vision analysis model to give a complete robotdriven environmental monitoring.

Keywords:

Robotics; Observation; Field and Landscape; Automation

Mentor(s):

Muhammad Mustafa Hussain (Engineering); Yusuf Kolawole Adebakin (Engineering)

Other Acknowledgement(s):

Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Bioinspired Origami Aerial Robotics STEM

Authors(s):
Juan Sebastian Ardila Lopez†

Abstract:

Transformation between aerial and aquatic modes presents a challenge in the exploration of natural environments and the development of multimodal robots. This work simplifies the biologically complex foldable wings of a flying fish (Exocoetidae) into a set of three foldable origamilike rigid facets with each facet joined together by an elastic hinge. The proposed concept explores the impact of introducing a bistable nonlinear elastic hinge at the facet joints. The bistable hinge is modeled after a prior work conducted on the design of a binder clip inspired (BCI) singledegree-of-freedom unit. Consequently, this leads to a wing design that is also statically stable in two distinct configurations: folded/collapsed and extended/deployed. A multi-degree-of-freedom aeroelastic model is built to approximate the structural response of the deployable wing under subsonic aerodynamic loads. A physical prototype is designed to validate the mathematical model predictions. The wing is placed on a wind tunnel to measure the lift, drag, and wing deflections under subsonic aerodynamic loads using a laser displacement measurement sensor. Variations of the wind speed in the tunnel are made to analyze the experimental relationship between deflection and wind speed and contrast it with the results from the analytical model. Using the experimental data, the model demonstrates high-fidelity predictions, and low-time deployment. The proposed demonstrator and analytical model addresses the challenge of developing a multi-modal robot with origamilike foldable wings that achieves flying-swimming efficient modes of transportation using a compact, lightweight actuation system, and sufficient load bearing capability in its aeroelastic performance.

Keywords:

Bioinspired; Aeroelasticity; Bistability; Origami Structure; Morphing Structure

Mentor(s):

Jose R Rivas (Engineering); Andres Arrieta Diaz (Engineering)

Other Acknowledgement(s): Varun Aggarwal (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Calcium-Dependent Regulation of Tiam1 and CaMKIIy During Mammalian Egg Activation

STEM

Authors(s):

Paula Daniela Avila Martinez†

Abstract:

Egg activation is a calcium (Ca2+)-triggered cascade of events that marks the transition from an unfertilized egg to a developing embryo. Key processes include resumption of meiosis, modification of the egg coat and egg plasma membrane to prevent polyspermy, and regulation of protein and RNA synthesis. CaMKIIy, a calcium/calmodulin-dependent protein kinase II isoform, acts as a known integrator of the Ca2+ signal during this transition. CaMKII exerts its effects through phosphorylation of substrates; the goal of this research is to investigate the possible role of Tiam1 (T-lymphoma invasion and metastasis) as a CaMKIIy substrate in mammalian eggs. Tiam1 is a guanine nucleotide exchange factor that activates small GTPases involved in cytoskeletal remodeling, vesicle trafficking, and cell division. While studies in other systems (e.g., neurons) have shown that Tiam1 participates in Ca2+ -dependent signaling pathways, their interaction and Tiam1's specific role during egg activation remain unclear, despite Tiam1 transcripts being enriched in mouse oocytes. In this study, we investigated the Ca2+ -dependent activation and localization of Tiam1 and CaMKIIy in fertilized and parthenogenetically activated superovulated mouse eggs. The calcium ionophore A23187 was used to artificially elevate

intracellular Ca2+ levels. Protein presence and spatial distribution were assessed by immunofluorescence and analyzed using ImageJ. Both proteins were detected in fertilized and ionophore-treated eggs, with localization in both cortical and cytoplasmic regions. Their localization patterns varied with calcium stimulation, suggesting potential regulation by intracellular Ca2+ levels. These findings provide new insight into how calcium signaling modulates Tiam1 and CaMKIIy activity and positioning during mammalian egg activation.

Keywords:

Egg Activation; Calcium Signaling; CaMKIIy; Tiam1;

Immunofluorescence

Mentor(s):
Agnes Doszpoly (Engineering); Tamara L Kinzer-Ursem (Engineering)
Other Acknowledgement(s):
Emily R Jakob (HHS)

Presentation Time: Session 1: 10:30-11:30am

RELATION BETWEEN LOCATION AND SEVERITY OF RIGHT CORONARY ARTERY LESIONS ON CORONARY ANGIOGRAPHY

STEM

Authors(s):

Phuong Ba†; Thuy Nguyen†; Linh Luu†; Thuy Truong†; Hoang Ly†

Abstract:

Introduction

Coronary artery disease remains a leading cause of death worldwide, primarily due to atherosclerotic lesions that restrict myocardial perfusion. The right coronary artery (RCA) is the second most affected vessel, and lesion location within it may influence the degree of stenosis and clinical outcomes. Understanding this relationship may aid in early risk stratification, treatment planning, and complication prevention. This study evaluates whether a statistically significant association exists between RCA lesion location and stenosis severity using dynamic coronary angiography.

Method

A cross-sectional review was conducted on coronary angiograms from 30 patients presenting with unstable angina. Patients with a history of coronary artery bypass grafting or percutaneous coronary intervention were excluded. Lesions were categorized into four anatomical locations: 1R (mid-segment, proximal), 2R (mid-segment, distal), 3R (distal), and 4R (proximal). Lesions involving multiple sites were considered diffuse. Severity was classified as: no lesion (0%), mild (1–24%), mild-moderate (25–49%), moderate (50–69%), and severe (70–90%). A Chi-square analysis was used to evaluate the association between lesion location and severity.

Result

A significant association was found between RCA lesion location and severity (Chi-Square = 30.694, p = 0.002). Lesions in the 1R segment most frequently showed higher severity, with 25% classified as moderate and 25% as severe. In contrast, 2R and 4R lesions were exclusively mild, while diffuse lesions were associated only with moderate severity.

Conclusion

1R lesions are most prone to severe stenosis, while 2R, 4R and diffuse lesions tend to be milder, possibly reflecting early multi-vessel disease. Identifying high-risk RCA segments may enable earlier, targeted interventions.

Keywords:

Right Coronary Artery; Atherosclerotic Lesions; Myocardial Perfusion; Dynamic Coronary Angiography; Stenosis

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine)

Presentation Time: Session 1: 10:30-11:30am

Association Between Systolic Blood Pressure Levels and Lesion Distribution in the Right Coronary Artery

Authors(s):

Phuong Ba†; Vinh Lam†; Khanh Le†; Barun Agarwalla†; Quan Nguyen†

Abstract:

Introduction

Elevated systolic blood pressure (SBP) is a key risk factor for coronary artery disease, but its link with lesion location in the right coronary artery (RCA) remains unclear. Understanding whether lesion distribution in the RCA varies across SBP categories may aid risk stratification and imaging interpretation for hypertensive patients. This study aimed to investigate the potential relationship between SBP levels and the anatomical location of atherosclerotic lesions in the RCA.

Method

A cross-sectional review was conducted on 30 patients with unstable angina who underwent dynamic coronary angiography. Patients with prior Percutaneous Coronary Intervention or Coronary Artery Bypass Grafting were excluded. Patients were grouped by SBP during dynamic coronary angiography: <120; 120–129; 130–139 and ?140 mm Hg. RCA lesions were classified as 1R (mid-segment, proximal), 2R (mid-segment, distal), 3R (distal), and 4R (proximal). A Chi-square analysis was used to evaluate the association between lesion location and SBP.

Results

Lesions at the 1R segment were most frequently associated with SBP levels greater than 140 mmHg (37.5%). Among patients with SBP above 140 mmHg, the 1R site was the most common lesion location (60%), compared with 0% with 2R lesions, 10% with 4R lesions. Although this association did not reach statistical significance (p = 0.526), it may suggest a trend toward a correlation between elevated SBP and lesion distribution within the RCA.

Conclusion

This suggests a possible correlation between SBP level and 1R lesion, highlighting the importance of effective hypertension management, as

better SBP control may help reduce the prevalence of 1R lesions and improve overall cardiovascular outcomes.

Keywords:

Right Coronary Artery; Atherosclerotic Lesions; Systolic Blood Pressure; Angina

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine)

Presentation Time: Session 1: 10:30-11:30am

Semiconductor Education as the Seed for Nigeria's Tech and Economic Growth

STEM

Authors(s):

Sogo Bakare† (Engineering); Virginia Lucille Hawkins* (Engineering); Steven Li* (Engineering|JMHC); William McMahon* (Engineering)

Abstract:

Nigeria is one of the world's largest consumers of technology but remains heavily dependent on imported semiconductor componentsimporting approximately \$128 million worth of semiconductor devices in 2023 while exporting only \$429,000 worth. This reliance limits domestic innovation, increases vulnerability to fluctuations in the global supply chains, and stifles economic growth. This research explores the question: How can academia, the semiconductor industry, and government policymakers work in harmony to drive sustainable technology and economic development in Nigeria? In this study, the SPICE framework is applied to define the problem scope, and the PRISMA method guides the literature search and review. A qualitative approach was used to analyze four peer-reviewed sources. The analysis draws a connection between the various models discussed in these papers to identify how curriculum design, university-industry collaboration, and state-led incentives can be adapted for Nigeria. The PITCH (Purdue-Ivy Tech Chips) program serves as a strong example of how academia, industry, and government can collaboratively build a more economically sustainable future. The findings emphasize the importance of experiential learning, government-backed R&D, and innovation-friendly policy frameworks. While Nigeria's current semiconductor exports mostly serve nearby nations like Benin and Niger. these trade channels hint at regional leadership potential if supported by systemic reform. This study proposes that the key to building a sustainable semiconductor sector is an integrated education-policy framework to develop a skilled workforce, attract investment, and place Nigeria in a stronger position within the global semiconductor ecosystem -requiring coordinated effort across academia, industry, and government.

Keywords:

Nigeria; Semiconductor Industry; Technology Development; Education-Policy Framework; Economic Sustainability

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Mentor(s):

Yash Ajay Garje (Engineering); Morgan M Hynes (Engineering); Bruce Wellman (Engineering); Labiba Rahman (Engineering)

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Eaton and Palisades: Assessing Post-Wildfire Challenges that Plague the Community

STEM

Authors(s):

Dewayne Eric Ballance† (Science)

Abstract:

This research aims to create a cohesive timeline of the Palisades and Eaton fires, and as well as the many challenges people will face postwildfire. With a cohesive timeline, we will gain a better understanding of the challenges that people face because it provides better information organization and progression tracking. A greater grasp of these challenges will allow for the minimization of chaos and lasting effects of future wildfire. The initial phase of research began with review of literature pertaining to wildfires and their effect on people. The review then expanded to explore challenges that were commonly faced during and after wildfire. Our focus then switched to gathering and organizing the events of the Eaton and Palisades fires into a digestible timeline by searching for news articles, government announcements, and timelines published by a collection of organizations. Both sets of information were then compared to determine the consistency between the literature and the challenges that people of the Eaton and Palisades fires faced. Comparing the Eaton and Palisades timeline with the literature reveals a consistency between the two sets of information. Given the growing threat that wildfire poses each year, understanding the challenges to come will be essential to efficient and maximum recovery.

Keywords:

[no keywords provided]

Mentor(s):

Cristiane Grossi Ferrarezzi (Engineering); Andrew Whelton (Engineering)

Other Acknowledgement(s):

Lipi Roy (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Custom Open-Ephys Plug-In for In-Vivo Experiments Involving Multichannel Stimulation and Recording

Authors(s):

Nicholas Herschel Burris† (Engineering)

Abstract:

Open-Ephys is an open source GUI based electrophysiological experimental workstation software that is becoming a new standard for multi-channel neural engineering research. It is written using JUCE, a platform originally created for multi-track music performance and recording digital audio workstation (DAW), and instantiates a DAW for neuroscientists with a plug-in based architecture that recognizes neuroscientists may not be exceptional software developers. In this work, a custom plug-in was written to support experiments using mutli-channel Low Frequency Alternating Current (LFAC) stimulation. The LFAC waveform, a sinusoid between 0.1 and 10Hz, needed to be generated and presented to an implanted nerve electrode through a custom-built isolated voltage/current source. Although this is currently done using a function generator, expanding the study to multiple channels needed the NI USB-6251 device to implement 2 channels of 2MS/s stimulation and multi-channel 40kS/s recording simultaneously. The custom plug-in allows for control over LFAC frequency, phase, pulse-width time-high, pulse-width time-low, pulse phase, number of pulses in the train, number of LFAC periods before pulse-train, and device auto-connection across 2-channels of LFAC. With the current hardware, the LFAC is limited to a 10kHz maximum frequency and pulse widths of at least 0.5µs. These are both, well within the requirements of the application. The plug-in is currently undergoing usability testing ensuring that the GUI is functional. The plug-in paired with the NI device will then be used in-vivo benchtop application in an earthworm experiment to validate LFAC elicited nerve conduction blocks (NCB).

Keywords:

Neuromodulation; LFAC; Neuroscience; Low Frequency Alternating Current Block

Mentor(s):

Ken Yoshida (Engineering); Nathaniel Liam Lazorchak (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Development of an Experimental Setup to Investigate Commercial Refrigeration Systems with Low-GWP Refrigerants

STEM

Authors(s):

Daniel Jose Carrascal Bonilla†

Abstract:

Vapor compression refrigeration systems are widely used in residential, commercial, and industrial applications. Many of these systems currently depend on high-GWP refrigerants, such as R404A (GWP100yr of 3,900), which contribute significantly to global warming and are subject to increasing regulatory restrictions.

This study investigates the performance of alternative low-GWP refrigerants, specifically R1234ze(E) and CO? (R744), in comparison to R404A. Refrigerants will be tested in an experimental setup consisting of a condensing unit and an evaporator coil under controlled conditions inside a pair of psychrometric chambers. Performance evaluation will focus on key thermodynamic indicators, such as energy consumption, system efficiency, and cooling capacity. A LabVIEW-based real-time monitoring interface has been developed to visualize and record the refrigeration cycle's behavior. This interface will integrate NI cDAQ hardware with temperature, pressure, flow, and power sensors, enabling both real-time analysis and streamlined post-processing. By combining experimental testing with software development, the project aims to create a robust framework for evaluating refrigerant alternatives.

The goal of this work is to identify next-generation refrigerants that maintain or improve the performance of traditional options like R404A. The outcomes of this research are expected to support the transition toward sustainable refrigerant solutions in commercial refrigeration systems.

Keywords:

[no keywords provided]

Mentor(s):

Aaron Jacob Hartzell (Engineering); Davide Ziviani (Engineering)

Other Acknowledgement(s):
Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Modifying Peptide Charge to Enhance Encapsulation in Self-Assembling Nanotubes

STEM

Authors(s):

Wyatt Tristan Carter† (Agriculture)

Abstract:

Peptide biomaterials are an emerging technology that has applications in regenerative medicine. Peptides self-assemble into various structures at the microscale and nanoscale level, including spheres, tubes, and disks. In one example, the trimeric coiled-coil peptide TriNL undergoes hierarchical assembly to form nanotubes with an extensive interior cavity. This cavity incorporates fluorescein labeled anionic dextrans via ionic interactions with the growing nanotubes. Due to the level of cationic amino acids within the TriNL sequence, only negatively charged cargo has been incorporated within the nanotube to date. The aim of this research is to modify the sequence of TriNL to replace specific amino acids to improve the scope of encapsulated cargo. In this work, a modified TriNL peptide was designed called TriNL-K28Q. The modified peptide has replaced positively charged lysine (K) with neutral glutamine (Q) at the 28th position; this modification is to reduce the overall charge of the nanotubes. The peptide was prepared using solid phase peptide synthesis, purified using high pressure liquid chromatography and characterized using MALDI-TOF MS. Scanning electron microscopy was used to investigate the modified peptide structure. TriNL-K28Q was observed assembling into structures about 20 µm long. TriNL-K28Q was tested with anionic, neutral, and cationic dextran and was found to encapsulate anionic and cationic dextran using confocal microscopy. Further testing will be done on determining the charge of TriNLK28Q and quantifying how much dextran is encapsulated in the nanotubes. The development of peptide nanotubes capable of carrying therapeutic biopolymers may have many applications in drug delivery and storage.

Keywords:

Peptide; Biomaterials; Nanotubes

Mentor(s):

Anna Pavlishchuk (Science); Jean A Chmielewski (Science)

Other Acknowledgement(s):

Pranshul Sardana (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Simulative Assessment of Electron Emission Mechanism Transitions in Planar and Non-Planar Nano-Diodes STEM

Authors(s):

Mihajlo-Joshua Foali Deganus† (Engineering)

Abstract:

As electronics continue to decrease in size to the nano-scale, the ability to generalize and understand the limits of nano-electronics becomes increasingly applicable and rewarding. Prior theoretical works have described nexus theory, as well as equating complex geometries to equivalent (canonical) planar systems. This allows for the generalization of full physics models, and the simplification of mathematical and simulation models. These, however, have yet to be fully verified. In this paper, we look at how applying these two methods, independently and in conjunction, compares to simulation results. Specifically, the transitions from the thermionic, field, and space charge limited emission regimes; in both planar (plate-to-plate) and prolate spheroidal (tip-to-plate) geometries. The data for this paper was gathered using the Reykjavík University Molecular Dynamics code for Electron Emission and Dynamics (RUMDEED) simulation code. Voltage was increased across the diode, at a set temperature and gap distance. The current density was calculated by the ramo-current and the emission density data outputs. The planar simulation data shows a smooth but distinct transition between the thermionic, field, and space charge limited emission mechanisms. Canonical plate-to-plate geometries, which possess an equivalent tip-to-plate geometry, have shown that there is indeed a congruence to using an equivalent planar system. These two findings, in concurrence, show that there is indeed much value in simplifying these nano-diode systems, allowing for greater computational efficiency.

Keywords:

Molecular Dynamics; Simulation; Space Charge Limited Current

Mentor(s):

Allison M Komrska (Engineering)

Other Acknowledgement(s):

Radhika Arvind Bhopatkar (Engineering); Allen L Garner (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Modeling Metabolic Dysfunction-Associated Steatotic Liver Disease Using Liver Organoids

STEM

Authors(s):

Anna Catherine Dressman† (Science)

Abstract:

Metabolic dysfunction-associated steatotic liver disease (MASLD) is a progressive liver disease characterized by excessive lipid accumulation in hepatocytes, leading to cellular dysfunction, inflammation, fibrosis. cirrhosis, and increased risk of hepatocellular carcinoma. Affecting nearly 25% of the global population, MASLD is projected to become the leading indication for liver transplantation. Traditional two-dimensional cultures have advanced our understanding of disease mechanisms at the cellular level, however, they are limited in replicating the complex architecture and dynamic cellular interactions present in vivo. To complement these models and enhance physiological relevance, we developed and assessed the capability of three-dimensional mouse and human liver organoid models to recapitulate key pathological features of MASLD, with a focus on hepatic lipid accumulation. Mouse liver organoids were generated from mouse hepatocytes and cultured under soluble conditions to maintain hepatic functionality. Human liver organoids were derived from induced pluripotent stem cell-derived hepatocyte progenitor cells by a two-step differentiation protocol. To induce lipid accumulation, organoids were exposed to varying concentrations of a 1:1 mixture of oleate and palmitate, mimicking the metabolic conditions observed in MASLD patients. Lipid deposition was quantified using Nile Red staining and lipid droplet analysis. Organoids treated with free fatty acids exhibited significantly increased lipid accumulation, validating their potential as an in vitro model for studying early disease pathogenesis. Future studies will focus on optimizing this model by integrating a liveron-a-chip platform to better model additional pathological hallmarks of MASLD, advancing its utility for translational research and preclinical drug screening.

Keywords:

Organoids; Fatty Liver Disease; Free Fatty Acids; Lipids

Mentor(s):

Sunghee Park (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Jiafei Zhu (Engineering); Radhika Arvind Bhopatkar (Engineering); Kylee Gall (Science)

Presentation Time: Session 1: 10:30-11:30am

The Shape of a Molecule Close to a Metal Surface: Insights from Density Functional Theory

STEM

Authors(s):

Carmen Raquel Erickson† (Science|JMHC)

Abstract:

Density functional theory (DFT) at the generalized gradient approximation (GGA) is a well-used model for approximating electronic structure using electron density gradients. The electronic structure of a system can also be modeled using partition DFT (PDFT), which fragments a system into sections to accurately describe molecular properties. Previous studies have shown that GGA-DFT fails to accurately describe the charge transfer of gas-phase reactions on catalytic systems, missing for example a key energy barrier when oxygen molecules approach an aluminum metal surface. Our group proposes the use of PDFT as an alternative method to model the oxygen molecule and aluminum metal interactions. The model was generated using PySCF software to evaluate the reaction barriers and sticking probabilities of an oxygen molecule on an Al(111) slab. This was done by varying the bond length of the oxygen molecule and molecule-metal distance for different sites on the surface. PDFT shows how the metal surface polarizes the electron cloud of the oxygen molecule distorting its shape. These results will provide insight on the kinetics of gas-phase reactions between oxygen and aluminum, key to oxidative catalysis.

Keywords:

DFT; PDFT; Molecule-Metal Interactions; Catalysis

Mentor(s):

Wenlan Miao (Science); Adam Wasserman (Science)

Other Acknowledgement(s):

Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Coated in slime: the physical properties of skin mucus across fish species

STEM

Authors(s):

Gabriela Garcia Cardenas†; Amelia Paige Ringor*

Abstract:

Relatively little is studied on fish skin mucus, but it is believed to protect against infection and improve swimming hydrodynamics by decreasing friction drag. Some studies have demonstrated that drag reduction is influenced by the rheological properties of the mucus, but these ideas have only been demonstrated in a few fish species. Currently, there is a foundational gap in our knowledge of the physical properties of skin mucus across fish species. In this project, we will try to fill these gaps by: 1) measuring the rheological properties of mucus, such as viscosity: 2) testing if mucus properties, such as production, vary among species; and 3) examining if mucus properties are related to body shape, scale presence, or fish habitat. For mucus collection, 14 species of fishes were held. Then mucus was gently scraped using clean bare hands and a metallic spatula. First, to measure viscosity for each species, a rheometer was used at different shear rates that were biologically relevant for fish swimming speeds. Preliminary results indicate that fish mucus is shear thinning, meaning it displays a lower viscosity with increased shearing rate. Second, we ask which species produced the most mucus by measuring mucus volume collected for each species, corrected by the total mass of all sampled fish for that species. Preliminary results indicate that Anguilla rostrata (EeI) is the species that produces the most mucus. This study explores the rheological properties of mucus with the expectation that these contribute to drag reduction and reflect species-specific adaptations.

Keywords:

Rheology; Non-Newtonian Fluid; Fish Slime; Viscoelasticity; Friction Drag

Mentor(s):

Dylan Kenji Wainwright (Science); Hana Noell Larkins (Science); Matthew Kaboolian (Engineering); Kendra A Erk (Engineering)

Other Acknowledgement(s):

Pranshul Sardana (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Structural analysis of EEEV in complex with a patient-derived potently neutralizing intact antibody EEEV-373

STEM

Authors(s): Roberto Angel Garzat

Abstract:

Eastern equine encephalitis virus (EEEV) is an extremely virulent alphavirus. Roughly 5-10% of infected people develop severe encephalitis and the mortality rate among them can be as high as 30%. Additionally, almost 90% of survivors of infection suffer long-term neurological problems. Despite the significant threat that this pathogen represents, there are currently no approved therapeutics or vaccines available for the EEEV virus for human use. Patient-derived neutralizing monoclonal antibodies are promising candidates for potential therapeutics as well as tools to elucidate epitopes on the virus which can then be used for design of vaccines or immunogens. In this report we extend the work on the complex of EEEV with EEEV-373, a potently neutralizing patient-derived antibody. The paper describing this research has been accepted and is about to be published in Nature Communications. The structure of the complex revealed that the antibody displays preferential binding on the virus across the icosahedral twofold. The structure was resolved to 3.8 Å, however, the resolution of the epitope-paratope region reached around 5 Å. Our research is geared toward improving the resolution of the epitope paratope region utilizing the same dataset in cryoSPARC. The main idea behind this is to see if we can resolve the details of the interactions between the CDRs and the residues comprising the epitope. Achieving higher resolution will provide us with as better understanding of this interaction which may aid in development of EEEV-373 as a therapeutic. Additionally, this may also help in designing other inhibitors targeting this particular epitope.

Keywords:

Eastern Equine Encephalitis Virus (EEEV); EEEV-373; Epitope-Paratope; cryoSPARC

Mentor(s):

Richard J Kuhn (Science); Abhishek Bandyopadhyay (Science)

Other Acknowledgement(s):

Andres Catalino Castillo Jimenez (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

A deep-learning based X-ray computed tomography reconstruction model for increasing throughput of imaging data

STEM

Authors(s):
Javier Guio Gomez† (Engineering)

Abstract:

X-ray computed tomography (XCT) is a powerful tool that can provide 3D information of the internal microstructures non-destructively. Due to this, it is widely employed in the semiconductor industry to detect internal defects. XCT works on the principle of taking thousands of X-ray projections at incremental degrees of rotation and reconstructing them into a 3D dataset, which can be very time consuming. Recent advances in machine learning provide new ways to address this challenge. This project explores the use of ZEISS DeepRecon Pro, a deep neural network-based reconstruction tool, to accelerate tomographic imaging by taking fewer projections without compromising image quality. Our study focuses on internal defects in solder ball grid array samples subjected to thermal cycling. The models were trained in full-projection scans and used to reconstruct down-sampled datasets which simulate faster scans to evaluate the model's ability to provide the same level of detail. The ground-truth and model-generated 3D images were compared to assess the model's performance through both visual inspection and quantitative metrics. This study provides insights for improving the robustness and reliability of the DeepRecon Pro model which will establish a foundation for integrating Al-based reconstruction into XCT workflows, making timeefficient and high-quality imaging more accessible for dynamic studies.

Keywords:

[no keywords provided]

Mentor(s):

Nikhilesh Chawla (Engineering); Satyaroop Patnaik (Engineering)

Other Acknowledgement(s): Parth Uday Kelkar (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Life cycle assessment of integrated biochemical and physicochemical processes aimed at recovering critical metals from municipal solid waste in landfills

STEM

Authors(s): Lilyana Gundayao†

Abstract:

Municipal solid waste (MSW) landfills represent an underexplored yet potentially rich secondary source of critical metals such as lithium, cobalt, and rare earth elements. As global demand for these materials accelerates, driven by the transition to renewable energy technologies and electronic infrastructure, the recovery of critical metals from landfill sites offers a promising alternative to environmentally intensive primary production. In addition to using waste, this approach enables a deeper understanding of the complex chemical and biological processes occurring within landfills. This project aims to develop and optimize integrated biochemical and physicochemical processes for the recovery of critical metals from landfill-derived materials, including leachate. A comprehensive life cycle assessment (LCA) and techno-economic analysis will be conducted using a cradle-to-gate analysis. This study will employ openLCA, an open-source LCA software tool. Using openLCA, the environmental impacts of secondary metal production through recovery from MSW landfills will be evaluated and compared to previously conducted studies of primary metal production from mining. The goal is to assess the environmental and economic viability of critical metal recovery compared to current business-as-usual approaches. The analysis will quantify and compare global warming potential, water consumption, and resource depletion of each scenario. These indicators will inform the scalability and feasibility of landfill-based recovery strategies and help evaluate their potential to support a circular economy and reduce reliance on primary metal extraction.

Keywords:
[no keywords provided]

Mentor(s): Inez Hua (Engineering) Other Acknowledgement(s): Varun Aggarwal (Engineering); Amisha Shah (Engineering); Caitlin Rose Proctor (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Potential enhanced degradation of contaminants when reacting with free chlorine adsorbed onto media used in tap water pitcher filters

STEM

Authors(s):
Juliana Gutierrez†

Abstract:

Growing public concern over water quality coupled with increasing violations of drinking water regulations has increased widespread reliance on pitcher filters for at-home treatment. While these filters are known to remove chlorine effectively, most studies only focus on contaminant removal efficiency without investigating the underlying mechanisms, leaving a critical knowledge gap regarding the current condition of the chlorine in the water. To address this, the present study seeks to assess whether free chlorine adsorbs onto pitcher filter media without undergoing chemical transformations or chemically decomposes to form other secondary reactive intermediates. Regarding this, different masses (1-2.5g) of the mixed filter media and each media component were exposed to free chlorine at 4 mg/L to monitor its concentration over time, resulting in a noticeable decrease. Additionally, spectrophotometric analysis was employed along with triplicate testing for precise outcomes. Initial results showed removal percentages over 90% for all mixed filter media masses, presenting a maximum value of 96.79% for 1.5g. This work demonstrates that pitcher water filters effectively remove chlorine from the agueous phase, although it remains unclear whether the chlorine is being adsorbed onto the solid phase filter media or undergoes a chemical reaction. Future research intends to develop mass balances for obtaining a better understanding of the free chlorine behavior when interacting with the media and to determine if it chemically degrades to form reactive intermediates, that may then react with other contaminants in solution.

Keywords:

Pitcher Filter; Chlorine; Drinking Water Treatment; Mass Balance

Mentor(s):

Amisha Shah (Engineering)

Other Acknowledgement(s): Andres Catalino Castillo Jimenez (Engineering); Goeun Jang (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Al in Ideation: Is it hurting or helping? A qualitative analysis of student discourse during engagement with the engineering design process

STEM

Authors(s):

Virginia Lucille Hawkins† (Engineering); Sogo Bakare* (Engineering); William McMahon* (Engineering); Steven Li* (Engineering|JMHC)

Abstract:

Given the nascent stage of AI in P-12 STEM education and the open access to these resources, it is critical to study the implications of AI in idea generation and cognitive engagement in students. This project seeks to evaluate the impact of utilizing generative AI during the ideation stage of the Engineering Design Process on projects produced by participants in the Purdue-Ivy Tech Chips (PITCH) summer program. After introducing the final design project to students, audio samples were collected of three teams' ideation phases. Based on the quality and completeness of other observed conversations, five additional teams were selected for interviews regarding their ideation process. At the end of the planning session, all participants were asked to voluntarily fill out a form with questions pertaining to their ideation stage. This qualitative data will be coded to recognize the cognitive phases students went through, comparing the results of those who used generative AI in the process to those who did not. Additionally, students' final designs were visually captured through photos and videos. These artifacts will be evaluated according to a standardized rubric to determine if Al use in early design phases significantly impacted a group's output. Conclusions from this research aim to better understand when and how Al tools can be integrated to best supplement ideation for high school students. Consequently, this lends itself to a recommendation suggesting intentionally integrating AI into various aspects of engineering curricula to fully tap the benefits of the Engineering Design Process.

Keywords:

Ideation; Artificial Intelligence; Engineering Design Process; Integration

Mentor(s):

Yash Ajay Garje (Engineering); Bruce Wellman (Engineering); Labiba Rahman (Engineering); Morgan M Hynes (Engineering)

Other Acknowledgement(s): Ioanna Katsamba (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Waveguide-Coupled Rydberg Excitons in Cuprous Oxide for Integrated Quantum Photonics

STEM

Authors(s):

Julio Herreros Garcia† (Engineering); Ruben Canora Alvarez* (Engineering)

Abstract:

Cuprous oxide (Cu2O) has emerged as a promising platform for quantum photonics due to its large exciton binding energy and ability to host Rydberg excitons – highly excited states with large spatial extent and strong nonlinear interactions. These features make Cu2O ideal for studying excitonic coupling in integrated photonic structures. Our research investigates whether Rydberg excitons in Cu2O can couple effectively to on-chip waveguides, which would mark a significant step toward scalable quantum photonics devices. Using multi-layer electron beam lithography both Cu2O pillar and waveguide are embedded in custom-fabricated photonics chips. This way we can explore both resonant and non-resonant techniques at cryogenic temperatures. (~4K). Our methods include the automation of a tunable continuous-wave laser system with piezo and motor control, synchronized with wavelength meter and photodetector readouts. Spatially resolved photoluminescence measurements were conducted across the chip for assessing the optical quality of individual pillars and identifying promising coupling sites. While our results revealed strong excitonic emission from selected pillars, preliminary tests showed limited evidence of successful outcoupling from the waveguides. After a thorough investigation, new measurements yield convincing results of successful coupling and outcoupling of light. These results have laid the groundwork for future investigations in which hopefully, higher n Rydberg states can be seen. Ultimately, this study contributes foundational insights for integrating Rydberg excitons into photonic architectures and informs futures designs involving ring resonators and more advanced coupling schemes.

Keywords:

Photonics; Rydberg Excitons

Mentor(s):

Hadiseh Alaeian (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Optical measurements of quantum effects in gaseous cesium STEM

Authors(s): Silas U Hokanson† (Engineering)

Abstract:

The weak force interaction is a major topic of study in the field of nuclear particle physics. It is notable for the phenomenon of Parity Non Conservation, also known as PNC, where the principle of parity symmetry is broken. Furthermore, various interactions do not obey the basic standard model of particle physics, and therefore various extensions to the standard model have been proposed. In order to constrain these extensions, this research aims to conduct measurements of different electric dipole matrix elements in the cesium nucleus. By measuring these elements precisely, we can measure precisely the value of the beta constant. By combining a precise measurement of beta with a theoretically computed value for M1HF, it is possible to compute EPNC, which allows measurement of the weak charge. Ultimately the goal of this research is to arrive at an extremely precise measurement of the strength of the weak force, which can explicitly rule out certain extensions to the standard model of particle physics. These precision measurements were obtained through various optical setups. Important tasks ranged from constructing stable high-speed voltage switching sources, stabilizing laser power and frequency, and CMOS beam profilers. Measurement systems included Lock-in amplifiers, photodiodes, and spectrum analyzers.

Keywords:

Cesium; PNC; Optics; Quantum

Mentor(s):

Daniel S Elliott (Engineering)

Other Acknowledgement(s):

Jonah Alexander Quirk (Engineering); Diego Esteban Garcia (Science); Pranshul Sardana (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Acoustic Enhancement of Porous Filters in HVAC Systems for Submicron Bioaerosol Removal

STEM

Authors(s):

Tyler James Hughes† (Engineering)

Abstract:

The average person spends 80-90% of their life indoors, making indoor air quality especially important. However, many Heating, Ventilation, and Air Conditioning (HVAC) systems struggle to remove common viruses from the air due to the particles' size. It is known that restrictive filters and acoustically enhanced HVAC systems can increase the capture efficiency of these particles. Restrictive filters are shown to have much less space between each fiber and are tightly woven, making them expensive relative to more porous filters. Acoustics have been shown to increase particle interaction with filters and channel walls through acoustic streaming, radiation forces, and the interaction force. Our lab aims to experimentally test if highly porous filters with acoustical interaction can perform similarly to highly restrictive filters. Experimental testing was done using the Aerogen Solo Nebulizer to generate particles at different sizes and measured using an optical particle scanner (OPS) and a scanning mobility particle sizer (SMPS). Using these scanners, the capture efficiency can be calculated by dividing the concentration of particles downstream by the concentration upstream and subtracting that from one. Early simulations have shown that the capture efficiency of a channel can increase by upwards of 123 times when acoustics is introduced. Additional research can be done into the fiber arrangement, shape, and material, as well as the frequency and amplitude of the acoustic field. Acoustically enhanced filtration has been shown to be a highly promising technology for removing viruses and leading to a healthier world.

Keywords:

[no keywords provided]

Mentor(s):

Sudharshan Anandan (Engineering)

Other Acknowledgement(s):

Ioanna Katsamba (Engineering)

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Presentation Time: Session 1: 10:30-11:30am

Studying the Formation of Metal Chalcogenide Clusters with Bidentate Ligands via Ligand Exchange.

STEM

Authors(s): Ilivas Iznat†

Abstract:

Metal chalcogenide clusters, with a basic formula of M6E8L6 or M3E3HL5 in the case of nickel (M-transition metal, E – Se, S, or Te, Lligand), have applications in fields ranging from electronics and energy storage to catalysis. The cluster core is formed and stabilized by the ligands. The composition of the cluster core and the ligands used can alter the magnetic properties, and the thermal and electrical conductivity of the material will vary based on the composition of the cluster core and the ligands attached to the core. It is often difficult to directly synthesize these clusters with certain ligands, so synthesizing clusters and then exchanging the ligands bound to the clusters is a promising alternative approach for cluster synthesis. For this project, we want to substitute two monodentate phosphine ligands in cobalt and nickel clusters with a single bidentate diphosphine ligand. The ligand exchange will be monitored by electrospray ionization time-of-flight mass spectrometry (ESI-TOF-MS) and peak assignments will be made based on accurate mass to charge ratio and isotope distribution. By starting with different monodentate phosphine ligands bound to the cluster, different substitution results with the diphosphine ligand are expected because of the initial ligand's size and its bonding energy with the metal. Collisioninduced dissociation (CID) will be used to reveal information about the clusters' stability with different ligand attachments. Overall, the project investigates synthesis, kinetics, and fragmentation of these clusters whose electromagnetic and catalytic properties are of interest.

Keywords:

Metal Chalcogenide Clusters; Ligand Exchange; Bidentate Ligands; Diphoshpine

Mentor(s):

Julia Laskin (Science); Bethany Ana Phillips (Science)

Presentation Time: Session 1: 10:30-11:30am

Optimizing Lookups in Modern Computer Architecture STEM

Authors(s):

Partth Suraj Kulkarni† (Science|JMHC); Mukul Agarwal* (Science); Kian Darius Kasad* (Science); Anish Mangla* (Science); Aaryan Deepak Wadhwani* (Science); Lillith Erickson* (Science)

Abstract:

Hash tables are widely used for fast data retrieval, but their performance can suffer when many keys hash to the same bucket. In such cases, traditional chaining methods use linked lists, which have poor cache performance and linear lookup time. This research explores a more efficient approach by replacing linked lists in hash buckets with AVL trees, which maintain balance and offer logarithmic lookup time.

We implemented this hybrid structure in C++, where each bucket stores keys in an AVL tree instead of a list. The project also involved optimizing memory layout for cache efficiency and comparing the performance against the standard unordered_map from the C++ Standard Library. We tested the implementation under a variety of key distributions, including cases designed to trigger many collisions.

Initial results show that the AVL-based buckets maintain consistent logarithmic access time, even under heavy collision scenarios. Compared to linked-list chaining, our structure shows better worst-case performance and reduced variance in lookup times.

This project demonstrates a practical improvement to hash table design for modern systems. In the future, we plan to extend the design to support concurrent operations and to explore when the structure should dynamically switch between lists and trees based on usage.

Keywords:

Optimization; Vector Computing; Data Structures; Performance Analysis; Computer Architecture

Mentor(s):

Gustavo Rodriguez-Rivera (Science)

Other Acknowledgement(s): Lipi Roy (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Parametric Study on Development Length for Post-Installed Rebar

STEM

Authors(s):

Alex Ertang Kuo† (Engineering)

Abstract:

Some bridges become traffic choke points due to lane reductions. The current solution is widening the bridge by jackhammering existing concrete to expose cast-in rebar, then splicing new rebar and pouring concrete. However, this method is time-consuming and may damage the existing structure, potentially reducing the bridge's load capacity. An alternative approach is to use post-installed rebar by drilling holes near existing rebar, anchoring new rebar with mortar, and then pouring new concrete. This avoids damaging the original concrete and is more efficient. To evaluate this method's effectiveness, the lab is testing postinstalled rebar specimens to validate simulation results. In parallel, the team is conducting a parametric study using finite element (FE) analysis with MASA (Macroscopic Space Analysis) as the solver. The study aims to develop an expression for the development length of post-installed rebar like the one provided in ACI 318 (2025) for cast-in rebar. Variables such as top cover, side cover, embedment depth, and bar diameter are altered one at a time in simulations to assess their influence on rebar capacity and failure mode. This systematic approach helps isolate the effects of each parameter to find the coefficients for the expression. Ultimately, creating a reliable expression for post-installed rebar development length will improve bridge extension practices by making design both faster and more efficient.

Keywords:

[no keywords provided]

Mentor(s):

Dheeraj Govindrao Waghmare (Engineering); Akanshu Sharma (Engineering)

Other Acknowledgement(s):

Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Exploring Interdependencies Between Self-Confidence, Workload, and Learning Stage For Intelligent Tutoring Systems

STEM

Authors(s):

Henry J Lee† (Science|JMHC|Graduate)

Abstract:

Intelligent tutoring systems (ITSs) have been utilized to assist humans in learning new skills in psychomotor learning. Self-confidence, workload, and learning stage are three important factors that contribute to psychomotor learning. Self-confidence and workload have been shown to influence learning outcomes, and psychomotor task performance can be measured in terms of the learning stage. To design ITS algorithms. models will need to capture interactions between relevant cognitive stages and learning outcomes. Previous works utilized reinforcement learning methods by training self-confidence state, workload state, and learning stage state Markov decision process (MDP) models to improve ITS's assistance capability and the models were trained with the assumption that the states were independent from one another. However, there may be cases where the states could be interdependent (e.g., the relationship between self-confidence and learning progression), or a different model can be explored entirely. In this work, the MDP framework is modified to capture and investigate the interdependencies between different cognitive states, including self-confidence, workload, and learning stage. Our findings suggest that coupling self-confidence with workload or learning stage may enhance the model's predictive capabilities; however, the increased number of model parameters in these coupling states could lead to overfitting. Additionally, we investigate how the models could be improved through k-means clustering, resulting in multiple models for each state to capture a range of human cognitive state behavior.

Keywords:

Intelligent Tutoring Systems (ITS); Cognitive State Modeling; Markov Decision Process; Reinforcement Learning

Mentor(s):

Madeleine Shuhn Tsua Yuh (Engineering); Neera Jain (Engineering)

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Investigating Microbes and Their Connection to Metals in Municipal Solid Waste Landfill Leachate with Simulated Bioreactors

STEM

Authors(s):
Oliver Yichi Li† (Engineering|JMHC)

Abstract:

The importance of rare earth metals (REMs) and other metals has increased as technology develops and trade conflicts arise. Securing a domestic supply chain of these metals will prove vital both economically and politically. One promising source is municipal solid waste (MSW) landfills; REMs, platinum group metals (PGMs), and other valuable metals have been found in noteworthy concentrations in MSW landfills. This research aims to investigate the possibility of recovering metals from leachate by characterizing the bacteria responsible for bioleaching metals into MSW leachate. A prototype batch bioreactor was constructed and filled with simulated MSW and Type 1 water. Nickel, cobalt-chrome, and aluminum coupons were submerged into waste. The bioreactor appearance, gas production, and physical changes on the coupons were observed. Along with visual and physical observations, DNA on the surface of each coupon will be extracted and analyzed to characterize the communities responsible for bioleaching metals into leachate. The bioreactor demonstrated promising visual signs of waste decomposition and biological activity. CO2 monitoring indicated anaerobic behavior in the current bioreactor environment as concentrations exceeded 10,000 ppm. Additionally, coupon colors changed during interaction with waste. Extraction of DNA from coupons is expected to allow for characterization of the community involved in bioleaching metals and is expected to vary significantly from other materials' biofilms. The success of this research can allow manipulation of communities involved in bioleaching metals into leachate. Utilizing microbial behavior to leach and therefore recover metals from MSW waste will not only enable economic benefits but will also provide a cost-effective means in a time of increasing demand.

Keywords:

Landfill Leachate; Metal Recovery; Municipal Solid Waste; Rare Earth Metals: Bioreactor

Mentor(s): Caitlin Rose Proctor (Engineering); Jorge Martinez Del'Angel (Agriculture)

Other Acknowledgement(s): Inez Hua (Engineering); Amisha Shah (Engineering); Parth Uday Kelkar (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Mineral Precipitation and Surface Roughness in Fractured amphibolite Rocks

STEM

Authors(s): Brenda Sofia Lizarazo Olivera†

Abstract:

This study aims to answer the question: How do these factors affect calcium carbonate growth in fractured rock? To explore this, we designed an experimental protocol with four main stages: (1) characterization of fluid chemistry and supersaturation conditions (log(?CaCO3) = 3.13, pH \sim 8.2); (2) 3D design and printing of a holder to support the rock in X-ray scanning; (3) monitoring the process using pH and conductivity sensors; and (4) high-resolution X-ray microCT imaging (\sim 18 µm voxel size) before and after the experiment.

Initial static experiments showed visible precipitation, but only under specific conditions (NaHCO3 330 mM + CaCl2 15 mM). An attempt to implement continuous flow failed due to rapid crystal growth clogging the tubing. The proposed alternative setup, which included continuous stirring with a magnetic plate and replacing the solution every 24 hours through a controlled inflow-outflow system, also failed. As a result, the static experiment was chosen instead. This approach aims to produce calcite layers of at least 5 μm within 48 hours. The protocol will contribute to improving models of fracture evolution and support the development of more effective strategies for geological carbon storage.

Keywords:

Calcium Carbonate Precipitation; Fractured Rock; Supersaturation

Mentor(s):

Laura J Pyrak-Nolte (Science); Alexandra Blair Clark (Science)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Physical Characterization of Indoor Dust from Homes in New York City, NY and West Lafayette, IN Using Laser Diffraction and Static Image Analysis

STEM

Authors(s): Minh An Nguyen Luu†

Abstract:

Infants can be exposed to environmental toxicants in indoor dust via ingestion and inhalation, processes that are sensitive to dust particle size. Hence, it is vital to study the physical properties of indoor settled dust. This study aims to examine the variation in indoor dust mass loadings and their particle size distributions, density, and morphology across diverse residential settings in the U.S., including both suburban/rural homes in West Lafayette/Lafayette, Indiana and urban homes in New York City, New York. Indoor dust samples were collected from homes with infants using a standardized vacuum protocol. The collected dust samples are pre-processed using mechanical sieving and then weighed with a high-precision analytical balance to determine indoor dust mass loading. Subsequently, a portion of the dust is used to characterize the particle size distribution via laser diffraction, density via a helium pycnometer, and morphology via static image analysis. Results indicate dust mass loading on carpets was significantly higher than on hardwood floors across urban and suburban/rural locations. Additionally, the dust mass loading was found to be the highest in the entryway, followed by the living room, and least in the bedroom. Particle volume size distribution results show wide variation with sizes, with two modes present: one in the sub-100?mm size range and another in the super-100?mm size range. Such physical characterization of indoor dust will assist in modeling infant dust exposure in home environments.

Keywords:

Environmental Characterization; Dust Morphology; Particle Size Distributions; Indoor Aerosols

Mentor(s):

Brandon Boor (Engineering); Satya Sundar Patra (Engineering)

Other Acknowledgement(s):

Pranshul Sardana (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Insights into Antibody Binding Sites Through Structural Analysis of HCV E1E2

STEM

Authors(s):
Nicole Martinez†

Abstract:

Affecting over 50 million people and causing 250,000 deaths annually, Hepatitis C virus (HCV) remains a major global health challenge with no approved vaccine. HCV is an RNA virus whose envelope glycoproteins, E1 and E2, form a heterodimer critical for host cell entry. The virus's high genetic variability and lack of a definitive structural model have long hindered efforts to design highly effective vaccines and identify conserved regions targeted by broadly neutralizing antibodies (bNAbs). Recent studies have made substantial progress by resolving more comprehensive structures of the E1E2 heterodimer in complex with human bNAbs, offering new insights into conformational dynamics, epitope accessibility, and potential immune vulnerabilities. This research evaluates recent structural models of the E1E2 complex, focusing on differences between Protein Data Bank (PDB) entries 8RJJ and 7T6X and their interactions with bNAbs. Using PyMOL and structural analysis, five bNAbs and their corresponding E2 sequence residues were examined to assess how each epitope region aligns with the active binding surface of the antibody and the referenced complexes. This approach allowed for precise mapping of epitope positions relative to structural variations, showing that antibodies can bind similar epitope sequences even when the epitopes are in different conformations. Crucially, the antibody-binding landscapes of 8RJJ and 7T6X exhibited important conformational differences regarding the flexible E2 front layer, altering bNAb engagement and epitope accessibility. These findings reveal that epitope presentation depends on structural context. HC11 and AR4A, a non-competing antibody pair, bind E1E2 across conformations, aiding conserved epitope mapping and informing vaccine and immunology research.

Keywords:

Hepatitis C Virus (HCV); E1E2 Glycoprotein Heterodimer; Structural Virology; Epitope Mapping; Conformational Dynamics

Mentor(s):

Richard J Kuhn (Science); Ryan George Peters (Science)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Analysis on the effectiveness of LLM's to assist inexperienced programmers in the debugging and generation of basic python scripts

STEM

Authors(s):

William McMahon† (Engineering); Virginia Lucille Hawkins* (Engineering); Steven Li* (Engineering|JMHC); Sogo Bakare* (Engineering)

Abstract:

Large Language Models (LLM) are excellent tools for programmers when used intentionally. They are especially useful in helping novice programmers accelerate their learning curve, as LLM can bridge the prerequisite knowledge gaps. LLM however are very broad in their output. and novice programmers lack the basic syntax knowledge and general programming skill to understand how to properly debug issues that could arise while coding. To solve this problem, this research aims to develop simple prompts and guidance for novice programmers in their interactions with LLM, so that they have a smoother learning experience with the LLM, thus minimizing cognitive overload and frustration. Rising Juniors and Seniors in the greater Lafayette area participated in PITCH, a two-week semiconductor focused program that culminated in a final design project. This final project consisted of 4-5 students working together with a browser based LLM to create a script for a "lilybot", a simple two wheeled robot with numerous sensors. We qualitatively analyzed the student interactions with Coderobots.ai (an online Chatbot powered through OpenAl's ChatGPT) and studied the questions asked by the students and the challenges they encountered in their learning process. Preliminary conclusions indicate that due to the lack of technical knowledge, students were unable to properly articulate their requests, thus making it difficult for the LLM to create the desired scripts. This research seeks to evaluate how structured support and guided prompting can enhance the effectiveness of LLM's in helping novice programmers generate functional python scripts.

Keywords:

Artificial Intelligence; Prompt Engineering; Programming Education; Al-Assisted Programing; Python

Mentor(s):

Yash Ajay Garje (Engineering); Morgan M Hynes (Engineering); Labiba Rahman (Engineering); Bruce Wellman (Engineering)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Time Series Analysis of SAR Backscatter STEM

Authors(s):

Grace Guan Man Meyer† (Hillsdale College); Emiko A Sano*

Abstract:

Effective farm management for optimal crop yield requires continuous monitoring of key indicators of crop and soil health, with soil moisture being one of the most critical parameters. While in-situ soil moisture sensors provide accurate point measurements, their spatial coverage is often insufficient to capture the heterogeneity across agricultural fields. Synthetic Aperture Radar (SAR) offers a promising alternative by indirectly estimating soil moisture through analysis of radar backscatter. Its sensitivity to surface dielectric properties and increased spatial coverage enables detection of the heterogeneity of agricultural fields. In this study, we developed a time series model for soil moisture retrieval using high-resolution S-band UAV-based SAR imagery. Data collection occurred biweekly from March to October during the 2024 and 2025 growing seasons. Ground truth soil moisture data were acquired through buried sensors, handheld probes, and soil sampling. The SAR backscatter was calibrated, converted to decibel values, and analyzed over time. An empirical model linking SAR backscatter to soil moisture was developed using linear regression techniques. This model will be validated against in-situ measurements across varying soil textures, roughness conditions, and vegetation cover types. Successful validation would demonstrate the model's potential for scalable, high-resolution soil moisture monitoring in precision agriculture. Future work will investigate its generalizability to broader land covers and under different viewing geometries.

Keywords:

Synthetic Aperture Radar (SAR); Unmanned Aerial Vehicle (UAV); Soil Moisture; Time Series; Drone

Mentor(s):

Melba M Crawford (Engineering); Weihang Li (Engineering); Fatemeh Azimi (Engineering)

Other Acknowledgement(s):

Varun Aggarwal (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Influence of Base Plate Thickness and Anchor Spacing on Combined Concrete and Pullout Failure of Bonded Anchors Under Tension

STEM

Authors(s):

Ngoc Gia Khang Nguyen† (Engineering)

Abstract:

Bonded anchors offer a cost- and labor-efficient solution for bonding concrete to dissimilar material. Their diverse dimensional configurations and high load-carrying capacity enable broad structural applications, such as anchoring the base of traffic light poles to concrete foundations. This research paper aims to predict the performance of 1×2 and 1×3 bonded anchor groups under combined pull-out and concrete cone failure (CC+PO) by accounting for the effects of base plate thickness and anchor spacing on load capacity and failure behavior. Previous studies have shown that the semi-empirical design model presented in EN 1992-4 provides inadequate estimations for this failure mechanism, as it fails to consider these parameters. The study was conducted in two phases: 3 dimensional nonlinear finite element models are developed, and validated with the existing experimental database. Further parametric numerical investigation is carried out by varying different parameters such as anchor configuration, base plate thickness, and material properties. The results from the FEA, experimental tests, are then compared with the predictions made using EN 1992-4 equations. Based on the collected data, equations to account for the effects of base plate thickness and anchor spacing are developed, aiming to correct discrepancies in the EN 1992-4 predictions and more accurately reflect actual anchor performance. Studying the relatively simple 1×2 and 1×3 anchor group configurations provides foundational insights and establishes a transferable methodology applicable to larger, more complex bonded anchor group arrangements.

Keywords:

Concrete; Bonded Anchor; FEA; Efficient Construction

Mentor(s):

Gaurav Somnath Chobe (Engineering)

Other Acknowledgement(s):

Ioanna Katsamba (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Bridging Lab and Field: A UWB SAR Testbed for Practical Sensing and Imaging Applications

STEM

Authors(s):	
Khang Nguyen	t

Abstract:

[Abstract Redacted]

Keywords:

Synthetic Aperture Radar (SAR); Unmanned Aerial Vehicle (UAV); Radar Imaging

Mentor(s):

Chunyi Peng (Science)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Modelling Deformable Cells in Inertial Flow Using Spherical Harmonics

STEM

Authors(s):

Brijesh B Patel† (Science); Alexander G Kelley‡ (Science)

Abstract:

Flow cytometry is used in various biological applications for categorizing different cells. It works by exploiting the inertial focusing of particles in flow. While this effect is well studied for rigid bodies, most cells of interest are deformable. The shape and position of soft cells during flow is not well known, though there is consensus that the elasticity of the cell plays an important role. Typically, cell dynamics are calculated numerically by discretizing the surface of the cell and running simulations of the flow. However, these simulations are computationally expensive and full solutions are only known for a few parameters. Additionally, experimental data is difficult to analyze due to the fast speed and small scale of the particles. Yet the principal factor determining the particle's focusing position is the shape of the particle, which depends on the elasticity of the cell. In order to reduce complexity, we build a reduced order model of the cell using spherical harmonics. Assuming the cell's volume remains constant through deformation, the cell's surface can be approximated with linear combinations of spherical harmonics. We developed an algorithm to fit these data using image processing and optimization, allowing us to analyze the coefficients. We then validate the model against experimental image data and previous simulation work under different elasticities and flow conditions. The data can then be used to construct a catalog of cell shapes to help aid in simulations.

Keywords:

Math Modelling; Inertial Focusing; Spherical Harmonics; Optimization

Mentor(s):

Kaitlyn T. Hood (Science)

Other Acknowledgement(s):

Varun Aggarwal (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Characterization of droplet breakup dynamics for water–isopropyl alcohol droplets in shock-induced flow conditions STEM

Authors(s):

Soham Pawaskar† (Engineering|Liberal Arts); Matthew S Leight‡ (Engineering|JMHC)

Abstract:

As high-speed aircraft traverse atmospheric regions, micron-scale droplets suspended in the air can interact with the produced shock fronts and potentially contribute to vehicle surface degradation, presenting the need for improved physical understanding and modeling of these interactions, which remains limited in current literature. This study investigates the shock-induced breakup of aqueous droplets using Purdue's 3-inch shock tube (P3IST) to characterize how droplet behavior varies across a range of flow conditions relevant to high-speed atmospheric flight, thereby supporting the development of a predictive model for droplet fragmentation. Droplets 150-300?microns in diameter, formed with solutions of water and isopropyl alcohol to vary surface tension, are dispensed into the driven section using a high-speed actuator. Shock waves producing flow speeds ranging from Mach 1 to 3 are initiated by a manually triggered electronic diaphragm burst system. The droplet breakup caused by the passing of the incident shock is captured by a high-speed camera focused through a Schlieren optical setup. Pressure data collected by a series of pressure transducers is used to quantify the temporal and spatial development of the shock. Observed breakup mechanisms followed vibrational, bag, bag-stamen, stripping, and potential transitional types. A physical correlation was established between the breakup mode and the Reynolds and Weber numbers describing flow and droplet properties, indicating the existence of three general regimes. However, further study is needed to improve the prediction and classification of transitional breakup types, and future research will separately investigate ice particle interactions to better represent conditions encountered at higher altitudes.

Keywords:

Shock Wave; Droplet Breakup; Purdue 3-Inch Shock Tube

Mentor(s):

Joseph S Jewell (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Coupled Risks of Lead Exposure and Genetic Variations in Alzheimer's Disease

STEM

Authors(s):

Kiersten Mackenzie Penquite† (Engineering|JMHC)

Abstract:

Alzheimer's Disease makes up around 70% of dementia cases and results in faster cognitive decline. While the exact cause of AD is unknown, various genetic factors and environmental factors can increase an individual's risk of developing AD. One such environmental factor that has been linked to AD is lead exposure which was common around the 1970s when lead was commonly used in paint, soldering for water lines. and other industrial processes. However, it is not known how different genetic variations coupled with lead exposure affect the risk of AD development. Therefore, by utilizing CRISPR gene editing technology, a variety of genetic conditions can be introduced to induced neurons in a lab with lead exposure to study their combined effects on cell behavior. Data will be collected with CRISPR Droplet sequencing(CROP-seq) which will provide the transcriptome of each cell along with which gene has been edited. Additionally, cells will be grouped by expression of the protein tau which is found in high levels in AD patients. Based on the results of the CROP-seq it will be possible to determine which genetic conditions with lead exposure result in a similar pathology in the cultured neurons as is seen in native AD cases. By comparing transcriptome data and tau accumulation under lead exposure, it will be possible to identify gene-environment interactions that result in phenotypes like AD.

Keywords:

Alzheimer; CROP-seg; iPSCs; Tau Protein; Neurons

Mentor(s):

Junkai Xie (Engineering)

Other Acknowledgement(s):

Varun Aggarwal (Engineering); chongli Yuan (Engineering)

Presentation Time: Session 1: 10:30-11:30am

3D Printed Dome-Patterned Arrays: Modelling, Fabrication and Design

STEM

Authors(s):

Mariana Peres Duarte† (Engineering)

Abstract:

Additive manufacturing (AM) has enabled the fabrication of parts with complex geometries, unlocking the potential of advanced design methods, such as topology optimization and compliant structures. Residual stresses due to AM have been traditionally perceived as undesirable and cause unpredictable component deformation, particularly in metal-based AM. Additionally, there are limited studies and methods to predict the influence on the response of additive manufactured fabricated thin-walled parts. Residual stresses can be beneficial in the design of compliant structures with multiple stables states, known as multistable structures. In particular, the compliant capabilities of such structures are enhanced in the presence of residual stresses by storing strain energy for shape reconfiguration, allowing for another route towards achieving multistability in structures. By further developing our knowledge surrounding the fabrication process and the resulting structural response of bistable dome-shapes structures, we can familiarize ourselves with the mechanics of the dome shaped-units and predict the resulting mechanical response of thin-walled structures. In this work, we aim to establish a simulation procedure for determining the effect of 3D printing on the mechanical response of thin-walled structures. Specifically, we conduct comprehensive numerical analysis of the selective laser sintering (SLS) and physical testing of a bistable dome using commercial software Abagus Finite Element Analysis. Model parameters from previous literature were compiled and tested in the simulation to assess its validity, yielding results consistent with those reported in the literature. The results of this study hope to provide a foundation for future additive manufactured modelling of dome-shaped structures.

Keywords:

Additive Manufacturing; Bistable Structures; Residual Stresses; Simulation

Mentor(s):

Gunes Kosterit (Engineering); Andres Arrieta Diaz (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Exploring the Emergence and Persistence of Drug-Resistant Malaria

STEM

Authors(s):

Daniela Alejandra Puentes Herrera†

Abstract:

Malaria is a severe infectious disease caused by Plasmodium parasites and transmitted to humans through infected Anopheles mosquitoes. Numerous control strategies, including the use of antimalarial drugs. have helped reduce malaria in many regions. However, the rise of drug resistance has become a major challenge for control efforts. Notably, while most malaria cases occur in sub-Saharan Africa, resistance often appears first in places where malaria is less common, such as Southeast Asia and South America, and then spreads to regions with more cases. The reasons behind this pattern remain poorly understood. To investigate this, we use an agent-based model to predict how resistance develops and spreads in different settings. Our goal is to understand how parasite strains and the mixing of their genetic material, genetic recombination, influence resistance under different transmission levels. Current hypotheses suggest that in areas with higher transmission, frequent exposure helps people build strong immunity. As a result, infections are less likely to cause symptoms and often go untreated. With less drug usage, drug-resistant pathogens spread slower. In contrast, in regions with fewer cases, weaker immunity leads to more symptomatic infections and greater drug use, creating conditions that favor resistance. The way parasite strains recombine to exchange genetic material inside mosquitoes adds complexity. This process can break apart resistance genes, slowing their spread, but it can also merge them with other parasite strains, potentially accelerating resistance. Our findings may help explain observed global patterns of resistance emergence and guide surveillance strategies in malaria-endemic regions.

Keywords:

Malaria; Drug Resistance; Genetic Recombination; Agent-Based Modeling

Mentor(s):

Qixin He (Science); Pradyut Kumar (Science)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Hyaluronan Gels for Tissue Mimics STEM

Authors(s):

Daniela Ramirez Castellanos†

Abstract:

The brain extracellular matrix is mainly composed of proteins and polysaccharides such as hyaluronan (HA), which plays a key role in tissue hydration, mechanical support, and signaling processes. The unique composition of brain tissue significantly affects drug transport and thus limits therapeutic delivery. Additionally, many drug candidates fail during clinical trials, which highlights the importance of creating more physiologically relevant in vitro models that improve preclinical testing of intrathecally injected therapeutics for neurological disorders. In this context, the present work aims to synthesize and characterize HA hydrogels as tissue mimics of the brain, with the ultimate goal of testing drug transport across brain-like matrices. HA was first thiolated to varying degrees, and the hydrogels were synthesized via polyethylene glycol diacrylate, divinyl sulfone, and ferric sodium EDTA crosslinking methods, targeting a physiological pH of 7.4 for the three formulations. The hydrogels were characterized based on pH, gelation, HA retention, macromolecular transport, microscopic structure, cell encapsulation, and rheological behavior. The expected outcomes of the project include obtaining uniform and soft hydrogels with appropriate stability and a tortuous structure that mimics the brain tissue and its main transport phenomena properties. As a conclusion, the present study offers a new approach to tissue mimic fabrication by focusing on HA as one of the main brain ECM components. Future directions include refining the synthesis method to develop a gel formulation that more closely replicates the native composition of brain tissue.

Keywords:

Hyaluronan; Brain; Tissue Mimics; Hydrogel; Characterization

Mentor(s):

Julie C Liu (Engineering); Marisa Ann Egan (Engineering)

Other Acknowledgement(s):

Emily R Jakob (HHS)

Presentation Time: Session 1: 10:30-11:30am

Measuring Systemic Inflammatory Effects of Synovial Joint Injury

STEM

Authors(s):

Amrita Rani Raparti† (Science)

Abstract:

Post-traumatic osteoarthritis (PTOA) is a type of degenerative joint disease that develops after a traumatic injury. Although we know that PTOA is primarily caused by traumatic joint injury, there are no cures. and the development and progression of PTOA are not well understood. Using murine models, we aimed to understand the onset and progression of PTOA. Murine models are great for simulating human diseases because their genetic make-up is similar to humans. Hence, we conducted an axial tibial compression of the right knee joint, which caused an anterior cruciate ligament rupture (ACLR) of skeletally mature mice. We will then compare various inflammatory genes of interest using reverse transcription quantitative polymerase chain reaction (RT-qPCR) of the injured joint over different time points, such as days 0, 1, 3, 7, 14, and 28. This will allow us to create a timeline of inflammation after ACLR and compare the abundance of pro-inflammatory (M1 macrophages) and anti-inflammatory markers (M2 macrophages). The presence of inflammatory genes: Itgam, Nos2, Arg1, and Adgre1, informs us of the type and presence of macrophage. The Itgam and Adgre1 markers indicate the presence of macrophages, while Nos2 and Arg1 indicate the presence of M1 and M2 macrophages, respectively. Running RT-qPCR, I anticipate M1 macrophage markers will be more abundant than M2 macrophage markers at later time points. Being able to determine the balance of M1 and M2 macrophages will help us establish a relative timeline of inflammation of the onset and progression of PTOA, which helps us understand PTOA better.

Keywords:

Post-Traumatic Osteoarthritis; Inflammatory Markers; Gene Expression; Macrophage Polarization; Anterior Cruciate Ligament Rupture

Mentor(s):

Deva Chan (Engineering); Ryan Michael Meister (Engineering)

Other Acknowledgement(s):

Radhika Arvind Bhopatkar (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Carbon composite support structure with integrated thermal management for time of flight detector for ePIC- EIC STEM

Authors(s):

Rafael Riesco Risco† (Engineering)

Abstract:

The upcoming Electron-Ion Collider (EIC) at Brookhaven National Laboratory features a state-of-the-art time-of-flight barrel detector, comprising 144 staves that extend over a 2.7-meter length and support strip silicon sensors. Managing the thermal gradient along these staves is critical for optimizing sensor performance and is a primary focus of the design challenge. This research investigates various stave configurations to achieve minimal mass and deflection under self-weight across the entire length, enhancing the structural integrity and integrated thermal pathways for operational stability of the detector. We conducted a series of heat transfer analyses to evaluate temperature gradients on the stave surfaces, guiding multiple design iterations. Prototyping and manufacturing of the staves were carried out at Purdue University. Thermal testing of the composite structures to validate the heat transfer models was performed through experimental testing using a dedicated water-cooling circuit. This poster presents a comprehensive overview of the design process, prototyping, manufacturing techniques, and the results from both simulation and experimental validation of the thermal management system. Our findings provide crucial insights into the thermal and mechanical considerations necessary for the successful deployment of the EIC's time-of-flight detector.

Kevwords:

[no keywords provided]

Mentor(s):

Sushrut Karmarkar (Science); Andreas Jung (Science)

Other Acknowledgement(s):

Pau Simpson Crusafon (Engineering); Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Determining the Functional Domains of a Ralstonia Type III Core Effector Protein

STEM

Authors(s):

Mateus Rocha Ripari† (Agriculture); Paula Natalia Natalia Paez Monroy‡; Elise Bennett*

Abstract:

Ralstonia solanacearum (Rs), a significant bacterial plant pathogen affecting crops worldwide, deploys type III effector (T3E) proteins, such as RipU, to promote colonization and disease development. This effort aims to study the core effector protein RipU from Rs strain K60 to understand the domains responsible for its interactions and localization within plant cells. Previously, RipUK60 was found to co-localize with microtubules and disrupted microtubule organization in transient expression assays. In the current study, truncated versions of RipU K60 fused to fluorescent proteins were cloned and expressed in Nicotiana benthamiana leaf tissue using Agrobacterium tumefaciens-mediated transient expression. Confocal microscopy was used to analyze protein localization and colocalization with cytoskeleton markers and yeast twohybrid assays evaluated direct interactions between the T3E protein, actin, and tubulin. RipU K60 was found to associate with both actin and tubulin, disrupting cytoskeleton organization. By investigating truncated versions and their interaction with cytoskeletal proteins, the study proposes domains responsible for the distinct localizations and interactions. This provides valuable insights into RipU functionality, posttranslational modification, and potential targets for future breeding programs.

Keywords:

Ralstonia; RipU; Effector; Cytoskeleton; T3E

Mentor(s):

Abigail Keelin Rogers (Interdisciplinary & Special Programs); Anjali Iyer-Pascuzzi (Agriculture)

Other Acknowledgement(s):

Emily R Jakob (HHS)

Presentation Time: Session 1: 10:30-11:30am

Fabrication of Patient-Specific Compliant Aorta model for In Vitro Flow Experiments

STEM

Authors(s):

Liam N Rochet† (Engineering)

Abstract:

The ability to accurately simulate the behavior of blood flow within human organs is essential for advancing cardiovascular research. Despite the availability of computational modeling options, physical models are the most accurate in terms of replicating and simulating real operations. This project is focused on fabricating a realistic model of the aorta using a mold-silicone casting method for use in in vitro flow experiments. The model replicates the complex geometry and physical properties of the aorta, enabling future validation through particle tracking velocimetry and 4D Flow MRI. We aim to show that this method offers a practical representation of the aortic structure that can support accurate flow measurements, something that many other aorta models lacked in prior research. The first step involves a manipulation process on the Solidworks and Meshmixer software packages, ensuring the proper wall thickness and other characteristic features of the aorta. From this computational blueprint, the inner core and outer molds are fabricated using 3D printing. Once generated, the molds and core are connected, and silicone is cast in the space between. The silicone is then cured to form the final model, and the molds and core are dissolved using acetone. Once this fabrication process is complete, the model is inspected to analyze the dimensional accuracy, overall uniformity, and other physical characteristics. We expect that the resulting aorta model will exhibit physiologically relevant functional properties. Ultimately, our process and production of the model could offer a practical solution for medical training and future vascular model applications.

Keywords:

Aorta Model; Silicone Casting; Flow Visualization; Particle Tracking

Velocimetry; 4D Flow MRI

Mentor(s):

Hyeondong Yang (Engineering); Brett A Meyers (Centers & Institutes)

Other Acknowledgement(s):

Emily R Jakob (HHS)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Semantic Segmentation and Reconstruction for LoD3 Buildings from Point Cloud Data

Creative

Authors(s):
Jeronimo Rodriguez†

Abstract:

Reconstructing semantic 3D building models at Level of Detail 3 (LoD3) remains a complex challenge in the field of urban modeling. Most existing methods focus on LoD2 representations, which lack important façade-level details such as windows and doors details that are essential for applications like urban planning, simulation, and autonomous navigation. While recent advances in deep learning and data fusion have shown progress, further development is needed to effectively combine diverse data types and manage uncertainty in the reconstruction process.

This research proposes an approach that uses point cloud data and orthophotos generated from oblique UAV imagery to support the reconstruction of LoD3 building models. The goal is to build a benchmark dataset to test a deep learning model that detects windows directly from raw UAV images and projects them onto existing LoD2 models to enhance them to LoD3. The dataset includes images captured using a DJI M300 drone with a P1 sensor, and the TUM2TWIN dataset is used as a reference to align with current LoD3 reconstruction standards.

The proposed pipeline will be tested across several reconstruction strategies using these benchmark datasets. This comparison aims to assess the accuracy and completeness of our method relative to existing approaches. By doing so, we aim to identify where the pipeline performs well, where it may fall short, and how it can contribute to more reliable and interpretable LoD3 modeling workflows.

Keywords:

Point Cloud; CityGML; Reconstruction; LoD3; UAV

Mentor(s):

Han Sae Kim (Engineering)

Other Acknowledgement(s):

Andres Catalino Castillo Jimenez (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Characterization of Superabsorbent Polymers for Internal Curing in Cementitious Materials

STEM

Authors(s): Lina Paola Rodriguez†

Abstract:

Concrete that is internally cured by water-swollen superabsorbent polymer (SAP) particles have demonstrated potential in enhancing both mechanical strength and long-term durability. As concrete is the most widely used building material worldwide and contributes approximately 6-8% of annual CO2 emissions, improving its durability is essential for reducing its environmental footprint. This research focuses on the characterization of SAP particles and their interactions within cementitious systems. The initial phase involves swelling tests in various fluids to evaluate absorption behavior under different chemical environments. Optical microscopy is used to examine the morphology of dry SAP particles and to assess variability in particle size and structure. which can influence performance. Additionally, mechanical testing of SAP-cured mortar is conducted to assess the structural impact of SAP inclusion. Preliminary swelling tests indicate that the gravimetric swelling capacity of SAPs varies over time and is influenced by the surrounding fluid environment. Optical microscopy reveals that the SAP particles exhibit different size distribution with variability in average particle diameter. Mechanical measurements reveal that the inclusion of SAPs leads to comparable or improved strength and demonstrates promising potential in mitigating shrinkage. These findings underscore the importance of chemical environment in SAP performance and highlight the potential of SAPs to enhance the sustainability and durability of cementitious materials through targeted internal curing strategies.

Keywords:

Superabsorbent Polymers (SAP); Hydrogels; Concrete; Swelling; Internal Curing

Mentor(s):

Kendra A Erk (Engineering); Halle Jo Block (Engineering)

Other Acknowledgement(s):

Andres Catalino Castillo Jimenez (Engineering)

[†] Presenting Undergrad Author; † Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Allometric scaling of macro-to-micro ratios of geometrical bone properties

STEM

Authors(s):

Kaley Roe† (Engineering)

Abstract:

Allometric scaling laws are used to describe how geometric properties of organisms change with body mass. These laws typically follow a basic equation of Y=aM^b, with M representing mass, a a constant, and b the allometric scaling exponent. This project focuses on scaling laws in bone. Two sets of geometric properties describe bone: (1) macroscale properties, such as length and diameter, as well as (2) microscale properties describing bone building blocks, i.e., osteons. Previous studies have explored how body mass relates to macroscale bone properties and how body mass correlates with microscale features. The objective of this study is to link micro and macro data on bone allometric scaling and to build new allometric scaling laws. Data was gathered from established literature using a plot digitizer and compiled into a crosslinked database for further analysis. We hypothesize that ratios between bone size parameters (diameter, length, cortical bone thickness) and osteon size parameters (osteon diameter, infill length, canal diameter) are independent of body mass, i.e., possess b = 0.0. This hypothesis is based on the consideration of bone as a quasi-brittle material, and the mechanics of failure of quasi-brittle materials guides the testing of the hypothesis. The initial analysis considered outer bone diameter and osteon diameter and did not verify the hypothesis; rather, b = 0.2. Future work seeks to expand the data set, to consider additional micro-macro scaling laws, and to combine the size scaling laws with additional factors. This work was supported by NSF award 1952993.

Keywords:

Allometric Scaling; Bone Properties; Ratios

Mentor(s):

Thomas H Siegmund (Engineering); Glynn Ellen Gallaway (Engineering)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Effects of Heat Stress on Blood Pressure Regulation and Cardiac Baroreflex Function

STEM

Authors(s):

Gisell Natalia Romero Delgado†

Abstract:

Heat stress disrupts cardiovascular homeostasis, posing significant challenges to blood pressure (BP) regulation. One of the primary reflexes involved in short-term BP control is the cardiac baroreflex, which integrates afferent input from arterial baroreceptors and modulates heart rate via both mechanical and neural components. However, it remains unclear how heat stress impairs or maintains this reflex, and what role each baroreflex arc plays in compensating for thermal cardiovascular strain. The aim of this study is to investigate how passive heat stress affects cardiac baroreflex function and its neural and mechanical components. Participants undergo controlled whole-body heat exposure via a water-perfused suit circulating water at 48°C to elevate core temperature by 1.5°C, while remaining supine. Measurements include core temperature (via ingestible pills), continuous arterial pressure, heart rate, and vascular parameters obtained by ultrasonography. The objective is to evaluate how heat alters baroreflex sensitivity and the relationship between BP and heart rate. Prior evidence suggests that while heart rate increases and BP tends to decline during heat exposure. baroreflex-mediated control may be preserved or selectively impaired depending on the reflex component. Understanding how heat alters the dynamic relationship between BP and heart rate will help clarify the contribution of each baroreflex arc and guide interventions to preserve cardiovascular stability in thermally challenging environments.

Keywords:

Cardiac Baroreflex; Passive Heat Stress; Blood Pressure; Ultrasonography; Heat

Mentor(s):

Bruno Tesini Roseguini (HHS); Igor Alexandre Fernandes (HHS)

Other Acknowledgement(s):

Emily R Jakob (HHS); Eloisa Herrera Ospina (HHS)

Presentation Time: Session 1: 10:30-11:30am

Can We Rely on Error Thresholds? Practical Attacks on Proof of Learning.

STEM

Authors(s):
Diego Roux Hernandez†

Abstract:

Machine Learning (ML) model training can be computationally expensive. To address this, we might outsource training to computationally capable workers (i.e. servers). In doing so, we trust that these workers will perform the required computations honestly. Commonly, we might be working with untrusted third-party workers, so we need a way to verify that no malicious acts occurred during training. Proof of Learning (PoL) is a method that allows us to verify that the adequate computations to train the model were performed. To achieve this, a trace of all, or some, computations are logged. Validating a PoL claim can be done by arriving at the same computational trace, or by recomputing each step. However, this approach faces practical challenges. For example, various hardware and software implementations have introduced optimisations that have resulted in nondeterministic behaviour, causing variations in between identical runs. Additionally, using distinct hardware may also yield similar variations. Therefore, PoL protocols need to account for some error margin during validation. The relationship between this error margin and practical attacks in training is currently not well-understood, and we aim to close this gap. We'll investigate the practicality of malicious trainer attacks under different PoL error margins with different aims (e.g., to derail or bias training) and study their success rate. We believe that the findings of this project could help practitioners better understand the trade-offs between security and performance in training. Further studies and implementations need to explore deterministic, hardware-invariant ML training algorithms that can compete with current runtime performance.

Keywords:

Trustworthy Machine Learning; Training Attacks; AI; Cybersecurity; Practical Attacks

Mentor(s):

Zahra Ghodsi (Engineering)

Other Acknowledgement(s):
Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Visualizing Loss Landscapes to Understand Instability in Reinforcement Learning for Language Model Alignment STEM

Authors(s):

Pranav Sanghi† (Science|Graduate)

Abstract:

Reinforcement learning from human feedback (RLHF) is a key technique for aligning large language models (LLMs) with human values, but its training dynamics are often unstable and poorly understood. This instability limits our ability to robustly apply LLMs in real-world, safetycritical applications. In this research, we aim to investigate how the geometry of the training loss landscape contributes to such instability, focusing on two prominent alignment methods: Proximal Policy Optimization (PPO) and Direct Preference Optimization (DPO), Our approach involves visualizing the structure of these loss landscapes by interpolating between reference and fine-tuned policy parameters, as well as sampling filter-normalized directions in weight space. We apply these techniques using a fine-tuned LLM on the Anthropic Helpful-Harmless dataset, and evaluate model behavior using a learned reward function. While results are still preliminary, this study is expected to yield insight into how optimization geometry correlates with training stability. By characterizing sharpness, curvature, and smoothness in the loss surface of each method, we aim to understand why PPO often suffers from instability, whereas DPO appears more robust. Ultimately, our work seeks to inform the development of more stable and interpretable RLbased alignment algorithms for future LLM systems.

Keywords:

Reinforcement Learning; Large Language Models; Machine Learning

Mentor(s):

Wei-Kai Chang (Science); Rajiv Ashu Khanna (Science)

Other Acknowledgement(s):

Pranshul Sardana (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Determining the Role of Histone Deacetylase Inhibitors as Enhancers of Axonal Regeneration After Spinal Cord Injury in Zebrafish

STEM

Authors(s):

Darshini Shankar† (Science|JMHC); Jaewoo Lee‡ (Science)

Abstract:

Spinal cord injuries (SCI) are a prevalent medical condition, affecting 15.4 million people globally. However, there is still a lack of treatment for SCI, particularly involving successful pharmaceutical therapies. Previous studies have utilized rodent models to determine that histone deacetylase (HDAC) inhibitors could improve functional recovery following SCI. HDAC inhibitors promote the acetylation of histones, which increases gene expression and may be associated with enhanced recovery after SCI. In this study, we aim to characterize the effects of two HDAC inhibitors, sodium butyrate and valproic acid, in promoting axonal regeneration following SCI in zebrafish. It is hypothesized that larvae treated with HDAC inhibitors will exhibit increased functional recovery and axonal bridging compared to vehicle-treated controls. Zebrafish are an ideal model for testing therapeutic drugs due to their ability to completely regenerate axons after acute SCI. For these experiments, SCI was performed at 5 days post-fertilization (dpf) by transecting the spinal cord at the level of the posterior end of the swim bladder. A visual motor response (VMR) assay was employed at 2 days post-injury (dpi) to characterize swimming behavior as an indicator of functional recovery. Anti-acetylated tubulin staining and stereoscope imaging were also utilized to quantify axonal bridging. Functional recovery and axonal bridging of larvae treated with sodium butyrate or valproic acid were compared to vehicle-treated larvae to identify significant differences. While the results remain preliminary, this study provides recommendations for future research to further characterize the effect of HDAC inhibitors on axonal regeneration as well as the underlying mechanism.

Keywords:

Spinal Cord Injury (SCI); Pharmaceutical Therapy; HDAC Inhibitors; Regeneration

Mentor(s):

Daniel Suter (Science); Jorge Emanuel Hernandez Dominguez (Interdisciplinary & Special Programs)

Other Acknowledgement(s): Pranshul Sardana (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Protein Purification of Alpha-Synuclein Strains for Seed Amplification Assay

STEM

Authors(s):

Samhita Mysore Shantharam† (Agriculture|Engineering|JMHC)

Abstract:

Parkinson's Disease is a devastating neurodegenerative disease characterized by lesions in the brain known as Lewy bodies. These lesions are the result of aggregation of the alpha-synuclein protein. The mechanisms that lead to these harmful lesions are still unclear and the vast majority of research has focused on identifying the cause. This lack of clarity poses incredible difficulty with diagnosis of PD, with confirmation only occurring upon post-mortem analysis. Seed Amplification Assay (SAA) is a relatively new diagnostic method that replicates the aggregation in vitro through a cyclical process and can be used with cerebral spinal fluid samples from patients. The addition of a highly concentrated solution of recombinant alpha-synuclein will catalyze the aggregation within a real-time quake-inducing conversion (RT-QuIC) system but a negative control is needed in order to reduce inconsistencies and noise with the data output. The current work of the project consists of purifying the K23Q strain of alpha-synuclein to act as a negative control for this experiment. The K23Q strain has been identified recently to be a relatively stagnant strain that resists aggregation. Protein purification consists of outgrowth in E. coli bacteria, protein lysis, size exclusion chromatography, and anionic exchange chromatography. Together, these techniques were implemented to extract and purify K23Q and improve diagnostic accuracy of SAA.

Keywords:

[no keywords provided]

Mentor(s):

Alicia Nicole Scott (Pharmacy); Jean-christophe Rochet (Pharmacy)

Other Acknowledgement(s):

Lipi Roy (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Neuron Classification for Fluorescence Lifetime Imaging STEM

Authors(s):

Sydney Cecelia Sobczak† (Engineering|JMHC)

Abstract:

A key challenge in neuronal studies, particularly in the context of neurodegenerative disease research, lies in the accurate and consistent detection of neurons having particular characteristics, as viewed through a microscopic lens. While Fluorescence Lifetime Imaging (FLIM) allows for the visualization of fluorophore-tagged neurons, current methods for identifying and classifying these cells are often manual, time-consuming, and vulnerable to human error, thus potentially leading to biased study conclusions. To address this, we develop a classification method to detect neurons based on neuron an assessment of health using intensity and fluorescence lifetime data. Our FLIM system employs a pulsed laser and an intensified gated camera, allowing measurement of the temporal fluorescence response. Using this system, we implemented a code to obtain a large amount of fluorescence data. Next, to select neurons of interest, we use a classification approach based on K-means clustering, solidity analysis, and feature thresholding to distinguish and separate neurons based on their health. The K-means clustering successfully separates areas inside and outside the sample well, allowing us to identify the edges and boundaries of the sample. This methodology demonstrates promise for efficient neuron analysis. Future work will focus on incorporating a larger and diverse dataset to refine thresholds and explore shape-based features to improve detection capabilities and accuracy based on neuron morphology.

Keywords:

[no keywords provided]

Mentor(s):

Kevin J Webb (Engineering); Abdelrahman Salem (Engineering)

Other Acknowledgement(s):

Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Evaluating the ability of large language models to generate verifiable specifications in VeriFast

STEM

Authors(s):

Minh Binh Tran† (Science)

Abstract:

Static verification is highly beneficial for ensuring software quality but demands significant human effort in manual specification writing. This is particularly true for the static verification of heap-manipulating programs with separation logic. While advancements in large language models demonstrate promise in various software engineering tasks, including invariant generation, a comprehensive assessment of such models' capabilities to produce separation logic-based specifications remains unexplored. This project bridges this gap by demonstrating the effectiveness of 3 popular LLMs in generating verifiable specifications for C programs in VeriFast. Our methodology involves performing rigorous data collection by prompting 3 such models in a sparse-split approach and conducting detailed qualitative analysis of their generated outputs. The study will compare these outputs against publicly available VeriFast benchmarks to thoroughly assess their accuracy, completeness, and adherence to conventional VeriFast specification patterns. The results are expected to provide critical insights into the specific strengths and limitations of current large language models regarding these qualitative aspects. Ultimately, this research aims to contribute actionable recommendations that will guide the development of more reliable and efficient Al-driven approaches to automate formal software verification.

Keywords:

Static Verification; VeriFast; Large Language Models; Qualitative Analysis; Separation Logic

Mentor(s):

Jenna L Wise DiVincenzo (Engineering); Wen Fan (Engineering)

Other Acknowledgement(s):

Marilyn Rego (Engineering); Sanya Dod (Engineering); Zhaorui Ni (Engineering); Danning Xie (Science); Lin Tan (Science); Varun Aggarwal (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Exploration of Photopolymers in Plastic Bonded ExplosivesSTEM

Authors(s):

Ryan J Turnbull†; Varunavi Kaveri Raghuraman* (Engineering)

Abstract:

Plastic bonded explosives (PBXs) are used for applications such as weapon systems, explosive demolition, and mining because they require greater activation energy to detonate, which ensures safety during storage and transportation. PBXs are comprised of an energetic compound, such as RDX, suspended in a polymer matrix which usually makes up 5-10 wt.% of the total composition. Most PBXs are manufactured using molding powders that are made with harsh solvents that release toxic byproducts into the environment and the process itself is time intensive. Utilizing a photopolymer based molding powder removes the need for solvents and decreases the overall manufacturing time. However, a completely uncured molding powder can lead to binder migration during the pressing process. Partially precuring the molding powder will mitigate this issue, but the amount of precure time also impacts the final material properties because it changes the degree of crosslinking prior to being pressed. The objective of this research is to investigate the material properties of PBXs made with a UV curable molding powder subject to varying precure times. Die pressed pellets comprised of sugar as a surrogate suspended in a photopolymer matrix were analyzed by collecting density, surface roughness, and compression testing data. Based on the data obtained from these experiments, an optimal precure time was selected. The results of this work can improve the implementation of a UV binder in PBX production to make the manufacturing process safer and faster.

Keywords:

Energetics; Mechanical Engineering; Material Science; PBX

Mentor(s):

Monique Suzanne McClain (Engineering)

Other Acknowledgement(s): Ismar Leonel Chew (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Polymer-Nanoparticle Composite Gels to Mimic Muscle Stiffness for Cultured Meat Platforms

STEM

Authors(s):

Maria Angelica Vasquez Hernandez†

Abstract:

Cultured meat production requires scaffolds that mimic the body's natural environment, such as hydrogel scaffolds, which guide the development of satellite muscle cells into new muscle fibers. In native muscle, the extracellular matrix (ECM) transmits physical and chemical signals to cells that regulate cell growth and differentiation. During myogenesis, the cells sense the stiffness of the environment, which influences their progression; therefore, replicating that stiffness in the hydrogel is key to achieving efficient muscle development. This study presents the synthesis and characterization of thiol-functionalized silica nanoparticles (fSNPs) in terms of size, morphology, and surface chemistry using dynamic light scattering, scanning and transmission electron microscopy, and Ellman's reagent to quantify thiol density. These fSNPs were incorporated into a polyethylene glycol-norbornene (PEG-N) hydrogel, crosslinked via thiol:ene click chemistry and designed to degrade enzymatically. Hydrogel stiffness was evaluated through bulk rheology in both dry and swollen states to assess the impact of nanoparticle incorporation. The incorporation of fSNPs is shown to increase hydrogel stiffness in a tunable manner. A live/dead assay was conducted with human mesenchymal stem cells (hMSCs) to ensure cell viability after 24 hours, with no observed cell death. Preliminary results indicate that stiffness increases with fSNP incorporation. This approach provides a versatile and reproducible platform for the design of tunable structural supports, with potential applications in cellular agriculture, tissue engineering and development of advanced biomimetic systems.

Keywords:

Nanoparticles; Cultured Meat; Hydrogel Scaffolds; Thiol-Functionalized

Mentor(s):

Siena Dawit Negash (Engineering); Kelly Schultz (Engineering)

Other Acknowledgement(s):

Pranshul Sardana (Engineering)

[†] Presenting Undergrad Author; † Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Evaluating Post-Fire Environmental Testing Guidance for Standing Homes: Gaps, Risks, and Recommendations STEM

Authors(s):

Kaitlyn Marie Wayne† (Engineering)

Abstract:

Wildfires generate complex mixtures of toxic contaminants, including hydrogen cyanide (HCN), hydrogen fluoride (HF), hydrogen chloride (HCI), heavy metals, and volatile and semi-volatile organic compounds (VOCs and SVOCs). These pollutants can persist in indoor environments long after flames are extinguished, posing potential health risks to returning residents. Although environmental testing guidance exists for homes that remain standing after wildfires, current approaches vary significantly in methodology, terminology, target contaminants, and recommended action levels, resulting in inconsistent protection for impacted communities. This project investigates the exposure pathways for occupants of fire-affected but structurally intact homes and critically evaluates whether existing testing practices adequately protect public health. We conducted a comparative analysis of major post-fire environmental testing guidelines intended for homeowners, examining differences in sample types, sampling locations, contaminant thresholds, and overall clarity of guidance. Our findings are supported by environmental data from the Home Environmental Testing Report Study, where households impacted by the Eaton and Palisades fires have submitted their home environmental testing reports. So far, it includes 140 resident responses and survey data reveals that many homes exhibit contaminant levels exceeding established safety thresholds yet are often not thoroughly remediated before residents return. Current guidance frequently lacks scientific rigor and fails to address the unique conditions of smoke-impacted, non-destroyed structures. Based on this analysis, we identify contaminants of greatest concern, highlight significant gaps in existing guidance, and offer evidence-based recommendations to improve post-fire environmental testing protocols. This work also emphasizes the importance of clear, consistent risk communication to better support homeowners during wildfire recovery.

Keywords:

Wildfire; Eaton; Standing Home; Contamination; Remediation

Mentor(s): Cristiane Grossi Ferrarezzi (Engineering); Andrew Whelton (Engineering) Other Acknowledgement(s): Lipi Roy (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Design of Electrically Small Dielectric Resonator Antennas STEM

Authors(s):

Jack Thomas Willard† (Engineering|JMHC)

Abstract:

Electrically small antennas (ESAs) continue to receive attention as their compact size and high directivity are useful for size constrained applications. An ESA is defined by Wheeler's criterion as a device where the product of the radius of the circumscribing sphere and wave number at the operating frequency is less than one. These are commonly constructed using metallic radiators; however, the complexity of these architectures places a ceiling on their performance. This prompts the design of alternative antennas including electrically small dielectric resonator antennas (ESDRAs). This research seeks to expand on existing ESDRA research by characterizing new antenna structures. The initial phase consists of reproducing the results of an existing ESDRA. New structures are then simulated and analyzed using Ansys High Frequency Simulation Software (HFSS). While the new designs undergo fabrication, standard antennas are characterized in an anechoic chamber to develop the reference data needed for measurements. The antenna structures discussed in this research indicate that ESDRAs are a valid alternative to existing antenna designs as they preserve radiation efficiency and increase aperture efficiency even as antenna size is electrically small. In the future, the fabricated ESDRAs will be measured and compared to the simulated models.

Keywords:

Antenna; Dielectric; Resonator; RF

Mentor(s):

Alex David Santiago Vargas (Engineering); Ahmed Abdelraheem (Engineering); Dimitrios Peroulis (Purdue University)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Investigating Tissue-Specific Voltage Patterns During Zebrafish Embryonic Development Using Calcium Imaging STEM

SIEM

Authors(s): Alice Y Zhou† (Science)

Abstract:

Developmental patterning of pigment cells in zebrafish serves as a model for studying how these processes contribute to morphological diversity and provides insight into the mechanisms of human congenital disease. Recent accumulating evidence suggested that bioelectrical signaling plays an important role in pattern formation of those melanocytes. To better understand this process, we utilized the UAS-Gal4 system with the GCaMP6G as a reporter fish line and examined of calcium transients to during embryonic development. This system provided us a real time tracking of calcium activities of pigment cells, such as xanthophores, which are marked by the aox5 gene. Preliminary results revealed visible fluorescence in xanthophore cells located around the eye and dorsal stripe, confirming the localization of GcaMP6G guided by aox5 promoter. Thus, our findings indicate the presence of bioelectric signaling involved in this process. Future work consists of quantitative analysis of fluorescence intensity and time-lapse imaging using the Zscale to monitor calcium activity throughout embryonic development. Further investigation can be done into the other melanocytes present in zebrafish, such as the melanophores (marked by mitfa) or the iridophores (marked by pnp4a), along with validation our results by for GEVIs (genetically encoded voltage indicators) to directly confirm voltage activity.

Keywords:

[no keywords provided]

Mentor(s):

Kuangyi Wu (Vet Med); Ziyu Dong (Vet Med)

Other Acknowledgement(s): GuangJun Zhang (Vet Med)

Presentation Time: Session 1: 10:30-11:30am

QFedLib - A Framework for Fully Homomorphic Encryption with Quantum Federated Learning for Preserving Sensitive Information

STEM

Authors(s):

Daniel Anoruo†; Alan S Yi† (Science)

Abstract:

As machine learning continues to advance in fields like healthcare and chemical engineering, concerns regarding data privacy and data breaches have been a topic of discussion for centralized machine learning models. Many legal regulations have been set in place to protect sensitive information across many domains, making it difficult for data to be shared among different institutions. To train models while addressing concerns around data privacy, Federated Learning (FL) was introduced as a method of decentralizing the data and enabling training locally among clients. During training, the model updates instead of the models themselves are shared back to the central server before aggregating into a refined version. Despite this approach being safe for protecting sensitive information, not only is FL slow from the distributed training, it is still vulnerable to attacks like model inversion and eavesdropping. To tackle these limitations, our research integrates federated learning with quantum computing and fully homomorphic encryption (FHE) to enhance both performance and security. We developed QFedLib, a library that combines the quantum framework Pennylane (Bergholm, 2018) with the PyTorch-based FL library Flower and embeds custom FHE capabilities for secure aggregation (Beutel et al., 2020). We also benchmarked our system on medical imaging tasks, including chest X-ray classification using the NIH dataset. Results showed that our FL model outperformed a centralized baseline in average accuracy. When incorporating quantum layers, training speed increased, though with a slight drop in performance likely due to current simulation constraints (Dutta, 2024). We plan on releasing our library as an open-source toolkit to support future research in privacy.

Keywords:

Quantum; Federated Learning (FL); Data Privacy; Fully Homomorphic Encryption

Mentor(s):

Yirang Park (Engineering); David Esteban Bernal Neira (Engineering)
† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
Jorge Enrique Neira Garcia (Polytechnic)

Presentation Time: Session 1: 10:30-11:30am

Solvent Effects on Rh/C Catalyzed Hydrogenation of Aromatic Compounds

STEM

Authors(s):
Benedict G Grill†

Abstract:

In multi-arene systems, the potential for selective catalyzed hydrogenation is one that has many applications to pharmaceutical and materials research. Current research on selective hydrogenation of biarenes through directing groups has the potential for late-stage selective saturation of single aromatic rings, possibly increasing drug libraries and allowing for higher drug potency to be achieved. Different functional groups, like amines, have their binding abilities to catalyst surfaces change based on ranging polarity of solvents. Our goal in this project was to determine the effects that solvents can have on adsorption of specific groups on to the catalyst binding sites to further determine the most applicable solvent to use for multi-arene hydrogenation, specifically suppression of rings with non-directing functional groups to allow for selective hydrogenation. We assessed the solvent's role in selective hydrogenation of directing group bearing substrates by analyzing the turnover frequency and conversion percentage of these hydrogenation reactions to determine the solvent effects. Four solvents were studied: ethanol, cyclohexane, tetrahydrofuran (THF), and dimethylformaldehyde (DMF). Analyzation of each compound with respective solvents were studied in both singularity and in competition with each other. Less polar solvents, such as THF and Cyclohexane were found to suppress substrates with non-polar functional groups in competition with substrates with polar functional groups, while more polar solvents such as Ethanol were less suppressive of the non-polar functional groups in competition. This research will be further applied to multi-arene hydrogenation based on the efficiency of the solvent in selective hydrogenation.

Keywords:

Selective Hydrogenation; Catalyzed Hydrogenation; Solvent Effects

Mentor(s):

Christina W Li (Science)

Other Acknowledgement(s): Irfan Ahmad (Science)

Presentation Time: Session 1: 10:30-11:30am

Simple Alkane Hydrogenolysis as a Model for Polyethylene Hydrogenolysis on Ruthenium

STEM

Authors(s):
Jeremy W Libby†

Abstract:

Polyethylene depolymerization is a process that could reduce plastic waste and allow for the monomers created to then be used both to produce new polyethylene but also for other industrial applications. However, polyethylene molecules are very large and have various branching features that make the modeling of the reaction kinetics very difficult and would have secondary reactions that might interfere with determination of the kinetics of the hydrogenolysis reaction. Therefore, the project is based around hydrogenolysis of simple alkanes with similar features to those of interest in polyethylene, such as branching or multiple close together branches, to understand the mechanism that the reaction follows. The kinetics will be determined using low conversion of ethane, propane, and isobutane on a 1 wt.% ruthenium on silica catalyst, and the products will be separated using gas chromatography to determine rates with hydrogen and alkane pressure, as well as reaction temperature. This study will compare results with other studies on iridium and provide recommendations for future experiments with more complex molecules that better model polyethylene, such as longer straight chain alkanes and longer branching alkanes with denser branches. In addition, this research hopes to inform future research about liquid state reactions that would be used in industrial depolymerization as opposed to the gas phase reactions used in modeling.

Keywords:

[no keywords provided]

Mentor(s):

David Hibbitts (Engineering); Angela Aguirre (Engineering)

Other Acknowledgement(s):

Jorge Enrique Neira Garcia (Polytechnic)

Presentation Time: Session 1: 10:30-11:30am

Investigating Ethylene Oligomerization by Utilization of Amorphous Lewis Acid Aluminum Containing Catalysts STEM

Authors(s):

Sky Okpaku†; Isabel C Standley* (Engineering|JMHC)

Abstract:

Crude oil refining has a large carbon footprint and produces heavy toxic byproducts, but by utilizing natural gas we can create transportation range fuels and commodity feedstock chemicals by directly converting natural gas liquids into hydrocarbons. Industrial processes utilize zeolites to synthesize smaller hydrocarbons, however, various constraints arise from the porous and crystalline nature of zeolite catalysts. To address these issues, we investigated amorphous Lewis Acid catalysts to catalyze oligomerization reactions without the restrictions that arise due to various properties of zeolites. Unfortunately, amorphous Lewis acid catalysts have been shown to have much lower reaction rates than zeolites, so we need to synthesize Lewis acid catalysts with reaction rates comparable to zeolites. Preliminary data suggests Lewis acid aluminum based catalysts have been shown to have higher reaction rates than Lewis acid catalysts that utilize larger metals when catalyzing ethylene oligomerization. To test these aluminum catalysts and their conversion rates, place the aluminum catalyst over a bed of quartz wool in a reaction tube then vary the temperature, run gas olefins through the tube, and analyze data produced by a GC connected to the reactor. Altogether, my team found that Aluminum catalysts serve as stronger Lewis Acids in these processes because of charge density and coordination with double bonds in olefins so these are more reactive than larger metal catalysts. Overall, our catalyst produces longer chained hydrocarbons from ethylene at rates higher than that of previously studied catalysts. Consequently, our aluminum catalyst could potentially be a viable option in oligomerization reactions.

Keywords:

[no keywords provided]

Mentor(s):

Ted Taewook Kim (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Electrochemical ethane dehydrogenation using fabrictemplated 3D cathodes for CO2 reduction

STEM

Authors(s):

Charity E Smith†; Ally Guo‡

Abstract:

Ethylene, produced through the dehydrogenation of ethane, is mainly used for the production of plastics and a variety of other chemicals. However, the production process for ethylene requires high-temperature heat and contributes to over 260 million tons of CO2 emissions per year. To alleviate this issue, this research focuses on utilizing renewable electricity for ethane dehydrogenation with solid oxide electrochemical reactors to decrease carbon dioxide output. Specifically, it focuses on improving the surface area of electrodes using a template-assisted ceramic synthesis approach. A glycine nitrate process was performed to synthesize electrode materials, and solid-state reactions were conducted to produce a proton-conducting ceramic electrolyte. The electrode was then fabricated with uniaxial pressing, followed by spin coating and brush painting with slurry and ink to deposit material onto the electrode. Fabric gauze was utilized to form a 3D porous structure using synthesized materials to increase surface area. Finally, the 3D cathode was integrated with the electrode and anode to complete the full PCEC cell. X-ray diffraction testing will characterize synthesized materials, testing for phase purity and crystal structure. In addition, electron microscopy will examine catalyst dispersion and the morphology of those materials. Utilizing EIS, I-V, and chronoamperometry measurements, the electrocatalytic performance, conversion rates, stability, and ethylene selectivity of electrodes can be measured. Finally, using gas chromatography, the composition of gases can be analyzed. This research attempts to tackle the issue of CO2 output in ethylene production by utilizing solid oxide electrochemical reactors. Further improvements include increasing surface area for higher infiltration.

Keywords:

[no keywords provided]

Mentor(s):

Brian Michael Tackett (Engineering); Po-Chun Huang (Engineering)

Other Acknowledgement(s):
Jorge Enrique Neira Garcia (Polytechnic)

Presentation Time: Session 1: 10:30-11:30am

The Effect of Acid Concentration and Temperature on the Dispersion of Lewis Acidic Aluminum Active Sites on Amorphous Silica

STEM

Authors(s):

Isabel C Standley† (Engineering|JMHC); Sky Okpaku*

Abstract:

Bronsted acidic catalysts such as zeolites are used in industry to produce transportation range fuels and feedstock compounds using light olefins. However, rapid deactivation, occlusion of micropores, dealumination, and changing active site concentrations are major challenges of zeolites needing to be addressed. Coordinatively unsaturated Lewis acidic Aluminum ions can oligomerize olefins like other Lewis acidic catalysts such as Gallium, Zinc, and Nickel with higher turnover rates. Crabtree et al. postulated that Aluminum's higher positive charge density allows electron rich carbon-carbon double bonds of olefins to easily coordinate onto active sites. Currently, the reactions rate for Aluminum based catalysts plateau in activity around weight loadings of 0.3wt% due to the formation of inert clusters of Aluminum on the surface of the commercial silica, indicating that commercial silica supports a small number of active sites. Synthesizing the Aluminum catalyst using tetraethyl orthosilicate (TEOS) and aqueous Aluminum creates more active sites from higher dispersion of metal on the surface of the silica. This synthesis method consists of combining Aluminum nitrate into acidic solution, adding TEOS while mixing and polymerizing the solution overnight. The catalyst is then calcined at high temperatures to eliminate residual compounds. Propylene oligomerization is performed using a fixed bed reactor and product gas stream is analyzed using a gas chromatograph. We hypothesize that increased acid concentration during synthesis will create more silanol sites for Aluminum bonding. Reaction rates are expected to increase with weight loading of Aluminum, predicted conversion will correlate linearly with trend line established from lower weight percentages.

Keywords:

Aluminum; Heterogeneous Catalysts; Silica Synthesis; High Dispersion; Propylene Oligomerization

Mentor(s):

Ted Taewook Kim (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 1: 10:30-11:30am

Evolution of P-AgBot: Autonomous Ground Sensor Deployment and Reading

STEM

Authors(s):

Joseph F Norwood†; Martin Vassilev‡

Abstract:

Managing hundreds of acres of farmland often necessitates the use of generalized practices, resulting in inefficiencies in water and nitrogen use. Precision agriculture aims to address this waste through accurate sensing and localized management strategies. Previous research introduced a new configuration of Purdue's agricultural robot, P-AgBot, capable of deploying and reading biodegradable soil sensors; however, this system lacks robust autonomy, requiring significant human intervention. This paper presents advancements to P-AgBot that improve its autonomy, achieving a 90% success rate for sensor deployment and reading, with operation times under two minutes per sensor. Improvements span the mechanical systems such as sensor mounts and chutes; the electrical systems from enclosures to component upgrades; and the software, leveraging deep learning for computer vision. Biweekly field deployments over a two-month period guided iterative refinements and validated system robustness. Results demonstrate that P-AgBot meets the desired performance targets and establishes a foundation for scalable, autonomous soil monitoring. Future work should explore multirobot swarm deployment to extend coverage and efficiency.

Keywords:

Autonomous Robots; Precision Agriculture; Sensor Deployment; Computer Vision; Deep Learning

Mentor(s):

David J Cappelleri (Engineering); Aarya Deb (Engineering); Ki Tae Kim (Engineering)

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: Session 1: 10:30-11:30am

P-AgBot: Development of an Unmanned Ground Vehicle for IoT4Ag Soil Moisture Sensor Reading and Deployment

Authors(s):

Martin Vassilev+; Joseph F Norwood‡

Abstract:

With global populations rapidly rising, the need for robotic automation in precision agriculture has become increasingly important. Integrating automated technologies is necessary to optimize resource use and minimize environmental impact. Soil moisture sensing is shown to be a powerful tool for monitoring moisture levels, allowing for optimized irrigation of crops and increased yield. However, challenges such as accurate sensor deployment, reliable sensor reading, and robust navigation in variable field conditions have limited the widespread adoption of such systems. This work introduces the development of Purdue-AgBot (P-AgBot), an unmanned ground vehicle (UGV) that autonomously deploys and reads IoT4Ag biodegradable soil moisture sensors. This research aims to achieve over 90% precision in sensor deployment and to improve the reliability of sensor readings, with a goal of exceeding 95% successful data retrieval. The project aims to reduce the average time for each sensor reading cycle to under 2 minutes. Advancements include autonomous navigation through the integration of ArUco markers for visual servoing, upgrades to the P-AgBot's electronics, and refinement of the sensor deployment system. These approaches have been experimentally verified with simulations as well as bi-weekly deployment in-field over a period of two months. Soil moisture sensors were shown to be autonomously deployed and read using the P-AgBot. The results of this research demonstrate the feasibility of scalable, automated soil monitoring, which has the potential to enhance water conservation and crop yields in precision agriculture. Future work will focus on expanding the system's capabilities to additional sensor types and further improving operational efficiency.

Keywords:

Precision Agriculture; Robotic Automation; Soil Moisture Sensing; Sensor Deployment; Autonomous Navigation

Mentor(s):

David J Cappelleri (Engineering); Aarya Deb (Engineering); Ki Tae Kim (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Design and Integration of a Robotic Trailer for Autonomous Agricultural Robots

STEM

Authors(s):

Daming Yang†; Jeet Brahmbhatt* (Engineering)

Abstract:

Intensifying climate instability, rapid population growth, and water scarcity are among the many threats to food security worldwide. Advances in autonomous robotics for precision agriculture, such as realtime crop and soil monitoring, offer promising solutions to mitigate these challenges. One such technology is the Purdue Agricultural Robot (P-AgBot), an unmanned ground vehicle (UGV) designed to collect agricultural field data while autonomously navigating between crop rows, even in areas with degraded satellite coverage. Although P-AgBot has the potential to reduce water and fertilizer use and improve yields by providing low-cost, continuous monitoring, its operational range is limited by its small form factor, necessary for inter-row navigation, and its onboard battery capacity. To address this, our team proposes integrating P-AgBot into a marsupial robotic system by retrofitting a trailer with systems to secure, recharge, and deploy multiple P-AgBots automatically. Due to the limited availability of commercial solutions, all automation systems were developed from the ground up. To accomplish this, we leveraged computer aided design (CAD), specifically SolidWorks part and assembly design tools and motion studies. After generating multiple configurations, simulation methods such as finite element analysis (FEA) and computational fluid dynamics (CFD) were utilized to produce a final design that optimized functionality, structural integrity, and manufacturability. This rigorous approach assures the system will withstand the dynamic and transient loads encountered on uneven, agricultural terrain, facilitating reliable field deployment. Ultimately, this marsupial system has the potential to significantly extend P-AgBot's effective range, enabling its adoption in industrial farming operations.

Keywords:

Autonomous Robots; Internet of Things; Simulation Software; Precision Agriculture; Crop Monitoring

Mentor(s):

David J Cappelleri (Engineering); Aarya Deb (Engineering); Ki Tae Kim (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: Session 1: 10:30-11:30am

The Purdue Subcritical Pile STEM

Authors(s): Marlen Jones†

Abstract:

Understanding how radiation effects microelectronic devices is critical for predicting their performance in extreme environments. With the growing interest in space applications and engineering advancements, it is crucial to evaluate the reliability of devices in high radiation environments. To predict and track the performance of microelectronic devices, radiation effects testing must be completed in known radiation flux conditions. This research aims to quantify the total neutron flux within Purdue's subcritical pile. The Purdue subcritical pile is a research facility used for radiation effects testing and education. It is composed of graphite, natural uranium, and external neutrons sources, and operates based on the principles of fission, moderation, and absorption. The makeup of the pile works to transfer neutrons throughout its volume, however, maintains a subcritical state, making it a safe and controllable testing environment. This makes it useful for experiments and testing electronics in a radiation environment without operating a full nuclear reactor with the goal of developing a comprehensive flux map of the pile. Indium-115 foils are exposed to the neutron flux in the pile at varying locations, and the decay of their activated isotope is measured using a scintillation detector and converted into a flux value. By measuring the neutron flux of multiple foils at various locations, a heat map was created, displaying the flux distribution throughout the pile. Future work includes comparisons against Monte Carlo simulated models, conducting further measurements, and integrating those taken into ML program, aimed at predicting the flux in locations not directly measured.

Keywords:

Subcritical Pile; Neutron Activation; Flux Mapping

Mentor(s):

Hannah Pike (Engineering); Peter Bermel (Engineering); Stylianos Chatzidakis (Engineering)

Other Acknowledgement(s):
David Matthew Czerwonky (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Low-Level Legacies and Simulation-Based ValiditySTEM

Authors(s): Andrew LeClair†

Abstract:

Authors: Andrew LeClair

Mentors: Samera Hossain (Nuclear Engineering), Dr. Allen Garner (Nuclear Engineering)

The space-charge-limited current (SCLC) represents the maximum steady-state current that can be injected into a diode. In a semiconductor, this is given by the Mott-Gurney law (MGL) for a onedimensional (1D), planar diode for electrons with zero injection velocity. Recent studies have extended the MGL to nonplanar 1D geometries and multiple dimensions by using point transformations to map the electric potential in the gap. This study uses the Sentaurus TCAD to validate these theories for more realistic geometries. We first compare the simulated SCLC in a planar NIN diode to theoretical results for the 2D planar MGL. We then compare simulation predictions for the SCLC for other geometries to theoretical results using the canonical gap distance obtained by point transformations. Future studies will explore the transition between the MGL and the vacuum SCLC, given by the Child-Langmuir law, by using the particle-in-cell code XPDP1 at different pressures. This work will elucidate device operation and limits across pressures for applications that include high-power microwave, thermionic energy converters, and semiconductors.

Keywords:

SURF; Particle in Cell; TCAD; SCLC (Space-Charge Limited Current); SCALE

Mentor(s):

Samera Hossain (Engineering)

Other Acknowledgement(s):

Allen L Garner (Engineering); David Matthew Czerwonky (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Computational Approaches to Thermal Characterization of Materials in IC Packaging

STEM

Authors(s):

Ammar M Mukadam† (Engineering)

Abstract:

Today's semiconductor chips are smaller, faster, and more powerful than ever before. However, this innovation comes at a cost: significant heat generation. Warmer internal temperatures counter this progress by negatively impacting a chip's performance, exponentially increasing power loss, and leading to irreversible damage. Thus, the materials and design of the package surrounding the chip must effectively spread and dissipate the heat generated. This research project characterizes 3D-printed stainless steel samples to understand how different laser-based printing methods affect heat flow. Additionally, we assess the material's thermal performance when incorporated within complex integrated circuit (IC) packages alongside thermal interface materials (TIMs).

First, an infrared microscope was used to measure the thermal conductivity of these stainless steel samples. To aid in this characterization, a data visualization GUI was developed to identify which printing procedures most effectively spread heat. We hypothesize that a material's microscopic air gaps and metal grain patterns will be the most significant contributors to its thermal conductivity.

Additionally, we tested the samples alongside TIMs, which fill microscopic gaps between layers in the chip package. This involved implementing parallel processing on a Raspberry Pi computing cluster and IC simulations to analyze how workload characteristics affect temperature and TIM degradation. We hypothesize that intensive sequential tasks will lead to thermal hotspots and stress, while highly parallel workloads will have less degradation and overall cooler temperatures.

Ultimately, this research showcases how computational tools, including simulation, high-performance computing, and data visualization, can be leveraged to evaluate 3D-printed materials within IC packages.

Keywords:

Packaging; Semiconductor; Thermal; Heat Transfer

Mentor(s):

Yingru Song (Engineering); Amy M Marconnet (Engineering); Ritwik Vijaykumar Kulkarni (Engineering)

Other Acknowledgement(s):

David Matthew Czerwonky (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Plasma-Activated Polyimide and Copper Electroplating for Hybrid Bonding in 3D Heterogeneous Integration

STEM

Authors(s):

Ethan Xinghan Tan† (Engineering|JMHC)

Abstract:

As 3D heterogeneous integration becomes the state-of-the art solution to advanced packaging, bonding reliability between layers becomes a key challenge. Hybrid bonding, which bond dielectric and copper surfaces simultaneously and directly to themselves, has emerged as a leading technique. Recent research has proposed polyimide as a substitute for traditional oxide dielectrics due to its thermal stability and lower bonding temperature. Polyimide's bonding performance after plasma surface activation and its compatibility with copper metallization processes require further investigation. This project evaluates the effect of plasma treatment on polyimide surfaces and the effects of different processing variables on a robust copper electroplating process. Initial work involves reviewing the impact of varying temperature and thicknesses during plasma surface activation on polyimide adhesion, with attention to surface roughness, functional group introduction, and wettability. These will be assessed through surface characterization techniques including X-ray Photoelectron Spectroscopy (XPS) and Fourier-transform infrared spectroscopy (FTIR). In parallel, a copper electroplating setup is developed to simulate post-activation metallization, using a simple acidic sulfate bath and common lab apparatus. Key process

variables such as current density, bath temperature, additive concentration, and agitation are optimized for uniform copper deposition. The copper electroplating performance will be evaluated by optical microscopy and thickness measurement via profilometers. This study provides foundational insights into copper metallization methods and plasma activated polyimide, laying the groundwork for the development of a polyimide hybrid-bonding process. Results will inform whether polyimide, when properly treated and metallized, is a suitable dielectric for hybrid bonding applications.

Keywords:

Heterogeneous Integration; Copper; Polyimide; Hybrid Bonding

Mentor(s):
Shubhra Bansal (Engineering); Faharia Hasan Bhuiyan (Engineering)
Other Asknowledgement(s):

Other Acknowledgement(s):
David Matthew Czerwonky (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Azithromycin Drug Resistance in Acanthamoeba STEM

Authors(s):

Lucas Riley Hendershot† (Agriculture)

Abstract:

Acanthamoeba, a genus of pathogenic free-living amoeba, are capable of inflicting significant diseases in humans and animals alike. Species belonging to the Acanthamoeba are responsible for causing granulomatous amoebic encephalitis (GAE), Acanthamoeba keratitis, skin and systemic diseases. Currently, the best treatment for these infections involves a chemical combinational therapy made up of nonspecific anti-biotics, anti-fungals, and anti-parasitics. However, recent studies have suggested Azithromycin, a macrolide antibiotic, to be a frontline therapeutic against diseases caused by Acanthamoeba and other free-living amoeba. Azithromycin has been proven to work by binding to the 50S subunit, specifically the 23S rRNA subunit in bacterial ribosomes. Upon binding, azithromycin reduces protein synthesis and prevents cell growth. Unfortunately, this mechanism has only been validated in bacteria and not in any amoeba species. This study aims to develop azithromycin resistant Acanthamoeba mutants to potentially yield the phenotypical mechanism of action or resistance pathway(s). Developing resistant mutants capable of reaching a 100-fold shift in its IC50 towards a compound is the first step in discovering a mechanical mode of action (MMOA) within Acanthamoeba. Mutants were developed using a step-wise approach and now we have mutants growing in 60x-80x concentrations of the original azithromycin IC50. We will use specific target sequencing and potentially whole genome sequencing of mutants to identify azithromycin's MOA. If successful, this study would be the first to utilize drug resistant Acanthamoeba for studying molecular modes of action. Understanding the MMOA of Acanthamoeba is vital to developing enhanced therapeutic drugs that can effectively mitigate the diseases caused by this organism.

Keywords:

Acanthamoeba; Free-Living Amoeba; GAE; Mechanism of Action; Drug Resistance

Mentor(s):

Christopher Aaron Rice (Vet Med)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Chayan Sharma (Vet Med)

Presentation Time: Session 1: 10:30-11:30am

System-Level Dynamics of an RC Vehicle: A Black Box Approach to Drivetrain Modeling

STEM

Authors(s):
Justin Zijie Gan† (Engineering)

Abstract:

This research focuses on developing a practical physics-based simulation of a 1/10th scale RC vehicle, specifically addressing the challenge of modeling complex internal drivetrains. Rather than laboriously modeling every gear and component, we employ a "black box" approach for the transmission and differentials, representing them by their system-level properties: overall gear ratios, lumped inertia values, and estimated efficiencies. This methodology enables efficient creation of a visually comprehensive CAD model and robust multi-body dynamics simulations in SolidWorks Motion Study, allowing for accurate analysis of dynamic power output to the wheels and overall vehicle performance without sacrificing feasibility or demanding unfeasible modeling time.

Keywords:

[no keywords provided]

Mentor(s):

Andres Felipe Hoyos Moreno (Engineering); Samuel Labi (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Design of an analog Proportional-to-Absolute-Temperature temperature sensor

STEM

Authors(s):

Dong Wang† (Engineering)

Abstract:

Proportional-to-Absolute-Temperature (PTAT) Temperature sensors suffer from nonlinearity due to temperature-dependent semiconductor effects, limiting accuracy in wide-temperature-range applications. This work presents the design and optimization of a CMOS-based PTAT sensor, targeting improved linearity and reduced sensitivity to supply and process fluctuations. Using the Cadence GPDK045 technology, we analyze temperature dependencies of core components—bipolar junction transistors (BJTs), CMOS, and current mirrors—through a combination of analytical modeling and transistor-level simulations. An optimized PTAT architecture is proposed with carefully selected emitter area ratios, cascode current mirrors, and an folded-cascode differential amplifier stage to enhance temperature linearity. Simulation results demonstrate a linearity error below ±1?°C across 0?°C to 100?°C, validating the effectiveness of the proposed design.

Keywords:

Analog Design; Temperature Sensor; PTAT

Mentor(s):

Seyedehmarzieh Rouhani (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Impact of Silver Ion Leakage from Electrochemical Sensors on Cell Heath: A Triple Negative Breast Cancer Study STEM

Authors(s):

Yashvi Choudhary† (Science); Sadie A Poirier‡ (Science|JMHC)

Abstract:

[Abstract Redacted]

Keywords:

Electrochemical Sensor; Ion Leakage; Electrodes; Miniaturization; Cell Health

Mentor(s):

Vanshika Gupta (Science); Jeffrey Edward Dick (Science)

Presentation Time: Session 1: 10:30-11:30am

Retrograde Distal End-Diastolic Flow as a Marker for Severe Right Coronary Artery Occlusive Lesions on Invasive Coronary Angiography

STEM

Authors(s):

Uyen Dang†; Thy Le†; Tri Nguyen†; Khoa Tran†; Thai Nguyen†

Abstract:

Background: Retrograde flow detected using noninvasive imaging modalities has been associated with the severity of coronary artery occlusive lesions, possibly reflecting a hemodynamic disturbance such as the water hammer shock phenomenon. However, no study to date has investigated reverse flow using conventional invasive coronary angiography (ICA) as an indicator for coronary artery lesions. This study aimed to evaluate the correlation between the presence of reverse flow and the severity of right coronary artery (RCA) lesion.

Methods: A cross-sectional study was conducted on 30 patients with unstable angina who underwent ICA. Reverse flow was defined as increased contrast attenuation in the RCA at the end of the diastolic phase. Lesion severity was categorized as no lesion (0%), mild (1–39%), moderate (40–69%), and severe (?70%). The chi-square test was used to evaluate the association between the reverse flow and severity of RCA lesions.

Results: Among 30 patients, 21 (70%) had right coronary artery (RCA) obstruction and 4 (13.33%) had thick boundary layer. End-diastolic flow reversal on ICA was observed in 23 patients (76.7%). Nearly 93% patients with moderate RCA lesions exhibited reverse end-diastolic flow, compared to 60–66% in patients with mild or no RCA lesions. There were 4 patients without RCA lesions demonstrated reverse flow on ICA; indicating that reverse flow may precede detectable coronary obstruction.

Conclusions: This study suggests a potential positive correlation between retrograde flow and RCA lesion severity. Distal end-diastolic reverse flow may reflect early hemodynamic changes and could potentially serve as an indicator of the severity of coronary artery disease.

Keywords:

Right Coronary Artery; Retrograde Flow; Invasive Coronary Angiography; Occlusive Lesion; Coronary Artery Disease

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine)

Presentation Time: Session 1: 10:30-11:30am

Listening Through the Noise: How a Frog-Biting Mosquito Finds Hosts in Urban Environments

STEM

Authors(s):

Nina Rose Hall† (Science|JMHC)

Abstract:

In addition to dealing with natural background noise, animals are increasingly exposed to anthropogenic noise such as road traffic. To cope with these auditory challenges, animals possessing pressuredifference ears have evolved distinct strategies to overcome the problem of acoustic masking. However, how insects with flagellar ears are affected by noise remains largely unknown. In this study, we examine if mosquitoes are impacted by traffic noise and analyze how they compensate for it. We used Uranotaenia lowii, a unique species of mosquito that relies on auditory cues to locate anuran hosts for blood meals. While this host-seeking behavior is well documented, little is known about how environmental noise impacts this ability. One possible mechanism that could help Ur. lowii overcome noisy conditions is Spatial Release from Masking (SRM), a phenomenon in which sounds are more easily detected when they originate from a different spatial location than competing background noise. We hypothesize that these frog-biting mosquitoes are influenced by noise and use SRM to improve their ability to detect frog calls. We performed behavioral experiments with speakers playing road traffic noise and frog calls to determine how Ur. lowii females respond to noise coming from spatially different sources. We predict that their ability to locate frog hosts will be reduced when background noise originates from the same direction as the frog call. Investigating if Ur. lowii relies on SRM can reveal how it continues to locate hosts in increasingly noisy environments and deepens our understanding of how urbanization may alter species interactions.

Keywords:

Eavesdropping; Ecology; Mosquitoes; Spatial Release from Masking (SRM); Urbanization

Mentor(s):

Ximena Bernal (Science); Richa Singh (Science)

Presentation Time: Session 1: 10:30-11:30am

Correlation Between Lesion Location and Timing of Lesion Appearance During the Cardiac Cycle in the Right Coronary Artery on Angiography

STEM

Authors(s):

Linh Luu†; Phuong Ba†; Uyen Dang†; Ngoc Nguyen†; Viet Vo†

Abstract:

Background: Mechanisms driving lesion formation at specific sites in the right coronary artery (RCA) remain unclear. However, novel acoustic mapping for RCA blood flow suggests four possible lesion sites: 1R (mid-segment, proximal), 2R (mid-segment, distal), 3R (distal) and 4R (proximal). This study investigated whether the transition from diastole-to-systole influences lesion location in the RCA. The hypothesis is that "Water?hammer" pressure surge during the diastole?to?systole transition causes the strongest, most frequent lesions at site?1R, weaker ones at distal site?3R, and milder, less common lesions at 4R (diastole) and 2R (systole?to?diastole).

Methods: Twenty-nine patients with unstable angina underwent a new dynamic coronary angiography technique. Initially, the coronary artery was fully injected with contrast. After the injection stopped, blood (white) began to replace the contrast (black). All lesions, flow movement, direction, and characteristics were recorded. The timing of lesion visibility on coronary angiography was then analyzed using the Fisher's exact test to determine its relationship with the cardiac cycle.

Results: A significant association was found between RCA lesion severity and timing during the cardiac cycle (Fisher's exact test, p?<0.05). Lesions at site 1R appeared predominantly during the transition from diastole-to-systole (68.8%), with some visible only during diastole. Lesions at site 4R were exclusively diastole, while those at site 2R appeared during the transition from diastole-to-systole.

Conclusion: The transition of flow at the end of diastole and systole creates a collision between antegrade and retrograde flow, causing coronary lesions, especially at 1R . This result unmasks the mechanism triggering plaque formation in coronary arteries.

Keywords:

Right Coronary Artery; Transition; Flow; Angiography

Mentor(s):
Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine)

Presentation Time: Session 1: 10:30-11:30am

Differences in High-susceptible Lesion Location on The Right Coronary Artery and Reverse Flow Between Normotensive and Elevated Systolic Blood Pressure Populations STEM

Authors(s):

Ngoc Nguyen†; Linh Luu†; Thy Le†; Viet Vo†; Thai Nguyen†

Abstract:

BACKGROUND: Atherosclerosis is the underlying pathology of coronary artery disease, often promoted by turbulent flow and low shear stress. Recently, acoustic retrograde pressure—linked to the water hammer effect—has emerged as a potential hemodynamic contributor to plaque formation. Our hypothesis is whether there is a statistically significant relationship between acoustic retrograde flow with lesion locations and systolic blood pressure (SBP) level.

METHODS:

30 unstable angina patients without prior Percutaneous Coronary Intervention or Coronary Artery Bypass Graft underwent coronary angiography. A novel dynamic analysis assessed reverse flow and lesion locations in the right coronary artery, comparing findings across SBP groups (120–129, 130–139, and ?140 mmHg) based on the readings after injecting contrast. For the 120–129 mmHg group, pre-sedation SBP averaging was conducted to more accurately reflect true baseline blood pressure.

RESULTS:

Reverse flow increased with higher SBP. In the unadjusted analysis, reverse flow was seen in 64.3% of patient with SBP <130 mmHg (9/14 patients) and 87.5% with SBP ?130 mmHg. Adjusted pre-sedation values showed similar trends: 66.7% for SBP <130 mmHg (6/9 patients) and 81% for SBP ?130 mmHg (17/21 patients)

The lesion site 1R was the most frequent location of reverse flow, particularly at SBP ?140 mmHg, where it occurred in 90% of patients. Lower SBP was associated with fewer and more variable lesion sites.

CONCLUSIONS:

Reverse arterial flow appears primarily related to lesion location rather than systolic blood pressure levels. However, the small sample size limits the ability to draw firm conclusions.

Keywords:

Right Coronary Artery; Reverse Flow; Blood Pressure; Systolic; Normotensive

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine)

Presentation Time: Session 1: 10:30-11:30am

Impact of Cholesterol Control on Coronary Lesion Development in Flow-Disturbed Segments Identified by Coronary Acoustic Action Map

STEM

Authors(s):

Thuy Truong†; Uyen Dang†; Tri Nguyen†; Vinh Lam†; Quang Hoang†

Abstract:

Background:

Intimal injury and oxidized low-density lipoprotein (LDL) are well-established contributors to atherosclerotic plaque development. Coronary Acoustic Action Map (CAAM) suggested acoustic retrograde pressure waves from the water hammer phenomenon may identify regions prone to endothelial injury. However, the impact of cholesterol in these high-risk regions remains unclear. We aim to investigate the correlation between LDL and lesion severity in flow-disturbed regions identified by CAAM.

Methods:

A cross-sectional study of 29 patients with unstable angina and no history of percutaneous coronary intervention or coronary artery bypass grafting. All patients underwent coronary angiography and were stratified by LDL levels as optimal (?70 mg/dL) and suboptimal (>70 mg/dL) groups. Lesion severity classified as: no lesion (0%), mild (<30%), moderate (30–70%), or severe (>70%) luminal narrowing in four flow-disturbed regions (1R–4R). The correlation between lesion severity and LDL was assessed using Fisher's exact test across all regions.

Result:

Among 29 patients (16 with optimal LDL ?70 mg/dL, 13 with suboptimal LDL >70 mg/dL), lesion severity was assessed across four regions (1R–4R). In region 1R, mild to severe lesions were present in both groups, but no significant association was found (p = 0.852). Regions 2R, 3R, and 4R showed predominantly no or mild lesions in both groups, with no significant differences observed (p > 0.05). Overall, lesion severity did not differ significantly between LDL groups across all regions.

Conclusion:

Although findings were not significant, likely due to small sample size, the trend toward greater lesion burden in the suboptimal LDL group—especially in region 1R—warrants further study.

Keywords:

Low-Density Lipoprotein; Coronary Acoustic Action Map; Atherosclerotic Plaque; Endothelial Injury; Retrograde Pressure Waves

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine)

Presentation Time: Session 1: 10:30-11:30am

Proximity Labeling to Identify Proteins that Interact Transiently with the ATP-dependent Chromatin Remodeler PICKLE in Arabidopsis thaliana

STEM

Authors(s):

Elysia Marlena Uggen† (Agriculture|JMHC); Joshua Paul Kaluf* (Agriculture)

Abstract:

[Abstract Redacted]

Keywords:

[no keywords provided]

Mentor(s):

Joseph P Ogas (Agriculture); Jiaxin Long (Agriculture); Jacob Ryan Fawley (Agriculture)

Presentation Time: Session 1: 10:30-11:30am

Association Between 1R Lesion Severity in the Right **Coronary Artery and Cardiovascular Risk Factors: Implications for Medication Management**

STEM

Authors(s):

Viet Vo†; Linh Luu†; Ngoc Nguyen†; Vo Duong†; Quan Nguyen†

Abstract:

Introduction: Acoustic blood flow mapping represents a recent advancement in identifying commonly lesion-prone regions of the right coronary artery (RCA): 1R (proximal mid-segment), 2R (distal midsegment), 3R (distal segment), and 4R (proximal segment). It is hypothesized that the water hammer shock effect, a backward-traveling pressure wave generated during the rapid transition from diastole to systole, contributes to lesion formation, with the 1R site believed to be the most vulnerable to this hemodynamic force. This study aims to further investigate the relationship between additional factors, particularly cardiovascular risk factors, and the severity of 1R lesions.

Methods: The study involved 29 patients who presented with unstable angina and underwent coronary angiography. Lesion severity at the 1R site was classified into four categories: no lesion, mild, moderate, and severe. Cardiovascular risk factors were also categorized, including lowdensity lipoprotein (LDL) levels, blood pressure status, smoking history, body mass index (BMI), alcohol consumption, age, and sex. Fisher's exact test was used to analyze the association between lesion severity at 1R and each cardiovascular risk factor

Results: Significant associations were observed between 1R lesion severity and both LDL level (p = 0.038) and smoking status (p = 0.021). A borderline association was noted with BMI (p = 0.051). No significant associations were found for blood pressure, alcohol use, age, or sex.

Conclusion: Elevated LDL cholesterol and current smoking were significantly associated with greater 1R lesion severity in the RCA. Targeted management of lipids and cessation of smoking may help reduce localized lesion progression.

Keywords:

Right Coronary Artery; 1R Lesion; Low-Density Lipoprotein; Smoking; **Blood Pressure**

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Mentor(s):
Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine)

Presentation Time: Session 1: 10:30-11:30am

Examining polyandry in a Uranotaenia lowii STEM

Authors(s):
Gloria Yaneth Rivas†

Abstract:

Polyandry, a mating system where a female mates with multiple males, is observed across numerous insect taxa which influences the species' genetic diversity, offspring viability, female fecundity, and the dynamics of sexual selection. While mosquitoes are generally considered monandrous, where females mate with only one male, emerging evidence suggests that some species exhibit polyandry. However, far less is known about such mating behavior in non-vector species, those that do not transmit pathogens to humans. This study examines polyandrous behavior in Uranotaenia Iowii, a mosquito species that primarily feeds on anuran hosts. We hypothesize that in populations with a 1:1 male-to-female ratio, female Ur. lowii will exhibit polyandry. To test this hypothesis, we carried out two controlled laboratory mating experiments which included blood feeding for egg production after each mating cycle and performing dissections to examine their spermatheca for signs of insemination. We then quantified the mating frequency and assessed the reproductive outcomes associated with polyandrous behavior. Our understanding of mating strategies in non-vector mosquito species provides a valuable comparative framework to evaluate the ecological and evolutionary significance of polyandry across the Culicidae family.

Keywords:

Ecology; Mating; Polyandry; Spermatheca; Uranotaenia lowii

Mentor(s):

Ximena Bernal (Science); Richa Singh (Science)

Presentation Time: Session 1: 10:30-11:30am

Counterfeit Electronics Detection for Microchips STEM

Authors(s):
Justin E Bullock†

Abstract:

Counterfeit computer chips pose significant risks to the security and reliability of consumer electronics, with potential implications for user safety. This research project explores improved methods for verifying chip authenticity through a comprehensive literature review. The study begins with the identification of a seed paper, from which key terms were extracted and used to conduct a refined search in Scopus using Boolean AND operations. The resulting datasets were exported as CSV files for screening and evaluation. Relevant articles, identified through a systematic review process, were categorized based on the testing methods they described. These methods fall into three main categories: External Inspection, Internal Inspection, and Electrical Testing.

External Inspection techniques including both optical and physical techniques, such as visual inspection, weight measurement, dimensional analysis, and X-ray fluorescence (XRF), can detect different anomalies, but one given technique may not always suffice. Internal features such as internal chip locations and layout, and wire bonds or interconnects are more difficult to measure quickly and require a reliable basis for comparison. Electrical testing can help detect questionable components when it can benefit from reliable guidelines from the manufacturers, such as technical datasheets listing the electrical characteristics in detail.

These findings of complementary strengths and weaknesses suggest that a combination of External Inspection, Internal Inspection, and Electrical Testing may offer a more robust strategy for detecting counterfeit chips. Further research is recommended to validate integrated approaches and improve detection accuracy.

Keywords:

[no keywords provided]

Mentor(s):

Sheng-wen Huang (Engineering); Peter Bermel (Engineering)

Presentation Time: Session 1: 10:30-11:30am

Proximity-Driven Capture of LnaB-Ubiquitin Complex Reveals AMPylation Mechanism

STEM

Authors(s):

Matthew Reitmajer†

Abstract:

Legionella NF-?B activator B (LnaB) is an actin-dependent AMPylase secreted by the bacterial pathogen Legionella pneumophila, which facilitates the conversion of phosphoribosylated ubiquitin (PR-Ub) into ADP-ribosylated ubiquitin (ADPR-Ub). However, the precise two-step mechanism by which LnaB catalyzes ATP hydrolysis and transfers AMP onto substrates remains poorly understood. To address this, the current project aims to capture the Ub-bound states of actin-activated LnaB. Given the transient nature of the LnaB-Ub interaction, this study employs a proximity-driven covalent tethering approach to increase the likelihood of capturing Ub-bound states. We hypothesized that by incorporating an electrophile at position Q40 of ubiquitin, it would react in a proximitydependent manner with a suitably positioned nucleophilic cysteine residue in the LnaB active site, thus facilitating the formation of a covalent complex through chemoselective ligation. To achieve this, we substituted serine 261 within the SHE motif of LnaB with a more nucleophilic cysteine residue, enabling covalent linkage to a genetically incorporated unnatural amino acid, p-(2-chloroacetamido)-phenylalanine (pCaaF), positioned at residue 40 of ubiquitin. The resulting covalently tethered complex, UbQ40pCaaF-LnaBS261C, was purified and incubated with equimolar amounts of actin, and will subsequently be subjected to cryo-electron microscopy (cryo-EM) to gain mechanistic insights into LnaB function.

Keywords:

LnaB; Ubiquitin; Crosslinking; AMPylation

Mentor(s):

Nipuni Maleesha Pannala (Science); Chittaranjan Das (Science); Shalini Iyer (Science)

Presentation Time: Session 1: 10:30-11:30am

Synthesis and Reactivity of Lanthanide with Redox-Active Frameworks towards early Chalcogens

STEM

Authors(s): Landon Oliver King† (Science)

Abstract:

Lanthanide elements have a stable oxidation state of (+3) and are limited in their reactivity with small molecules due to the relative redox inertness of the metals. To overcome this, redox active ligands can be used to temporarily store electrons, which can then be used for small molecule activation. The purpose of this research was to first synthesize and characterize both bis and tris redox active ligand complexes with neodymium, gadolinium, and ytterbium. Next, we explored their reactivity towards sulfur and oxygen with these redox-active complexes in the hopes of finding a pathway to stable terminal chalcogens. The Bart group has previously published the Neodymium bis ligated system as well as its reactivity towards S8. Extending this work, the successful synthesis of the Neodymium tris ligated system, as well as the bis and tris system for Ytterbium and Gadolinium were completed and characterized with x-ray crystallography. Reactivity of the early chalcogens, sulfur and oxygen, was explored and yielded a repeatable creation of the 6-member sulfurmetal metallocycle in a twist boat formation with both Yb and Gd. Along with the metallocycle, an unexpected and repeatable 7-member sulfur chain was observed and characterized by x-ray crystallography. Exploration of oxygens reactivity with the bis ligated systems yielded change in spectroscopic data but proved difficult to produce single crystals suitable for x-ray crystallography. This twist boat conformation is contrasted with the transition metals preference towards chair conformations.

Keywords:

Inorganic; Redox; Lanthanide; Chalcogen

Mentor(s):

Kelly Lorraine Gullett (Science)

Other Acknowledgement(s):

Suzanne C Doucette (Science); Andrew William Mitchell (Science); Matthias Zeller (Science)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 2: 12:00-1:00pm

Machine Learning Optimization & Sensor Characterization for Advanced Particle Detection Systems

STEM

Authors(s):

Ana Sofia Calle Munoz†; Anna G. Klupshas* (Science)

Abstract:

Silicon-based sensors are crucial in modern particle physics experiments, enabling precise tracking of charged particles in high-energy collisions. As particle accelerators like the Large Hadron Collider (LHC) at CERN advance into higher luminosity regimes, the development, testing, and optimization of such sensors become increasingly important for accurate data collection and new physics discoveries. My research focuses on two complementary efforts to improve silicon pixel detector performance for next-generation experiments.

First, we investigate regression optimization algorithms intended for deployment on SmartPixel sensor hardware. This machine learning approach is designed to predict spatial and angular variables of particle tracks from charge deposition data. Using Mixture Density Networks (MDNs) trained on large simulated datasets, the model learns statistical correlations between deposited charge cluster patterns and track parameters. Ongoing efforts involve enhancing prediction accuracy through the introduction of regularizers in the loss function, dynamic scheduling of hyperparameters, and Pareto front analyses to balance trade-offs between physical and statistical performance.

In parallel, we contribute to the quality control testing of MaPSA (Macro Pixel Sub-Assemblies) sensors developed for the High-Luminosity LHC upgrade. Using a semi-automated probe station and a Linux-based testing environment, we perform critical validation procedures, including leakage current, pixel response, and masking tests to evaluate sensor performance. Each sensor is assigned a quality grade based on these results, determining its suitability for deployment.

Keywords:

Particle Physics; Machine Learning; Detection Systems; Quality Control

Mentor(s):

Miaoyuan liu (Science); Jan-Frederik Schulte (Science)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Arghya Ranjan Das (Science); Ethan Michael Colbert (Science); Yao Yao (Science); Shiqi Kuang (Science)

Presentation Time: Session 2: 12:00-1:00pm

Comparative In Vitro Evaluation of Intestinal Permeation Enhancers for Oral Delivery of Octreotide: Salcaprozate Sodium (SNAC) and Palmitoylcarnitine

STEM

Authors(s):

Valeria Certuche Sanchez†; Grace Coomes‡ (Pharmacy)

Abstract:

Acromegaly is a chronic endocrine disorder resulting from pituitary adenomas that trigger excessive secretion of growth hormone (GH), leading to elevated insulin-like growth factor 1 (IGF-1) levels and serious systemic complications. Octreotide, a synthetic somatostatin analog, is the first-line pharmacological treatment. Although traditionally administered via injection due to its poor intestinal permeability and enzymatic instability, recent technologies have enabled the development of oral formulations.

Although peptide-based drugs like octreotide offer high potency and receptor specificity, oral administration remains a major challenge, impacting patient compliance and quality of life in long-term therapies. One promising strategy to overcome these barriers is the incorporation of permeation enhancers (PEs) into oral formulations.

We have been exploring formulation strategies for the oral delivery of octreotide using intestinal permeation enhancers, specifically salcaprozate sodium (SNAC) and palmitoylcarnitine (PC), while also evaluating some surface activity parameters of these excipients in relation to their effects on permeability. The experimental groups included octreotide alone (100 $\mu\text{M})$ and combinations with SNAC (10 and 20 mM) or PC (0.1 and 0.5 mM), aiming to assess their synergistic effects on transport across the intestinal barrier.

These formulations are being tested for chemical stability under acidic (pH 2.2, KH2PO4) and neutral (pH 7.4, PBS) conditions. Degradation was monitored by reverse-phase high-performance liquid chromatography (RP-HPLC) at 220 nm.

Intestinal permeability has been tested using an in vitro model simulating the intestinal epithelium, based on Caco-2 monolayers cultured for 21 days on Transwell® inserts. The integrity of the monolayers was monitored by measuring transepithelial electrical resistance (TEER),

serving as an indicator of tight junction function. Expected outcomes include the quantification of apparent permeability coefficients Papp to compare the effectiveness of each enhancer in promoting octreotide transport across the intestinal model.

Keywords:

Peptide Drugs; Oral Peptide Delivery; Permeation Enhancers; Caco-2 Cell; Formulation

Mentor(s):

Gregory Thomas Knipp (Pharmacy)

Presentation Time: Session 2: 12:00-1:00pm

Conceptual Design of an Underwater Actuator for Active Vibration Control of Offshore Pile Driving

STEM

Authors(s):

Luis David Garcia Almeida†

Abstract:

Offshore wind energy installations require pile driving, a process that generates seabed vibrations in the 50–500?Hz range. These vibrations create underwater noise that can negatively affect marine ecosystems, raising environmental concerns as offshore energy continues to expand.

This project presents the conceptual design of a seabed-mounted actuator, the core component of an active vibration control system intended to counteract these disturbances. A structured engineering methodology was applied, beginning with a Product Design Specification (PDS) and a Quality Function Deployment (QFD) matrix to define key performance and environmental requirements.

Various actuation technologies such as electrohydraulic, electromechanical, and electrohydrostatic were evaluated based on criteria including force capacity, frequency response, marine durability, and implementation feasibility. The comparative analysis provides a solid foundation for selecting a feasible and efficient actuator architecture suited for underwater vibration control.

Early-stage CAD models were developed to visualize the actuator architecture, and a preliminary analysis of seabed dynamics was conducted to inform force and frequency requirements. This work provides a foundational design for future simulation, prototyping, and experimental validation, contributing to more sustainable offshore wind development aligned with marine ecosystem protection.

Keywords:

Offshore Wind; Pile Driving; Vibration Mitigation; Actuator Design; Renewable Energy

Mentor(s):

Yangfan Liu (Engineering)

Other Acknowledgement(s):

Juhyung Kim (Engineering); Jinghe Yu (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 2: 12:00-1:00pm

Fluid-structure interactions in non-axisymmetric perivascular spaces

STEM

Authors(s):
Juan Andres Gil Duque†

Abstract:

The perivascular spaces (PVS) surrounding cerebral arteries play a key role in cerebrospinal fluid (CSF) transport and waste clearance in the brain. In this study, we numerically investigate flow in non-axisymmetric eccentric annular geometries, which are representative of the PVS. focused on the motion driven by arterial wall pulsations for different eccentricities, wave profiles, and grades of brain stiffness. Fluid-structure interaction (FSI) was implemented between the CSF flow and the brain tissue as an extension of the model developed by Coenen et al. (JFM. 2021, doi:10.1017/jfm.2021.525). Our results showed that eccentricity modulates the spatial distribution of pressure and flow, with increased eccentricity leading to higher axial velocity and reduced hydraulic resistance. This reduced hydraulic resistance is attributed to a reduced effect of wall friction on the CSF flow. Moreover, we observed that the net average flow was diminished. Furthermore, rigid approximation models may underestimate hydraulic resistance along the PVS under dynamic boundary conditions. We find that incorporating FSI in this study provides more accurate models of flows in perivascular spaces.

Keywords:

Perivascular Spaces; Fluid-Structure Interaction; Fluid Mechanics; Fluid Simulations

Mentor(s):

Ivan C Christov (Engineering); Nishanth Surianarayanan (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Isotropic Fractional Hall State to Nematic transition at v=7/2 mediated by nuclear spin polarization

STEM

Authors(s):
Juan Camilo Ospina Villa†

Abstract:

Half-filling in the second Landau level of the two-dimensional electron gas (2-DEG) in high quality GaAs/AlGaAs heterostructures typically hosts topologically ordered states. However, changes in the system Hamiltonian can drive transitions to anisotropic phases. We present transport measurements revealing a metastable anisotropic phase at v=7/2 in a GaAs 2-DEG, which relaxes back to an isotropic state over time. Notably, this anisotropy emerges only when sweeping the magnetic field down from high values and is absent when sweeping up, indicating a strong history dependence. By studying this behavior across different temperatures and sweep conditions we show that the anisotropy may be linked to nuclear spin polarization, which modifies the electron Zeeman energy via the Overhauser field without breaking rotational symmetry. Additionally, measurements on samples with varying densities highlight the tunability of this transition via sample parameters. Our results offer a new route to control anisotropic electronic phases through nuclear spin environments, providing fresh insight into the competition between topological order and nematicity in the second Landau level.

Keywords:

Fractional Quantum Hall Effect; Nuclear Spin Polarization; 2-DEG; Gallium Arsenide; Anisotropy

Mentor(s):

Michael James Manfra (Science); Ramon Felipe Guerrero Suarez (Science)

Presentation Time: Session 2: 12:00-1:00pm

Exploring Fungal Diversity: Isolation and Characterization of Endophytic Fungal Isolates from Cacao Trees (Theobroma cacao) in Colombia

STEM

Authors(s):

Angela Maria Ossorio Trochez†

Abstract:

[Abstract Redacted]

Keywords:

Endophytic Fungi; Cacao; Biological Control; Plant Pathogen

Mentor(s):

Mary Aime (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Catalytic Hydrodeoxygenation of Coffee Oil for the Production of Jet-Fuel-Range Hydrocarbons

Authors(s):

Maria Jose Sanchez Velez†; Alyssa Camryn Kohl‡ (Engineering); Sidney Shea Bauer‡ (Engineering)

Abstract:

The aviation industry relies on kerosene-based jet fuels composed primarily of C9-C16 hydrocarbons, which are efficient but derived from depleting fossil sources. This research explores the production of jetfuel-range hydrocarbons from spent coffee grounds (SCGs), a waste biomass rich in triglycerides and fatty acids. The goal is to develop a more sustainable method to convert coffee oil into hydrocarbon fuels through catalytic hydrodeoxygenation (HDO) reactions. Coffee oil was extracted from SCGs using ethyl acetate and reacted with metallic catalysts (CoMo/Al?O?, NiMo/Al?O?, Pt/Si) in a 100 mL Parr reactor under high temperature and pressure. Water was used as a hydrogen donor instead of molecular hydrogen to enhance safety and reduce cost. Experimental conditions varied in temperature (220–300?°C), time (1.5– 12 hours), and catalyst concentration (5%-30%). GC-MS analysis of the organic fractions revealed a clear dependence on both catalyst type and reaction time. Samples reacted for shorter times showed a predominance of unreacted fatty acids, such as hexadecanoic and linoleic acid, indicating incomplete HDO. The PtSi catalyst yielded the poorest performance, with minimal hydrocarbon conversion. In contrast, reactions carried out for more than 7 hours using NiMo and CoMo catalysts produced a significantly greater diversity of linear and cyclic hydrocarbons within the jet fuel range. These preliminary results confirm the viability of coffee oil as a renewable feedstock for jet fuel production using water and bimetallic catalysts. Future work should focus on optimizing water-to-oil ratio, and temperature to improve conversion efficiency and maximize hydrocarbon yield.

Keywords:

Sustainable Fuel; Spent Coffee Grounds; Bimetallic Catalysts; HDO

Mentor(s):

enrico Martinez Sainz (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Integrating Modularization and Generative Design for Holistic Design Optimization

STEM

Authors(s):

Sebastian Valencia Zapata†

Abstract:

Prefabricated construction has emerged as a promising strategy to improve sustainability, cost-efficiency, and on-site safety by leveraging off-site industrialized manufacturing. Among the design approaches, top-down modularization decisions have guided the transformation of traditional building designs into prefabricated systems while preserving architectural intent. This research investigates a graph-based top-down methodology to modularize existing BIM designs and assess their prefabrication potential.

The proposed approach expands the modularization process by incorporating a heterogeneous set of building elements, including walls, doors, and windows, and encoding spatial and semantic relationships such as adjacency, hosting, and room function within a unified graph representation. By capturing these rich interactions, the framework seeks to enable a more realistic and flexible analysis of modular potential. Current efforts focus on constructing this graph-based data model and identifying similarity patterns among substructures, with the long-term goal of informing modular design decisions. This work will contribute to a richer and data-driven foundation for modular design strategies in prefabricated construction.

Keywords:

Modularization; Graph Modeling; Prefabricated Construction; Design Automation

Mentor(s):

Soowon Chang (Polytechnic)

Presentation Time: Session 2: 12:00-1:00pm

Effects of Regenerative Agriculture on Urban Soil Health STEM

Authors(s):

Joniyah Renee Alford† (Agriculture)

Abstract:

Urban soils differ significantly from agricultural soils, shaped and often degraded due by factors such as the urban heat island effect and intensive development. With a large portion of the global population residing in urban environments, ensuring food security through urban agriculture requires fertile soils. The purpose of this study was to determine and evaluate the effects of common regenerative agricultural practices on urban soil health. This study focuses on two community gardens in Indianapolis, Indiana – one a large, multifaceted operation, and the other a smaller, experimental, and educational garden managed by one individual. Land adjacent to these sites and managed conventionally served as controls. The regenerative practices at the gardens were compared and soil samples were taken from each site at locations under similar management. These samples were then compared by analyzing soil health indicators such as compaction, nutrient availability, and biological composition. Compaction was measured using a penetrometer. Nitrogen, phosphorus, potassium, pH, electroconductivity, total dissolved solids (TDS), and the fungal-bacteria ratio were measured in each sample using probes, sensors, and testing kits. Soils treated with regenerative agricultural practices are expected to exhibit better health than those with conventional practices. Producing results that quantify the impact of regenerative agricultural practices could be utilized to educate and influence urban development sectors and communities in Indianapolis. Further research explores how these practices can be integrated into city planning, policy frameworks, and community-led initiatives to promote healthier, more resilient urban ecosystems.

Keywords:

Urban Soils; Soil Health; Agricultural Management

Mentor(s):

Anna Aleksandro Paltseva (Agriculture)

Other Acknowledgement(s):

Emily Spray (Agriculture)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 2: 12:00-1:00pm

Understanding the Ecology and Physiology of 'Ohi'a Lehua Trees in the Face of Rapid 'Ohi'a Death?

STEM

Authors(s):

Mark T Crooks† (Agriculture)

Abstract:

While 'ohi'a lehua (Metrosideros polymorpha) is the most abundant tree on the Hawaiian Islands, comprising 80% of the native forests, this tree has recently faced mortality due to a novel fungal pathogen called Rapid 'Ohi'a Death (ROD). Understanding the mechanisms underlying the tree's ability to resist ROD is critical for its survival and restoration efforts. One trait potentially underlying resistance is nonstructural carbohydrate (NSC) reserves, which are the sugars and starch that trees store and then remobilize to support metabolic functions during typical and stressful conditions. We quantified sugar and starch concentrations throughout 'ohi'a lehua trees (n=9) over the course of one year (February 2024-February 2025). In addition, we tracked flowering patterns from trail camera images to relate this carbon-demanding process to NSC dynamics. Overall, our work will improve our understanding of how 'ohi'a lehua trees store and use their NSCs throughout the year and will help to identify times of the year when the trees may be most vulnerable to ROD. Ongoing efforts will focus on understanding how 'ohi'a lehua trees respond to drought stress. This information will both add to the collective knowledge on the species as well as provide key insights into 'ohi'a lehua trees' responses to combined abiotic and biotic stress.

Keywords:

Ohi'a lehua; Rapid 'Ohi'a Death; Nonstructural Carbohydrates; Hawaiian Islands

Mentor(s):

Morgan Emily Furze (Agriculture); Asa Lear McCurdy (Agriculture)

Other Acknowledgement(s):

Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Investigating the role of Rm62 RNA helicase in R-loop homeostasis, gene regulation, and neurodegeneration in aging.

STEM

Authors(s):

Louis Michael Delaby† (Agriculture|JMHC)

Abstract:

By 2080, individuals aged 65 and older are projected to outnumber children under 18 worldwide, raising concerns about age-related diseases like Alzheimer's disease (AD). These disorders are characterized by distinct molecular features, including transcriptional stress, genome instability, and chronic immune activation. Although these hallmarks of age-related pathologies are well documented, the underlying mechanisms driving these cellular changes remain largely unknown. Recent studies highlighted the role of R-loops, three-stranded nucleic acid structures composed of an RNA:DNA hybrid and a displaced single-stranded DNA, in contributing to age-related pathologies. These structures can trigger genomic instabilities by promoting transcriptionreplication conflicts and inducing double-strand breaks. DEAD-box RNA helicases, including DDX17 (Rm62 in Drosophila), are evolutionarily conserved proteins coordinating various aspects of RNA metabolism. including formation and resolution of R-loops, critical for maintaining gene expression. However, the role of DDX17/Rm62 in preserving genome stability and regulating transcription in aging and AD remains poorly understood. We utilized Drosophila melanogaster as a model organism due to its well-established use in studying age-related disorders and conservation of key molecular pathways with humans. Our findings demonstrate that reduced Rm62 levels resulted in global accumulation of R-loops. Transcriptome profiling using next-generation sequencing of Drosophila heads with reduced Rm62 levels identified widespread disruption in gene expression, including upregulation of genes involved in heat shock and immune responses. Overexpression of Rm62 rescued age-related declines in climbing ability. In a Drosophila model of Alzheimer's disease, reduction of Rm62 levels exacerbated the eye degeneration phenotype, suggesting a protective role for Rm62 in aging and age-related neurodegeneration.

Keywords:

R-loops; Rm62 Helicase; Aging; Gene Expression; Neurodegeration

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Mentor(s): Hana Hall (Agriculture); Kendall Cottingham (Agriculture)

Other Acknowledgement(s): Nima Goodarzi (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Harnessing the MVA pathway and IPP transporter to modulate MVA/MEP cross-talk and terpenoid flux in Solanum lycopersicum

STEM

Authors(s):

Anna Alden Fisher† (Liberal Arts|JMHC)

Abstract:

Terpenoids are among the largest and most functionally diverse classes of plant secondary metabolites, contributing to key fruit and vegetable traits, including pigmentation, flavor, aroma, and nutritional value. Their biosynthesis relies on the mevalonic acid (MVA) pathway and the methylerythritol phosphate (MEP) pathway, which exchange intermediates via the isopentenyl diphosphate (IPP) transporter. Using Solanum lycopersicum as a model system, we aimed to a) enhance terpenoid production by targeted manipulation of the MVA pathway and b) address gaps in the current understanding of terpenoid metabolic flux. Previous stable isotope labeling experiments confirmed metabolic crosstalk between the two pathways, with each pathway contributing 15-30% to the flux of the other. Terpenoid biosynthesis is developmentally regulated, and the expression of a gene encoding the IPP transporter also increased during fruit ripening. Transient transformation of mature green tomato fruits with Agrobacterium tumefaciens overexpressing key MVA pathway enzymes (e.g. HMGR1 coupled with PMK; IPK) with or without the IPP transporter led to significant changes in downstream metabolites from both pathways. Metabolomic analysis revealed statistically significant increases in limonene, carotenoids, ubiquinone, and sterols relative to empty vector (EV) fruits overexpressing IPP transporter. These results suggest that simultaneous overexpression of key MVA enzymes and the IPP transporter reshapes precursor availability and redirects metabolic flux toward terpenoid biosynthesis. Overall, our findings demonstrate that combinatorial pathway engineering can effectively modulate flux through both the MVA and MEP pathways, offering a promising strategy to enhance terpenoid biosynthesis in crops.

Keywords:

Terpenoid; MVA Pathway; Isopentenyl Diphosphate; Cross-Talk; Metabolomics

Mentor(s):

Natalia Dudareva (Agriculture); Manuel Bellucci (Agriculture)

Other Acknowledgement(s):

Mearaj Ahmed Abdul Jabb Shaikh (Agriculture); Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Investigating the role of Set3 and Set4 in azole resistance in Candida glabrata

STEM

Authors(s):

Carolyn Jia† (Agriculture|JMHC)

Abstract:

[Abstract Redacted]

Keywords:

[no keywords provided]

Mentor(s):

Scott D Briggs (Agriculture); Justin Bradley Gregor (Agriculture)

Other Acknowledgement(s):

Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Drought Stress in Maize STEM

Authors(s):

Amelia Johnson† (Agriculture|Science)

Abstract:

[Abstract Redacted]

Keywords:

[no keywords provided]

Mentor(s):

Michael V Mickelbart (Agriculture); damon Lisch (Agriculture)

Other Acknowledgement(s):

Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Creating and Testing Al-Driven Educational Support Systems for Interdisciplinary Biological Engineering Learning

Authors(s):

Ekagrah Kumar† (Agriculture|Engineering); Shreyans Jain‡; Ha Nguyen‡

Abstract:

This research addresses the growing need for Al-driven educational support in complex, interdisciplinary fields such as biological engineering. An Al tutor was developed and tested for Purdue University's ABE 20100 (Material and Energy Balances) course, aiming to enhance student understanding, develop engineering problem-solving skills, and foster competence as future engineers. The methodology utilizes Large Language Models (LLMs) with Retrieval-Augmented Generation (RAG), allowing the tutor to generate contextually relevant and accurate responses directly from provided course materials. including the syllabus, textbooks, and class slideshows. Prompt Engineering was used to define the tutor's role as a patient, knowledgeable, and adaptive educator that uses the Socratic method for teaching. The system employs evidence-based and Personalized Adaptive Learning (PAL) strategies, such as active recall, spaced repetition with self-assessment, and immediate, customized exercise feedback, tailoring the learning experience to individual student progress and identifying difficulties. Preliminary testing using text-based guizzes indicates the tutor's effectiveness in promoting student engagement and improving understanding through interactive exercises and tailored guidance. A key finding is that AI tutors can significantly complement traditional instruction, offering scalable, adaptive, and personalized learning experiences crucial for mastering interdisciplinary engineering concepts. Preliminary studies demonstrated Al's potential to reduce learning time and enhance efficiency in educational settings. However, challenges persist with accurately handling complex numerical and analytical problems, which future developments must address. More complete evaluations will be conducted on learning outcomes in ABE 20100 when the course is next offered.

Keywords:

Biological Engineering; Engineering Education; Artificial Intelligence; Large Language Models; Intelligent Tutoring Systems

Mentor(s):
Martin R Okos (Engineering); Dharmendra Saraswat (Engineering)

Other Acknowledgement(s): Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Analyzing Biofilm Formation on PVC-coated Magnetic Beads for High-throughput Microbiome Applications

STEM

Authors(s):

Mallory A Luse† (Agriculture|Engineering); Lillian Grace Maldia* (Engineering)

Abstract:

High-throughput experimental platforms, introduced by liquid handling robots, enable efficient analysis of microbial function, assembly, and interactions. With the use of magnets, generalizable methods have been developed to enable these robots to handle solid materials, where many microbes thrive. To replicate the surface properties prevalent in water systems, stainless steel beads have been coated with polyvinyl chloride (PVC) allowing them to be compatible with robotic handling. Small-scale environments were recreated in glass jars to model both drinking water and hydroponic systems. Fabricated PVC beads and PVC pipe coupons were incorporated to standardize the beads, ensuring they are representative of broader PVC-based systems and suitable for replicable microbiome analysis. Flow cytometry and DNA extraction methods were used to assess biomass growth in the bulk water and the biofilm. These results were analyzed to optimize raw DNA yield, which was used in downstream DNA sequencing and has the potential to be utilized in qPCR analysis. Experimental data has shown that the beads and coupons obtain similar DNA yields per surface area, highlighting the viability of this method as a low-cost alternative to PVC pipe coupons. The results from downstream sequencing will allow for more in-depth analysis of the similarities of microbiomes on the two surfaces, further standardizing the method of PVC beads to PVC coupons. Overall, this research aims to develop optimized methods that allow liquid-handling robots to study the microbiome on diverse solid materials, improving the safety of water systems.

Kevwords:

Microbiome: Liquid-Handling Robot; Flow Cytometry; DNA Extraction; Water System Safety

Mentor(s):

Caitlin Rose Proctor (Engineering); Roland Conrad Wilhelm (Agriculture); Arval Viji Elango (Agriculture)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Jeffrey P Youngblood (Engineering); Yirou Wang (Engineering); Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Investigating the role of Remodelers and Modifications of Chromatin in Gibberellin-Dependent Responses in Arabidopsis thaliana

STEM

Authors(s):

Laurie Lei McIntyre† (Agriculture|JMHC); Elysia Marlena Uggen‡ (Agriculture|JMHC); Joshua T Stephenson* (Agriculture)

Abstract:

[Abstract Redacted]

Keywords:

[no keywords provided]

Mentor(s):

Joseph P Ogas (Agriculture); Jiaxin Long (Agriculture)

Other Acknowledgement(s):

Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Examining the Effects of Candida albicans and Candida glabrata Metabolites on Cell Proliferation in Gastric Cancer Cells

STEM

Authors(s):

Tanvi Karthika Nadimpalli† (Agriculture)

Abstract:

As microbial metabolites gain recognition for their bioactive properties, this study investigates the effects of fungal supernatants on cancer cell proliferation, focusing on Candida albicans and Candida glabrata. Past studies have shown that these opportunistic pathogenic yeasts, common in the human microbiota, secrete bioactive compounds such as Betaglucan, chitin, mannan, and mannoproteins, which have demonstrated immunomodulatory and antitumor properties. However, their direct impact on tumor cells remains relatively underexplored. To address this, cell-free supernatants were collected from high-density cultures of C. albicans and C. glabrata and applied at 10-, 100-, and 1000-fold dilutions to SNU719, an Epstein-Barr Virus (EBV)-positive gastric carcinoma cell line. The fungi were cultured at both 30°C, their optimal growth temperature, and 37°C, the core temperature of the human body, to assess whether environmental temperature influences the potency of secreted metabolites. Cells were treated for 72 hours before viability was measured using the Cell Counting Kit-8 (CCK8) assay. Preliminary trends suggest a dose-dependent relationship, with lower dilutions reflecting higher concentrations of fungal metabolites—leading to an increase in cancer cell viability and proliferation. However, this relationship is still being evaluated and confirmed through ongoing experiments. Temperature-dependent differences in bioactivity are also under assessment. These findings suggest that secreted products from opportunistic pathogenic fungi, Candida Albicans, and Candida Glabrata, can induce tumor cell growth and may be influenced by host-relevant conditions. This work contributes to a growing understanding of hostmicrobe interactions in cancer and supports further investigation into fungal-derived metabolites as regulators of tumor behavior.

Keywords:

Candida albicans; Candida Glabrata; Fungal Metabolites; Gastric Carcinoma; Cell Proliferation

Mentor(s): Majid Kazemian (Agriculture); Yuxin Zhuang (Agriculture)

Other Acknowledgement(s): Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Sanitization of Seeds -A Mechanism for Produce Growers to Reduce the Risk of Foodborne Pathogen Contamination of Fresh Produce

STEM

Authors(s):

Niah L Patel† (Agriculture|JMHC)

Abstract:

Contamination of produce with human pathogens is a major cause of foodborne illness. Pathogens can reach the food supply by a number of different routes, including the contamination of produce seeds. Seed sanitizers, therefore, are a potential means of preventing foodborne illness. We tested the efficacies of peracetic acid, sodium hypochlorite, and calcium hypochlorite in reducing the presence of Salmonella typhimurium, Listeria monocytogenes, and Escherichia coli O157:H7 in the seeds of cucumber, lettuce, and cantaloupe plants, respectively. We found that sodium hypochlorite at a concentration of 19,000 ppm was most effective at reducing E. coli and Salmonella, and peracetic acid at a concentration of 5000 ppm was most effective at reducing Listeria. These sanitizers may have the potential to be used in agriculture to reduce the incidence of foodborne illness, providing a resource for produce companies and local farmers to improve the safety of their produce.

Keywords:

Foodborne Illness; Foodborne Pathogens; Seeds; Sanitizers; Food Safety

Mentor(s):

Hansel Andres Mina Cordoba (Agriculture); Vinoothna Ramisetty (Agriculture); Amanda J Deering (Agriculture)

Other Acknowledgement(s): Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Understanding the Role of Genes in Wheat Root Size STEM

Authors(s):

Tina Schroedel† (Agriculture)

Abstract:

Climate change necessitates a change in the use of tools and practices used in agriculture. Achieving food security under environmental conditions, such as drought, and reducing carbon emissions are the main goals of today's agriculture. A larger root system in wheat could potentially help with both of these challenges. Previous efforts in the Mohammadi laboratory identified genomic regions responsible for large root systems in an Australian accession 'Penny' via QTL mapping technique (Shaltouki et al., 2024). Two candidate genes, COBRA and auxin-responsive protein (ARP), in this region were used for further studies. A genotype-independent tissue-culture free transformation method, recently developed in the laboratory (Nepal et al., 2025), was used to overexpress these two genes in the wheat genotype 'Apogee'. The purpose of the project is to analyze putatively transformed plants for the overexpression of COBRA and ARP. The T0 generation plants were planted and DNA was extracted from the plants in three groups: wild type (no genetic modification), ARP, and COBRA, a hygromycin PCR was performed, followed by gel electrophoresis to confirm transgene presence. The resulting positive T0 plants were advanced to the T1 generation. After PCR confirmation of T1 plants and harvesting seeds, the T2 generation is getting ready for planting. The T2 generation will be used for plant phenotype and gene expression testing and examining the potential role of overexpression of ARP and COBRA in enhanced root systems.

Keywords:

Food Security; Climate Change; Wheat; Gene Overexpression

Mentor(s):

Mohsen Mohammadi (Agriculture)

Other Acknowledgement(s):

Maliheh Shaltouki Rizi (Agriculture); Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Embeddedness and Profitability: The Case of Small Businesses in the US Midwest

Social Science

Authors(s):

Clara Michelle Shoopman† (Agriculture|JMHC)

Abstract:

Maximizing the profitability of small businesses is key to growing the economy. Small businesses are defined as any independent business with less than 500 employees and make up most businesses in the United States. This study investigates the association between firm profitability and different business goals, aspects of socioemotional wealth (SEW), as well as business/owner characteristics. Socioemotional wealth encompasses nonfinancial values driving businesses. While SEW is frequently associated with family firms it can also be found in nonfamily firms. This study differentiates between SEW aspects like life satisfaction, the renewal of bonds through succession, and identification of the owner with the firm. The data is from the NCR-Stat: Small Business Survey, published by the North Central Regional Center for Rural Development. Using a linear regression for our quantitative analysis no single business goal was found to have a significant association with profitability. However, each aspect of SEW did have a statistically significant correlation with profit. Life satisfaction and the renewal of bonds through succession were positively correlated with profit but identification with the firm had a negative association with profit.

Keywords:

Small Business; Profitability; Socioemotional Wealth; Embeddedness

Mentor(s):

Maria I Marshall (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Effects of Mediator of Paramutation 1 on Embryo DeathSTEM

Authors(s): Jacob R Streeter† (Liberal Arts)

Abstract:

[Abstract Redacted]

Keywords:

[no keywords provided]

Mentor(s):

damon Lisch (Agriculture)

Other Acknowledgement(s):

Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

A conserved function for Cdc14 phosphatases in fungal cell wall homeostasis

STEM

Authors(s):

Ethan C Tuttle† (Agriculture)

Abstract:

Cdc14 phosphatase is a highly conserved member of the dual-specificity subfamily of the protein tyrosine phosphatases. Cdc14 is important for virulence of numerous fungal pathogens of plants, humans, and insects. Our lab wants to understand the function of Cdc14 that makes it required for pathogenic fungi to infect their host. In Candida albicans, an opportunistic human pathogen, Cdc14 contributes to fungal cell wall integrity. I have used the auxin-inducible degradation (AID) system to determine if Cdc14-related cell wall phenotypes in C. albicans are also observed in the model yeast Saccharomyces cerevisiae. In this system, Cdc14 gets rapidly degraded after auxin addition. In C. albicans, the resulting Cdc14 deficiency leads to increased cell wall thickness, cell size, and wall chitin content. To look for these same phenotypes in S. cerevisiae, I utilized transmission electron microscopy to quantify cell wall thickness and fluorescence microscopy to quantify cell size and chitin content. I also used biochemical assays to measure the amount of beta-glucan, mannan, and chitin present in fungal cell walls. I found that most of the cell wall phenotypes previously discovered in C. albicans were also present in S. cerevisiae. I conclude that this function of Cdc14 is conserved in diverse fungi and may underlie the requirement for virulence in fungal pathogens.

Keywords:

Microbiology; Fungal Pathogens; Cell Wall Regulation; Cdc14

Phosphatase

Mentor(s):

Mark C Hall (Agriculture)

Other Acknowledgement(s):

Michelle V. Lihon (Agriculture); Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

The Role of PKL and INO80 Chromatin Remodelers in Apical Hook Formation in Arabidopsis thaliana

STEM

Authors(s):

Blaine Andrew Wagner† (Agriculture|JMHC)

Abstract:

[Abstract Redacted]

Keywords:

Chromatin Remodeling; Apical Hook Formation

Mentor(s):

Joseph P Ogas (Agriculture)

Other Acknowledgement(s):

Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Experimental Testing of Computationally Predicted Enzymatic Pathways Towards Small Molecules

Authors(s):

Madelyn Clair Watson† (Agriculture|Engineering)

Abstract:

Biocatalysis uses enzymes to catalyze chemical reactions towards small molecules, including food, fuel, firepower, fabrication, and fitness. Computer aided synthesis planning (CASP) tools use machine learning and rule-based methods to analyze target compounds in a retrosynthetic manner. A target is identified, and various pathways are formed in a backwards, piecewise manner before arriving at simple precursors. These CASP tools leverage insights from over 16,000 biocatalysis candidates within various enzymatic reaction databases. As a result, they can use common reaction chemistries used in industrial biocatalysis, including hydrolysis, reverse hydrolysis, redox, C-C bond formation, and C-X bond formation, to suggest pathways towards small molecule commodity chemicals. Notwithstanding these impressive capabilities, very few CASP predicted pathways have been experimentally tested. In this study, we test a computationally predicted pathway towards isopropanol. This reaction involves the reduction of acetone to isopropanol by alcohol dehydrogenase (ADH), coupled with the oxidation of NADPH to NADP+. Reaction samples were run under a plate reader using UV- spectrometry at 340 nm to monitor changes in NADPH concentration over time and to assess reaction kinetics. These ideas were compared with literature to determine whether the reaction was performed successfully. Additional SDS-PAGE analysis was performed to evaluate the purity of the ADH enzyme, and FPLC assays are planned for further characterization. This work demonstrates the potential of validating CASP-predicted biocatalytic pathways experimentally, providing a foundation for future efforts in pathway optimization and scale-up.

Keywords:

Enzymatic Reaction; Retrosynthesis; Biocatalysis

Mentor(s):

Bianca de Paula Macedo (Engineering); Nilanjan Samanta (Interdisciplinary & Special Programs); Karthik Sankaranarayanan (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Uncovering Bioelectric Cues in Fin Patterning: Imaging the Bioelectric Signaling in Somite using Tg(ubi-ASAP1) Fish

Authors(s):

Kashyap Akkinapally† (Engineering)

Abstract:

Bioelectric signaling during embryonic development remains largely uncharacterized, although recent work suggests that bioelectric signals play a crucial role in this process. Here, we examine a mutant zebrafish Dhi4458, in which the inwardly rectifying potassium channel gene. kcnj10a, causes elongation of all the fins. We hypothesize that the ectopic expression of kcnj10a during somitogenesis causes bioelectric changes in the fish mutant compared to wildtype fish. To test this hypothesis, we utilize a transgenic reporter fish line, Tg(ubi: ASAP1), which encodes Accelerated Sensor of Action Potential 1, to measure membrane potential in 18- to 24-hour-old fish embryos. At the 6-8 somite and 15-somite stage, I did not find a significant difference in membrane potential changes using a fluorescent microscope. So far, no conclusion can be drawn due to the data quality and limited sample size. I will utilize a confocal microscope to enhance sensitivity, examine more fish embryos across various developmental stages, and optimize analysis methods in the future.

Keywords:

Bioelectricity; Developmental Biology; Somitogenesis; Embryonic Development; Zebrafish

Mentor(s):

Ziyu Dong (Vet Med); Sung Jun Park (Vet Med); GuangJun Zhang (Vet Med)

Presentation Time: Session 2: 12:00-1:00pm

Mantle Minerology on Venus STEM

Authors(s):

Stephen A Anderson† (Science)

Abstract:

Geochemical information regarding Venus is limited and comes mostly from the Russian Venera 13, 14, and Vega 2 missions that landed between 1982 and 1985. These probes collected elemental information from the surface that suggests the bulk composition of Venus is similar to that of Earth. While the surface geology of Venus has been mapped, the interior of the planet is less constrained. For rocky planets, the mineralogy of the crust and mantle influence the evolution of both the surface and interior, which is important for studies of volcanism, plate tectonics, and habitability. This study uses Venera and Vega composition data and the Gibbs free energy minimization program Perple X to model the mineralogy and density structure of Venus's mantle. Our theoretical models reveal the influence of pressure, temperature, and starting composition on the resulting mantle structure. Current estimates of Venus mantle composition span a large range in MgO:SiO2 and trace element (e.g., Na2O) abundances that lead to significantly different mineralogy. The interior thermal gradient of Venus is similarly unconstrained and was found to have important implications for the crust-mantle boundary, phase stability, and presence of melt. These model results will be verified experimentally using a multi-anvil press to better understand the mineralogical composition and density of Venus's mantle. Given the uncertainty and limited geological information from Venus, this study will also determine the most relevant data future missions, such as NASA's DAVINCI and VERITAS or ESA's EnVision, could collect in order to improve models for the interior of Venus.

Keywords:

[no keywords provided]

Mentor(s):

Kelsey Prissel (Science)

Presentation Time: Session 2: 12:00-1:00pm

Insights into Substrate Specificity of Sulfotransferase 2B1b towards Hydroxycholesterol in Cancer

STEM

Authors(s):
Juliana M Bedoya Villegas†

Abstract:

Sulfotransferase 2B1b (SULT2B1b) is a major enzyme in steroid metabolism that catalyzes the transfer of a sulfate group from the universal donor, 3'- phosphoadenosine-5'-phosphosulfate (PAPS), to 3?hydroxysteroid substrates such as cholesterol, enhancing their solubility and modulating their biological functions. Although its physiological relevance is well recognized, SULT2B1b is notable for its substrate promiscuity, which remains incompletely understood. In this study, we performed a comprehensive biochemical, biophysical, and structural characterization of wild-type human SULT2B1b to investigate the molecular basis of its substrate specificity. Fluorescence-based and DESI-MS based activity assay was used to study SULT2B1b catalytic efficiency towards five different substrates. Biophysical approaches, such as nano-differential scanning fluorimetry and isothermal titration calorimetry, were applied to probe protein stability and substrates binding affinity. Additionally, crystallographic studies were conducted to resolve the three-dimensional structure of the enzyme, allowing visualization of key active site residues involved in substrate recognition. Together, these results not only enhance our understanding of its functional diversity but also provide mechanistic insight into how altered steroid metabolism may contribute to cancer and support the development of targeted modulators for therapeutic applications, as well as open new avenues for studying diseases associated with alternative steroid substrates.

Keywords:

SULT2B1b; X-Ray Crystallography; Hydroxycholesterol; Steroid

Metabolism; Sulfotransferase

Mentor(s):

Beinan Yang (Agriculture)

Other Acknowledgement(s):

Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Influence Diagrams for Robust Multi-Target Tracking STEM

Authors(s): Priyank Behera† (Science)

Abstract:

Kalman-filter-based multi-target tracking is fundamental for many modern sensor-fusion and military architectures. However, conventional Kalman updates are notoriously fragile and inaccurate in the presence of colored noise. These errors can compound on each other and ultimately lead to filter divergence. This paper proposes a numerically robust alternative using Gaussian Influence Diagrams (GIDs). By reframing the Kalman filter as a sequence of local Bayesian decision problems, the GID framework preserves conditional independencies and enables update equations expressed solely through factorizations. This research benchmarks the proposed Influence Diagram JPDAF (ID-JPDAF) against the classical Joint Probabilistic Data Association Filter (JPDAF). We generated several simulated multi-target radar scenarios using a nearly constant-velocity model. Performance was assessed over 1000 Monte-Carlo trials using root-mean-square error, track continuity, and covariance-positivity metrics. For track association and detection metrics, we used GOSPA localization score and SIAP. In addition, we tested a data set featuring colored measurement noise to validate real-world applicability. ID-JPDAF was more accurate with this dataset, and its performance across standard multi-target tracking metrics were not worse than a classical JPDAF. The findings suggest that influencediagram reasoning offers a path to numerically robust multi-target tracking for next-generation defense systems.

Keywords:

Data Association; Bayesian Statistics; Kalman Filtering; Multi-Target Tracking

Mentor(s):

Charles Robert Kenley (Engineering)

Other Acknowledgement(s): Pranshul Sardana (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Using UTE-MRI Bound Water Maps to Predict Human Tibia Mechanical Properties via Finite Element Modeling

Authors(s):

Grant Andrew Belush† (Engineering|JMHC)

Abstract:

Tibial stress fractures are common injuries typically caused by increased repetitive activities like running and walking. However, they can be difficult to predict because traditional methods to detect bone fragility. such as bone mineral density (BMD) measurements, are often ineffective. Novel ultrashort echo time (UTE) magnetic resonance imaging (MRI) gives insight into bone water content and its spatial distribution, providing new information about bone quality which can be used to develop more accurate finite element (FE) models for better fracture prediction. This project aims to develop UTE-MRI based FE models to predict bone stress injury. The model results were compared to experimental mechanical testing results to determine the effectiveness of the FE models in predicting whole-bone mechanical properties. To start, UTE-MRI images of each bone were acquired and used to create bound water maps for each bone. FE models were then created with material properties derived from the bound water maps, and they were used to simulate four-point bending to predict the stiffness and yield load for each bone. These values were compared to properties derived from experimental four-point bending low-cycle fatigue tests. This study compares the results of bound water-based FE models of the human tibia to experimental mechanical testing results. It is expected that FE model accuracy will be improved by incorporating bound water information for each bone, allowing for better prediction of whole-bone mechanical properties. This could have future clinical applications to accurately predict bone stress injuries.

Keywords:

Bone Mechanical Properties; UTE-MRI; Finite Element Analysis; Stress Fractures

Mentor(s):

Rachel Kathleen Surowiec (Engineering); Wikum Roshan Ban Ranasinghe Mudiyanselage (Engineering)

Other Acknowledgement(s): Lipi Roy (Engineering); Cooper Niles Rusch (Interdisciplinary & Special Programs)

Presentation Time: Session 2: 12:00-1:00pm

Bacteria Identification using Hyperspectral Imaging Related to Environmental Monitoring Fields

STEM

Authors(s):

Ameya Vikram Bhargava† (HHS)

Abstract:

Hyperspectral imaging (HSI) enables spatial acquisition with full spectral profiles at each pixel, allowing for the label-free identification of bacterial strains based on their unique spectral signatures. In this study, we applied HSI to distinguish between different bacterial strains by analyzing their unique spectral signatures. Specifically, we evaluated Escherichia coli (HCB1736) and Pseudomonas elyakovii (ATCC 7006519), two representative strains with known biochemical differences. Our findings demonstrated that each strain exhibited a consistent and distinct spectral pattern, with HCB1736 showing a spectral intensity peak within the 640-660 nm range, while ATCC 7006519 displayed a broader spectral signature across the 605-615 nm range. These results were reproducible across multiple experimental runs. Compared to conventional techniques such as PCR and gel electrophoresis, HSI significantly reduced the time required for strain-level identification. This method presents a promising alternative for rapid bacterial screening, with potential applications in microbiological diagnostics and contamination monitoring. Future work will expand to include additional strains to validate the robustness and scalability of this approach.

Keywords:

Hyperspectral Imaging; Spectral Profiles; Label-Free

Mentor(s):

Arezoo Ardekani (Engineering)

Other Acknowledgement(s):

Emily R Jakob (HHS); Kaeul Lim (Engineering); David Perez Herrera (Science)

Presentation Time: Session 2: 12:00-1:00pm

Hypersonic Wind Tunnel and Constrained Ballistic Model Design and Analysis

STEM

Authors(s):

Kaitlyn Elizabeth Bird† (Engineering); Aaron Su‡ (Engineering)

Abstract:

The aerospace industry often relies on conventional hypersonic wind tunnels such as BAM6QT (Boeing AFOSR Mach-6 Quiet Tunnel) to evaluate high-speed interactions in a uniform, disturbance-free, and quiet flow environment. However, these tunnels have limitations for maintaining extended runs, varying test parameters, and performing rapid trials. Project partner, Auriga Space, proposes employing a novel linear acceleration system to propel test bodies through stationary air, providing benefits of reducing testing downtime, expanding pressure and temperature envelopes. To investigate the feasibility of this solution, projectile models and a tapered strut assembly were configured in SolidWorks and a series of finite element analysis (FEA) simulations were conducted with different materials. Due to the limited space that promotes acceleration within Auriga's system, prototypes were analyzed for the ability to withstand up to 30,000G of bidirectional acceleration while assessing stress, strain, and thermal loads inflicted onto the vehicle. FEA simulation results indicated ceramic alumina as the best material for the projectile and struts on Auriga's model. The ballistic model design was imported into ANSYS Fluent for quiet tunnel testing as it would take place in BAM6QT and eventually Auriga's device. The model's current assessments include assessing flow choking with CFD simulations alongside monitoring shock interactions, boundary layer behavior, and drag. These tests incorporate Auriga's requirement for 900 m/s velocity with laminar flow and include vacuum, atmospheric, and high pressure ranges. Initial results depict Auriga's linear testing approach as a promising, flexible substitute to hypersonic wind tunnels by offering more diverse testing on vehicles.

Keywords:

Hypersonic Wind Tunnel; BAM6QT; Computational Fluid Dynamics (CFD) Simulations; Finite Element Analysis (FEA) Simulations; Linear Acceleration System

Mentor(s):

Joseph S Jewell (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Abigayle Elaine Moser (Engineering); Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Securing the Software Supply Chain With Trusted Build Systems

STEM

Authors(s):

William David Boulton† (Science); Damian Munoz‡

Abstract:

The software supply chain is an increasingly complex network of tools and operations used to create software, but inadequate security in the build pipeline leaves it vulnerable to compromise. Prior efforts, like intoto, provide a framework for securely tracking build metadata, while other projects, like rebuilderd, attempt to validate the software bill of materials (SBOM) by reconstructing build artifacts to detect tampering. This work extends those initiatives by proposing a trusted build system (TBS) that uses trusted execution environments (TEEs) to ensure the validity of a build. TBS implements a protected build environment using Arm TrustZone to introspect the reconstruction process. Such introspection is carried out by tracing the execution of the build process through system-call instrumentation and stack introspection. After an artifact is successfully recreated, the TEE can endorse the result and provide confidence to users that the software was not tampered with. TBS is part of the larger open-source project SBOMctl, which aims to implement secure-by-design software supply chain infrastructure.

Keywords:

Trusted Execution Environments; Software Bill of Materials; Trustzone; Trusted Build System; Software Supply Chain

Mentor(s):

Santiago Torres Arias (Engineering); Eman Abdul-Muhd Abu Ishgair (Engineering); Abhishek Reddypalle (Engineering)

Other Acknowledgement(s):

Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Characterizing Inorganic Ions in Municipal Solid Waste Landfill Leachate to Improve Processes to Recover Critical Metals

STEM

Authors(s):

Ethan Patrick Connolly† (Engineering|JMHC); Heather Murillo*

Abstract:

Municipal Solid Waste (MSW) landfills are sources of several environmental pollutants, one of which is landfill leachate, the water that flows through the landfill and collects traces of the materials within the landfill. While leachate has been extensively researched in terms of its pollution potential as well as how its general composure changes with various factors such as age and climate, the recovery of critical metals from the landfill leachate remains insufficiently explored. Critical metals are defined as materials such as rare earth elements and heavy metals that can often be found in e-Waste and are both in high demand and in short supply globally. This research addresses the problem of inefficient recovery methods of critical metals from leachate and seeks to understand the behavior of these metals with certain redox and pH sensitive ions such as nitrite, nitrate, ammonium, and sulfate. These ions are targeted due to their known tendency to form complexes with critical metals in leachate. The methods used in this research involve collecting landfill leachate samples from across the United States and analyzing their composition using Ion Chromatography (IC). This method provides information on the concentration of ions in leachate which will, in turn, provide information on the likely behavior and state of critical metals in the leachate. Results from this research will eventually inform the design of recovery systems for critical metals in leachate, laying the groundwork for their mass recovery and reuse.

Keywords:

Landfill; Leachate; Resource Recovery; Speciation; Redox-Sensitive lons

Mentor(s):

Guanchun Wang (Engineering); Amisha Shah (Engineering)

Other Acknowledgement(s):

Parth Uday Kelkar (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Investigation of Performance of Anchorages in Narrow **Foundations Under Predominant Moment Loading**

Authors(s):

Charles R Curione† (Engineering)

Abstract:

Anchors, which are steel components used for connecting structural or non-structural elements to concrete, are fundamental in construction. They are subjected to tension, shear, or bending moments. When an anchor group is subjected to a bending moment, such as in the case of column-to-foundation joints, a tension-compression couple is generated. The tension is resisted by anchors, while the compression is transferred into the concrete through the connecting baseplate. This compression increases the tensile capacity of the anchors. Current design guidelines such as American Concrete Institute and Eurocode outlining this effect have certain limitations. They are not valid when the anchor group is located close to one or more edges. Therefore, the design of moment loaded connections in such cases is overly conservative. This paper demonstrates that a revised equation for quantifying the increase in anchor strength is necessary for anchors under bending moments in parallel-edge narrow foundations. Using Finite Element analysis and small-scale experiments, numerical and visual data was collected on both moment-loaded and tension-loaded specimens. The numerical and experimental investigations showed that anchorage was significantly stronger under moment in narrow foundations. Moreover, the moment strength increase factor grew as the anchor-to-edge distance decreased. This study thus concludes that a revised anchorage strength equation is needed for the accurate design of moment-loaded connections in narrow concrete foundations. The revised equation will make the design of foundations safer and more economical.

Kevwords:

Anchorage; Concrete; Civil Engineering; Construction; Finite Element Analysis

Mentor(s):

Gaurav Somnath Chobe (Engineering)

Other Acknowledgement(s):

Ioanna Katsamba (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 2: 12:00-1:00pm

Particle-Reinforced Polymers for 3D Printing in Space STEM

Authors(s):

Aryan Dayal† (Engineering); Nicholas Joseph Ostendorf‡ (Engineering)

Abstract:

Additive manufacturing, such as 3D printing, offers significant promise for space applications due to its capability to produce complex parts on demand. However, current 3D printing technology lacks the necessary mechanical adaptability and durability required for space environments. To address these challenges, this research aims to enhance the mechanical properties of 3D printed parts by incorporating amphiphilic Janus particles into polymer resins. Janus particles, characterized by chemically distinct hemispheres, offer unique capabilities in controlled assembly and property enhancement due to their anisotropic nature. This research utilizes silica particles of 3µm diameter, which are initially dispersed as a monolayer onto a glass slide using a micromechanical motor integrated with 3D printed parts, followed by the platinum coating of one hemisphere via sputtering. Initial Scanning Electron Microscopy (SEM) imaging of the particles revealed successful coating, with minimal instances of irregularities. Furthermore, initial AC testing demonstrated the successful assembly of two-dimensional and three-dimensional structures under varying experimental conditions. The prepared Janus Particles will be dispersed in a UV-curable resin with electric fields applied before curing to induce particle assembly. The composite samples will be prepared in molds of the appropriate dogbone shape and cured under UV light. Following the creation of the test samples, mechanical performance will be evaluated using an Instron Tensile instrument following D638 standards. This research seeks to overcome existing material limitations by demonstrating the efficacy of Janus particle-enhanced resins. The knowledge gained through these experiments will be used to guide future developments in space-grade additive manufacturing.

Keywords:

Additive Manufacturing; Polymer Composites; Janus Particles

Mentor(s):

Carlos J Martinez (Engineering)

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Al for Musicians - Performance Audio Evaluator STEM

Authors(s):

Peter Edvardsson† (Science); Shamita Yedlapalli† (Science); Kayla Y. Xu† (Other); Shih-Yao Sun† (Engineering); Ji Bing Ni‡ (Science); Ropan Datta‡ (Science)

Abstract:

This project aims to use digital technology to transform how musicians practice, posing particular utility to intermediate music learners. Private tutoring costs force such students to balance improvement with expenditure, necessitating an infrequency of lessons that leaves many hours of unsupervised practice in-between.

To bolster the productivity of this practice time, our research aims to develop and deploy a mobile app that tracks the performance of a string player through given sheet music, providing visual in-score feedback of their pitch accuracy, intonation, and tempo.

We explore a score-alignment based approach to recorded performance assessment, deriving reference audio from the score by synthesizing its MIDI data or adapting a professional recording. Using the Dynamic Time Warping algorithm, we align this reference with live performance audio. The resulting warping path enables us to estimate each note's unknown performance timestamp based on the known reference timestamp. Leveraging the calculated score position alongside fundamental frequency estimation algorithms, we determine whether the performance is too sharp or flat at any given note, evaluating the intonation of the performer. We visualize this feedback through in-score annotations.

The empirical accuracy of our approach can be measured manually. We calculate alignment error by hand-labeling the onsets of live notes and taking their difference from the warping-path-informed onset predictions. Our intonation calculations can be checked against the live spectrogram. Furthermore, we intend to conduct user studies at the end of summer to receive feedback from other musicians assessing the usability, accuracy, and learning impact of our research.

Keywords:

Signal Processing; Score Following; Performance Error Detection; Musical Performance; Music Processing

Mentor(s): Yeon Ji Yun (Liberal Arts); Yung-Hsiang Lu (Engineering)

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Ultrafast Squeezed Quantum Light Generation and Measurement

STEM

Authors(s):
Jose Gutierrez†

Abstract:

Ultrafast nonlinear optical processes offer a powerful platform to probe quantum properties of light on femtosecond and attosecond timescales, under strong field interactions. While classical observables in nonlinear spectroscopy are well studied, a key challenge remains in directly characterizing quantum field observables under strong-field interactions. Quantum states of light, such as squeezed states, are vital for applications like gravitational wave detection at LIGO and the development of quantum information technologies. This project investigates the generation and control of quantum-squeezed states of light in a MgO crystal using femtosecond laser pulses. Specifically, we aim to reconstruct the Wigner Distribution Function (WDF), which characterizes the quantum state of the generated field, using balanced homodyne detection. The experiment employs a 50-femtosecond laser centered at 808nm with a 1kHz repetition rate, interacting with a nonlinear optical crystal. Delay times are varied in 200-attosecond steps to modulate the nonlinear response. Homodyne detection is used to measure quantum field observables called quadratures, from which the WDF is reconstructed; revealing squeezing characteristics of the light field. Preliminary results show distinguishable squeezing features in WDFs generated from both raw and filtered homodyne data. Filtering based on the modulated nonlinear response enhances visibility of squeezed regions in phase space. Additionally, quadrature uncertainties from 2D Gaussian fits indicate a tunable squeezing effect, with maximal squeezing observed at specific time delays. These trends are consistent across both spectrometer-based and balanced photodiode detection methods, demonstrating controlled generation of femtosecond squeezed light via attosecond-scale field modulation.

Keywords:

Ultrafast; Squeezed Light; Femtosecond; Attosecond

Mentor(s):

Niranjan Hirisave Shivaram (Science); Shashank Kumar (Science); Russell Lee Zimmerman (Science)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Pranshul Sardana (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Thermal Mapping of Furnace Insulation using Raspberry Pi and IR Sensors to Predict Maintenance

STEM

Authors(s): Isaiah T Harris†

Abstract:

In many industrial settings, up to 10-30% of all energy used can be wasted through inefficient oven or furnace systems. This can annually cost tens of thousands of dollars. Beyond energy costs, heat loss leads to inconsistent oven temperatures that can cause deformities in heattreated products which results in material waste and poor-quality control. To resolve these problems this research focuses on developing a lowcost, remote monitoring system that maps the exterior temperature of ovens using a Raspberry Pi and an infrared (IR) camera. In collaboration with an industry partner, Rea Magnet Wire whose main product is coated electrical wires using continuous oven process, the system aims to monitor structural degradation and heat leakage of oven insulator by capturing temperature map, analyzing inconsistencies in real-time. The system includes data pipelines to visualize temperature map images and temperature historians in a web-based dashboard. The Raspberry Pi and sensor will be deployed on the factory floor. The monitoring system is anticipated to support predictive maintenance that enhances energy efficiency, lowers operational costs, and ensures improved manufacturing quality.

Keywords:

Predictive Maintenance; Structural Degradation; Thermal Mapping; Industrial Ovens

Mentor(s):

Eunseob Kim (Engineering)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

LLM as Channel to Understand Learning Challenges STEM

Authors(s):

Ana Maria Hernandez Lasso†

Abstract:

Large Language Models (LLMs), like ChatGPT, offer new learning support in programming education. However, in the absence of clear guidelines, continued usage by students can be risky, as these tools may cause overreliance, limited understanding, or unethical behavior. This study investigates how students enrolled in an introductory programming course interact with ChatGPT when they ask for help. Prior studies have largely focused on outcomes or literature-based analysis; few explore students' behavior and thinking processes from a qualitative perspective on how students actually do, think, and feel while solving tasks with Al support. This research uses real conversations between students and ChatGPT during the course. Through open coding, we labeled expressions of confusion, prompt strategies, and reactions to Al responses; these were refined into broader themes using axial coding. Later, themes were analyzed to understand how students' emotional and cognitive states influenced their prompting strategies and shaped their conversations. Most students relied on the model to solve problems directly, while a smaller group crafted detailed prompts or combined Al support with their own reasoning. Prompts often reflected uncertainty, and reactions varied from being guided to critical questioning, revealing underlying patterns in how students approach problem-solving with Al. These distinct approaches highlight the need for more structured and student-centered guidance on AI use within the curriculum. This study informs the design of instructional strategies, such as scaffolding prompt techniques or fostering reflection, that promote ethical, personalized, and meaningful integration of LLMs into programming education.

Keywords:

Large Language Models; LLMs; ChatGPT; Programming Education; Student-Al Interaction

Mentor(s):

Miguel Alfonso Feijoo Garcia (Polytechnic); Alejandra Magana DeLeon (Polytechnic)

Other Acknowledgement(s):
Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Quantum DeepONet Architectures for Transient Operator Learning in Power Systems

STEM

Authors(s): Sebastian Hurtado†

Abstract:

Modern power systems require fast and accurate solutions to complex operator equations involving continuous signals, yet classical numerical methods remain computationally prohibitive for real-time applications. To address this challenge, we propose a quantum machine learning framework based on Deep Operator Networks (DeepONets) that leverages quantum computing principles, such as superposition and probabilistic measurement, to improve computational efficiency and uncertainty quantification in operator learning tasks. We explore three classical-to-guantum data encoding strategies: unitary encoding, which encodes classical data into unitary matrices applied as quantum gates; angle encoding, mapping real-valued data into gubit rotation angles; and Fourier encoding, representing input functions via truncated Fourier series with coefficients encoded as quantum states. Furthermore, we develop diversified ensembles of quantum DeepONets formed via random initialization and data shuffling, and introduce a correction term to mitigate variability in quantum circuit outputs when estimating uncertainty intervals. Model performance is assessed using mean squared error, relative L2 error, and uncertainty coverage on complex operator learning problems. This approach demonstrates the potential of conformalized quantum DeepONet ensembles as a scalable and reliable method for transient operator learning in power systems.

Keywords:

Quantum DeepONet; Uncertainty Quantification; Power System Operator Learning

Mentor(s):

Guang Lin (Science); Christian Bolivar Moya Calderon (Science)

Presentation Time: Session 2: 12:00-1:00pm

A Digital Health Solution to Mitigate Overuse Injury Risk in Elite Platform and Springboard Diving

STEM

Authors(s):

Tom Long Huynh† (Engineering|Liberal Arts)

Abstract:

Elite springboard and platform divers are at high risk for wrist overuse injuries due to repetitive, high-velocity impacts and frequent joint hyperextension upon water entry. Current injury prevention strategies rely heavily on subjective pain reports and coach intuition. This lack of objective biomechanical data leaves divers vulnerable to progressively worsening asymptomatic injuries and severe, repetitive strain injuries. We are developing a wearable, wrist-worn smart sensor to measure and quantify individual impact decelerations and wrist extension angles upon water entry, providing easily interpretable data for coaches and athletes to inform training decisions with empirical evidence. The minimum viable prototype (MVPr) comprises a wrist-mounted inertial measurement unit (IMU) using the MPU6050 sensor and Arduino microcontroller. Preliminary results demonstrate the feasibility of detecting real-time wrist extension angles and impact decelerations in a diving context. Following MVPr testing and refinement, we will integrate support circuitry. telemetry, and miniaturize the system onto a flexible, printed circuit board with a form factor similar to an epidermal patch. This second iteration will monitor trends across training sessions and alert coaches and athletes to high-risk behavior via Bluetooth. Once validated against optical motion capture, data will be collected from elite divers, and a machine learning algorithm will be trained to detect and predict movement patterns associated with overuse injury risk. This research addresses the challenges of capturing objective diving performance metrics by engineering a wearable IMU that does not disrupt any aspect of the diver's performance while providing critical data to inform training protocols and identify injury risk.

Keywords:

Overuse Injury; Injury Mitigation; Olympic Diving; Wearable Sensor; Inertial Measurement Unit (IMU)

Mentor(s):

Matthew Peter Ward (Engineering); Damen Alec Wilson (HHS)

Other Acknowledgement(s):
Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Characterizing the Composition Shift of R454C with and without Lubricants using Gas Chromatography STEM

Authors(s): Amelia C Jaffe†

Abstract:

Current hydrofluorocarbon (HFC) refrigerants are estimated to contribute to about 2% of greenhouse gas emissions. Recent legislation limiting the allowable global warming potential (GWP) of refrigerants has increased interest in more environmentally friendly options. Alternatives to HFCs include hydrofluoroolefins (HFOs), hydrocarbons (HCs), and natural refrigerants such as CO2. Some of the most promising refrigerants are zeotropic mixtures due to their low-GWPs and ability to perform similarly to conventional refrigerants. These blends exhibit a tendency to undergo composition shift during phase change which is not well understood. To study this behavior, a pumped two-phase loop test stand with a condenser section consisting of several measurement instruments was used. Samples of R454C, a HFC/HFO blend of R32 and R1234yf, were removed from circulation after the condenser section and then passed through a gas chromatograph. Comparing composition shifts in R454C with and without lubricants helps to characterize R454C and determine the conditions for its optimal performance. Future work will involve repeating the experiments with other zeotropic mixtures containing HCs and CO2.

Keywords:

[no keywords provided]

Mentor(s):

Joshua Michael Cox (Engineering); Vivian Lizeth Toca Diaz (Engineering); Riley Bradley Barta (Engineering)

Other Acknowledgement(s):

Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Automation Methods for Gamma Ray Spectroscopy and Data Analysis

STEM

Authors(s):

Siddhant Jain†; Mason Patrick Julius Levere† (Science); Myron Milad Tadros† (Engineering); James Thomas Pittard* (Science); Sydney Metz* (Science|JMHC)

Abstract:

Gamma-ray spectroscopy is used by nuclear physicists to better understand the structure of the nucleus in excited states. By observing the decays from an excited nucleus, we can deduce its allowed energy states and transitions that might reveal promising applications for specific states called "isomers". Isomers are states with a comparably long lifetime, allowing for the storage of energy. However, few suitable isomer states are currently known, and more sensitive analysis techniques and more data in general are required to identify more isomer states. The current analysis techniques demands human-based expert labor, making isomer identification slow and prone to bias and omissions. We develop a machine learning (ML) analysis technique by recasting the task as an image-to-graph translation problem. We explore different solutions for this problem and build intuition by using a custom Monte-Carlo-derived toy data set for training and validation prior to analyzing actual data with small signal yield of < 1%. Our aim is to deliver an analysis framework capable of carrying out spectroscopy substantially faster, with minimized bias, and reproducible.

Keywords:

Gamma Ray Spectroscopy; Machine Learning; Nuclear Physics; Monte Carlo; Level Scheme

Mentor(s):

Andy Jung (Science); Mark Ward (Science); Ace Rounds (Science)

Other Acknowledgement(s):

Pranshul Sardana (Engineering); Radhika Arvind Bhopatkar (Engineering); Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Designing Gesture-Based Instructional Videos to Enhance Statistical Reasoning in STEM Education

STEM

Authors(s):

Zhengyi Jiang† (Science)

Abstract:

Statistical concepts, for instance, Central Tendency, Variability, and Regression, are fundamental, yet challenging for most STEM students. Prior research demonstrates that embodied learning, and in particularly gestures, can improve conceptual understanding by connecting complex theories to physical representations. However, few studies have translated these findings into practical instructional tools. This project bridges the gap between embodied cognition research and practical pedagogy by developing gesture-augmented instructional videos for statistics education. Building on earlier findings, where students used spontaneous gestures to explain statistical concepts, we now focus on intentional design of instructional videos to amplify these benefits. In collaboration with Purdue Envision Center and UIUC, we intend to produce videos on Central Tendency, Variability and Regression, where the conceptual explanations are coupled with representational gestures (McNeil, 1992). The choice of the candidate gestures are informed by students' spontaneous use of gestures while explaining the concepts. Using PowerPoint, we storyboard slides that pair categorized gestures from McNeill's framework with statistical graphs. Each slide includes minimal scripted narration to align gestures with key concepts, including best-fit lines and distributions. Preliminary work has yielded: Candidate gestures from past interviews, e.g., cueing gestures for correlation strength, and prototype slides where gestures dynamically interact with graphs and other visuals. Feedback from statisticians on the team ensures pedagogical accuracy. This work advances embodied learning by transitioning from observational research to actionable instructional design. The videos aim to provide an accessible, multimodal approach to statistics education, with potential applications in undergraduate STEM curricula. Future phases will test efficacy in classroom settings.

Keywords:

STEM Education; Statistical Learning; Video Production; Embodied Cognition; Cueing Gestures

Mentor(s): Jason Wade Morphew (Engineering); Junior Anthony Bennett (Interdisciplinary & Special Programs)

Other Acknowledgement(s): Pranshul Sardana (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Mechanically Driven Variations in Bone Composition via FT-NIR (Fourier transform near infrared spectroscopy) for Improved Fracture Risk Assessment

STEM

Authors(s):

Nikhil Kasumarthi† (Engineering)

Abstract:

Estrogen deficiency associated with menopause leads to significant deterioration in bone health. This condition is characterized by a decrease in bound water content and an increase in inflammation inside bone cells, in addition to overall bone loss. These changes result in weaker and more fragile bones, often leading to fractures. To study this, researchers commonly use ovariectomy (OVX) in rats, where the ovaries are surgically removed to simulate estrogen loss. This study investigated whether two treatments could prevent or slow bone deterioration in OVX rats. The first treatment involved calcitonin, a hormone thought to improve bone water content. The second treatment was a specialized diet containing anti-inflammatory compounds such as guercetin. resveratrol, and curcumin. Rats were divided into three equal-sized groups: 1) OVX controls with no treatment, 2) OVX rats treated with calcitonin, and 3) OVX rats fed the anti-inflammatory diet. After four weeks of treatment, bone samples were collected from all groups. Bones were analyzed using imaging and biochemical techniques to measure matrix-bound water and inflammation levels. Preliminary results show that the dietary treatment group exhibited enhanced bone remodeling and reduced inflammation compared to controls. Analysis of the calcitonin group is ongoing, especially regarding its effects on bone water and mechanical strength.

Keywords:

Bone Fragility; Fracture; Estrogen Deficiency; Spectroscopy

Mentor(s):

Rachel Kathleen Surowiec (Engineering); Wikum Roshan Ban Ranasinghe Mudiyanselage (Engineering)

Other Acknowledgement(s):

Lipi Roy (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Finite Element Method Characterization of Human Radius Bone Strength

STEM

Authors(s):

Brian Arild Kelly† (Engineering)

Abstract:

Bone fracture risks increase with age because of bone degradation. Bone mineral density (BMD) is a common metric used to evaluate bone health, but it fails to account for bone geometry variation. The use of BMD alone can result in misjudgment of actual bone stiffness and strength. A potential alternative to the sole use of BMD to assess bone biomechanical properties is the use of bone finite element method. With the finite element method, solutions to elasticity in a solid body (such as a whole bone) are obtained by discretion into element assemblies and a weak form matrix solution. The whole bone model can be placed under realistic boundary conditions to simulate stress and strain distributions, accounting for both material and geometric properties. To validate the whole bone finite element models, simulation data was compared with experiments on 3d printed bone surrogates. Twelve cadaveric radius bones were obtained from donors. High Resolution peripheral Quantitative Computerized Tomography (HR-pQCT) scans were obtained. Images were used to measure BMD values and bones were ranked in terms of BMD. Finite element models were created from the image scans and 3-point bending experiments were simulated. Each of the bones were 3D printed and subjected to 3-point bending. The bones were then ranked in terms of yield load. BMD ranking is then compared to yield load ranking. We hypothesize that there exists a significant difference in BMD and predicted yield load rankings.

Keywords:

Finite Element Analysis; Radius Bone; CT-Scan; Bone Mineral Density; 3-Point Bending

Mentor(s):

Thomas H Siegmund (Engineering); Glynn Ellen Gallaway (Engineering)

Other Acknowledgement(s):

Parth Uday Kelkar (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Characterization of Hydrogel Matrix for Evaluating Schistosoma Egg Migration

STEM

Authors(s):

David Kichul Kim† (Engineering); Hannah Yeonsoo Park‡ (Engineering|JMHC)

Abstract:

Schistosomiasis, a parasitic disease caused by Schistosoma worms, remains widespread in Africa, south America and parts of Asia, One major question of many researchers is to understand how Schistosoma eggs penetrate through soft tissue and initiate granuloma formation. We hypothesis that egg migration occurs either through forces exerted by surrounding fibroblasts or via a self-propelling mechanism intrinsic to the egg. To clarify how Schistosoma eggs migrate through host tissue, we built an in vitro platform that lets eggs interact with fibroblasts and form granulomas while their motion is tracked. Polyacrylamide gels were cast with controlled water volume (0-200 microliters) using Bio-Rad Fast-Cast reagents, tuning stiffness from 7.5 kPa to 12 kPa to replicate soft-tissue mechanics. Fluorescent beads embedded on the gel surface act as markers. An inverted fluorescence microscope captures their displacements, which result from gel deformation or egg-driven forces. A MATLAB code combining spatial cross-correlation and fast-Fourier transforms extracts local velocity vectors using particle image velocimetry (PIV) conventions. Test images of 256 x 256 pixels were processed in under five seconds, yielding vector fields that resolve bead shifts down to a single pixel. These preliminary results confirm that the system can measure the movement from the fluorescent beads, which the movement of eggs can also be measured once placed on the gel surfaces that mimic real tissue. Future work will involve correlating velocity magnitudes with the stiffness of the gel.

Keywords:

Schistosomiasis; Egg Migration; Polyacrylamide Gel; Particle Image Velocimetry; Fluorescence

Mentor(s):

euiwon Bae (Engineering)

Other Acknowledgement(s): Parth Uday Kelkar (Engineering); Brianna N Corman (Vet Med); Joseph Paul Robinson (Vet Med)

Presentation Time: Session 2: 12:00-1:00pm

Automation Methods for Gamma Ray Spectroscopy and Data Analysis

STEM

Authors(s):

Mason Patrick Julius Levere† (Science); Myron Milad Tadros† (Engineering); Siddhant Jain†; James Thomas Pittard* (Science); Sydney Metz* (Science|JMHC)

Abstract:

Gamma-ray spectroscopy is used by nuclear physicists to better understand the structure of the nucleus in excited states. By observing the decays from an excited nucleus, we can deduce its allowed energy states and transitions that might reveal promising applications for specific states called "isomers". Isomers are states with a comparably long lifetime, allowing for the storage of energy. However, few suitable isomer states are currently known, and more sensitive analysis techniques and more data in general are required to identify more isomer states. The current analysis techniques demands human-based expert labor, making isomer identification slow and prone to bias and omissions. We develop a machine learning (ML) analysis technique by recasting the task as an image-to-graph translation problem. We explore different solutions for this problem and build intuition by using a custom Monte-Carlo-derived toy data set for training and validation prior to analyzing actual data with small signal yield of < 1%. Our aim is to deliver an analysis framework capable of carrying out spectroscopy substantially faster, with minimized bias, and reproducible results.

Keywords:

Gamma Ray Spectroscopy; Machine Learning; Nuclear Physics; Monte Carlo; Level Scheme

Mentor(s):

Andy Jung (Science); Mark Ward (Science); Ace Rounds (Science)

Other Acknowledgement(s):

Pranshul Sardana (Engineering); Radhika Arvind Bhopatkar (Engineering); Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Place-based Semiconductor Education and Its Impact on K-12 STEM Pipeline Development in Emerging Hubs STEM

Authors(s):

Steven Li† (Engineering|JMHC); William McMahon* (Engineering); Virginia Lucille Hawkins* (Engineering); Sogo Bakare* (Engineering); Andrew Robert Ryan* (Engineering|JMHC)

Abstract:

The CHIPS and Science Act (2022) demonstrates a strategic initiative to bring semiconductor manufacturing back to the United States, accelerating semiconductor hub growth. However, the industry faces a critical talent shortage, particularly due to geographic inequalities in STEM education pipelines. These disparities risk triggering "zero-sum" national growth and efficiency losses—where gains in certain regions come at the expense of others—leading to workforce displacements and localized economic shocks. This research examines approaches to how place-based/geographic K-12 education cultivates regional STEM identity and fosters the future STEM workforce. The initial research phase involves collecting data from the high school students who participated in the Purdue-Ivy Tech Chips Program (PITCH) through preand post-daily and focus group sessions. Current data, alongside prior program literature that used Photovoice and thematic analysis, present insights into students' awareness, self-efficacy, and regional identity to showcase STEM workforce development within their local communities. To contextualize these findings globally, literature reviews from various regions worldwide (including Taiwan, China, and the EU) will be analyzed using Bereday's four-stage model (description, juxtaposition, interpretation, and comparison). Through this framework, global trends in semiconductor engineering education are examined within the context of socioeconomic influences. This research contributes to the ongoing discourse on mitigating zero-sum risks, presents a critical case for equitable growth in the semiconductor industry, and offers a framework for policy strategies that invest in place-based K-12 STEM education.

Keywords:

K-12 Education; Semiconductor; Comparative Education; CHIPS Act; Place-Based Policy

Mentor(s):

Yash Ajay Garje (Engineering); Bruce Wellman (Engineering); Labiba Rahman (Engineering); Morgan M Hynes (Engineering)

Other Acknowledgement(s):

Ediz Guzey (Purdue University); Kent Nickolas Fruchtman (Engineering); Varun Aggarwal (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Colloidal Stability of Mo-containing Double Transition Metal MXenes via UV Vis-NIR Spectroscopy

STEM

Authors(s): Madison E Lisenko†

Abstract:

Since their discovery in 2011, MXenes have emerged as a leader in twodimensional materials for energy storage, electronics, and biomedical applications. Their synthesis traditionally begins with the formation of the MAX precursor from elemental powders. Using a top-down approach, this phase is processed via selective etching and delamination to create a few- to single-flake colloidal solutions. MXenes can form various layered crystalline structures, following the equation MnXn-1Tx, of which n = 3, 4 are observed in this study. As of 2015, double-transition metal (DTM) MXenes were reported and show promise in the field of electrochemistry and as super capacitors. Despite their potential, one major pitfall of MXenes is their susceptibility to oxidation, which decreases their effectiveness over time. This challenge remains relatively unexplored for DTM MXenes and is examined for Mo2TiC2Tx and Mo2TiC3Tx using UV-Vis-NIR here. This spectroscopy method tracks absorbance changes over time in the ultraviolet and visible regions to assess material degradation. Measurements are used alongside Beer Lambert's Law to determine the concentration of each solution. Samples were collected using UV-Vis-NIRS and recorded every 3 days over the course of a 14-day period. Initial results indicate that upon oxidation, the solution exhibits lower absorbance, which is consistent with a decrease in flake concentration in the solution. Further studies, including implementation of organic solvents, can help slow the oxidation processes while following this same analysis process.

Keywords:

[no keywords provided]

Mentor(s):

Annabelle Leigh Bedford (Engineering); Anupma Thakur (Engineering); Babak Anasori (Engineering)

Other Acknowledgement(s):

Lipi Roy (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 2: 12:00-1:00pm

Modeling the Role of Mechanosensation in Epithelial Wound Closure Dynamics

STEM

Authors(s):

Aditya Mallepalli† (Science)

Abstract:

Epithelial wound healing is important for maintaining tissue health and survival in multicellular organisms. When the tissue is damaged whether by mechanical injury or laser ablation—it responds by activating several coordinated closure mechanisms. These include the contraction of an actomyosin ring around the wound, active crawling of cells toward the injury, and rearrangements driven by cell polarity. Although these mechanisms have been studied individually, their combined behavior and adaptation to different wound conditions remains poorly understood. This research investigates how mechanical feedback—especially, a stretch-induced increase in cellular contractility—affects the healing process. Computational vertex modeling is used to simulate wound healing and examine how changes in wound area or tissue properties affect healing outcomes. The model incorporates a mechanosensitive feedback mechanism, based on experimental observations, in which tissue stretch leads to increased contractile forces in cells. Initial simulation results indicate that at certain conditions mechanosensation has an unexpected role of delaying rather than accelerating the healing process. This preliminary result is congruent with some experimental observations and suggests that feedback loops in the system of mechanical signaling may be more complicated than previously thought. This work compares a range of different configurations of models and wound types, to begin to understand when and how different mechanisms of healing emerge. This work will generate a framework for quantitatively interpreting experimental evidence and details how cells coordinate mechanical forces during tissue repair. These insights may help identify conserved healing strategies across species and guide future research on tissue regeneration.

Keywords:

Computational Vertex Modeling; Epithelial Wound Healing; Mechanical Feedback

Mentor(s):

Linlin Li (Engineering); FNU Nilay Kumar (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Emily R Jakob (HHS)

Presentation Time: Session 2: 12:00-1:00pm

Design of Reconfigurable Antenna Using Origami PatternsSTEM

Authors(s):

Adina Ioana Margineantu† (Science); Jamie Chanadol Henson‡ (Engineering)

Abstract:

Parabolic antennas allow humans to receive signals over large distances and have applications in satellite and wireless communications, radar systems, radio astronomy, and remote sensing. The incoming electromagnetic waves are directed onto the focal point of the paraboloid due to the geometric properties of the concave reflector. Currently, parabolic antennas are only compatible with the frequency ranges that they are designed for, not giving the users much flexibility. Due to their rigidity and weight, they are also costly and difficult to deploy into space. This research aims to design a reconfigurable parabolic antenna that uses the properties of origami patterns to be dynamic in signal coverage. Varying tessellations of the conical Kresling pattern demonstrate ways to build an approximate foldable parabola that can be opened when rotated or pushed downwards. By layering two or more conical Kresling patterns, that can fold independently of one another, a single antenna can receive signal from a variety of geographic areas and distances. The antenna is intended to be constructed from aluminum mesh so that it can be easily folded, lightweight, and more easily sent to space. This research lays the groundwork for future designs of parabolic antennas that can be customized for the needed frequency and signal range.

Keywords:

Aerospace; Origami; Reconfigurable; Design; Antenna

Mentor(s):

Ran Dai (Engineering)

Other Acknowledgement(s): Yuto Tanaka (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Manufacturing Fiber Reinforced Composites by Vacuum-Assisted Resin Transfer Moulding Infusion and Characterization of Elium 191 XO/SA Resin Using DSC STEM

Authors(s): Valentina Marin†

Abstract:

One of the main challenges when working with Elium 191 XO/SA resin is its sensitivity to temperature, as it can polymerize at room temperature without elevated-temperature curing. Controlling the heat released during polymerization is essential to prevent defects like thermal runaways or voids. Elium 191 XO/SA is important for producing recyclable fiber reinforced composites used in demanding structural applications such as wind turbine blades, where both performance and sustainability matter. This project focuses on analyzing the polymerization behavior of Elium 191 XO/SA under controlled heating conditions. Although DSC has been used for other resins, limited data is available for Elium 191 XO/SA. Without a validated kinetic model, predicting its behavior under different manufacturing conditions remains difficult. The initial phase involves conducting both dynamic and isothermal Differential Scanning Calorimetry (DSC) to capture the full heat flow profile of the resin. The resulting data is used to fit kinetic models and determine the enthalpy of reaction and degree of conversion. In the second phase, this kinetic information will inform the vacuum-assisted resin transfer molding (VARTM) process. While DSC alone cannot predict macro-scale effects like overheating, combining it with material properties helps identify conditions that may cause under polymerization or excessive heat buildup during infusion. This research addresses the challenge of characterizing a thermoplastic resin that cures at room temperature. making the process one that requires both speed and precision. The goal is to develop processing parameters that ensure full polymerization while minimizing structural defects, ultimately improving the mechanical performance and reliability of high-performance composites.

Keywords:

Differential Scanning Calorimetry (DSC); Vacuum-Assisted Resin Transfer Molding (VARTM); Resin; Cure Kinetics; Thermoplastic Composites Mentor(s):
Anastasia Tsaveas (Engineering); R Byron Pipes (Engineering)
Other Acknowledgement(s):

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Expression and Purification of the G Protein Subunit Galphaq in E. Coli

STEM

Authors(s):

Julia Rose Millikin† (Science)

Abstract:

Gg is a guanine nucleotide-binding protein (G protein) involved in signal transduction composed of three different protein chains. It is activated by G protein-coupled receptors (GPCRs) on the cell surface in response to external stimuli, releasing the bound G protein heterotrimers as the subunits Galphag and Gbetagamma. Deactivation of the GPCR is initiated by a G protein receptor kinase (GRK), whose activity in pathophysiological conditions has been linked to heart disease and cancer. To continue structural studies on GRKs and GPCRs, a supply of active Galphag is useful for binding to GRK2-GPCR complexes. increasing their stability and hopefully resolution in cryo-EM studies. Galphaq for structural studies is typically expressed in insect cells, which have high cost and time requirements. Utilizing E. coli cells will mitigate both time and cost. To optimize E. coli expression, Galphag can be tagged to increase solubility, and post-induction temperature altered to reduce protein aggregation. To this end, hexahistidine and SUMO tags were added to the N-terminus and a FLAG tag added to the C-terminus. Two post-induction conditions were selected, 30 degrees Celsius for 12 hours and 20 degrees Celsius for 20 hours. Aliquots of Galphagtransformed bacterial cells were grown to optimum density, and then expression was induced and temperatures altered. Anticipated results include active, properly folded Galphag protein expressed in E. coli cells, detected by molecular weight and a trypsin protection assay. Using this optimized expression protocol, Galphag can be produced for cryo-EM studies, increasing overall quality of GRK2-GPCR structures.

Keywords:

G Protein; GPCR; Protein Expression; E. coli

Mentor(s):

John Tesmer (Science); Priyanka S Naik (Science); Indranil Arun Mukherjee (Science)

Other Acknowledgement(s):

Radhika Arvind Bhopatkar (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 2: 12:00-1:00pm

Enhancing Carbon-Negative Cement Composites with Surface-Modified Cellulose Nanomaterials

STEM

Authors(s):

Mahira Mim†; Bryn R Goldstein*

Abstract:

The construction industry makes a significant contribution to global carbon emissions, creating an urgent need for sustainable alternatives to cement. This research develops an innovative carbon-negative Cellulose Cement Composite (C3) that incorporates surface-modified cellulose nanomaterials to improve strength, durability, and water resistance while capturing carbon dioxide from the atmosphere. The cellulose-cement interface is optimized through modifications with 3aminopropyltriethoxysilane (APTES), tetraethyl orthosilicate (TEOS), and tannic acid (TA) to improve interfacial strength, water absorption and degradation of the cement matrices. Initial experiments successfully demonstrated the modification of CNMs (cellulose nanocrystals and nanofibrils) with APTES/TEOS/TA, supported by zeta potential analysis. Current investigations are focused on characterizing these composites using isothermal calorimetry to evaluate interactions in CNM-cement and CNM-cement-excelsior systems. Preliminary findings confirm that such modifications enhance water resistance while maintaining mechanical properties, though scaling these effects to bulk composites remains challenging. This project addresses critical gaps in scalability and longterm performance. The development of C3 aims to provide sustainable construction material that combines structural performance with carbon sequestration potential. Future work will focus on optimizing formulations for biodegradation and mechanical performance. This work contributes to global efforts in creating environmentally responsible building materials that actively address climate change while meeting the structural demands of modern construction.

Keywords:

Sustainable Construction Material; Carbon-Negative; Cellulose Cement Composite (C3); Surface Modification

Mentor(s):

Akshat Verma (Engineering); Jeffrey P Youngblood (Engineering)

Other Acknowledgement(s): Emily R Jakob (HHS)

Presentation Time: Session 2: 12:00-1:00pm

Fabrication of STM-Compatible Hexagonal Boron Nitride/Graphite Devices for Quantum Defect Studies

Authors(s):

Priya Mishra† (Science); Kyung Jun Lee‡ (Engineering); Manaswini Singh‡ (Science)

Abstract:

Hexagonal boron nitride (hBN) has emerged as a promising host for spin defects in two-dimensional materials due to its wide bandgap, chemical stability, and potential for room-temperature quantum applications. However, there is still a lack of direct experimental investigation of individual defects' atomic structure and their quantum behavior. We propose to address this challenge by developing a novel method to create isolated atomic vacancies in hBN under ultra-high vacuum and study them using scanning tunneling microscopy (STM). This presentation will focus on demonstrating the fabrication of STMcompatible hBN/graphite devices to achieve the above goal. To create these devices, we exfoliated hBN of varying thicknesses, validated with atomic force microscopy (AFM), and used dry-transfer methods to create heterostructures specifically designed for STM measurements. We also utilized vacuum annealing to make the surface of our substrate atomically clean of surface adsorbates and polymer residue. Finally, we plan to introduce controlled defect formation under ultra-high vacuum and study them with STM. Successful fabrication of these samples will provide hBN devices suitable for STM measurements, enabling direct correlation between atomic-scale defect structure and their quantum properties, providing experimental validation of theoretical predictions.

Keywords:

2D Materials; STM; Quantum Physics; Atomic Defect; Quantum Sensing

Mentor(s):

Tiancong Zhu (Science); Christopher Antonio Ulate (Science)

Other Acknowledgement(s):

Parth Uday Kelkar (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Comparing different machine learning methods for AMR gene class prediction after FMT treatment

STEM

Authors(s):

Rebekah E Mou† (Engineering)

Abstract:

Antimicrobial resistance (AMR), a major modern healthcare problem, can be limited by supplementing heavy antibiotic regimes with new treatments called fecal microbiota transplants (FMTs) in the case of patients for whom antibiotics have become ineffective. Machine learning (ML) methods have emerged as a potentially fast and effective way to visualize and predict AMR gene dynamics, though there have been few direct comparisons between different machine learning methods within this application. This research aims to establish direct comparisons between different machine learning methods in analyzing or predicting frequencies of antimicrobial resistance genes in post-FMT patients. To do this, we trained various supervised ML methods (Random Forest, XGBoost, and Linear Regression/Lasso) to predict post-FMT AMR gene frequencies. Additionally, unsupervised ML models like PCA and t-SNE were used for exploratory analysis and visualization of gene clusters. Using the hyperparameter optimization framework Optuna, we determined the optimal hyperparameters for each ML model and evaluated the most accurate supervised ML method for each gene class. For both supervised and unsupervised models, SHapley Additive exPlanations (SHAP) was used to determine feature importance and model interpretability. Preliminary results suggest that Random Forest, while commonly regarded as a strong baseline in machine learning, performed less accurately than other models in predicting AMR gene abundance. This research aims to provide groundwork for further comparison of ML methods in an AMR space and background for the usage of the most optimal ML methods in predicting AMR gene frequencies.

Keywords:

Antimicrobial Resistance; Artificial Intelligence; Machine Learning; Microbiome; Fecal Microbiota Transplant

Mentor(s):

Alejandro Dale Kimball (Centers & Institutes); Ilya Slizovskiy (Vet Med)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Characterizing Sulfur Speciation and Inorganic Content in Landfill Leachate Using Ion Chromatography

STEM

Authors(s):

Heather Murillo†; Ethan Patrick Connolly* (Engineering|JMHC)

Abstract:

Landfill leachate is often treated solely as a hazardous waste product, but it contains valuable dissolved materials such as heavy metals and rare earth elements. These compounds have economic and environmental value, especially in the context of resource recovery and reducing the need for new mining activities. However, the chemical behavior of leachate remains poorly characterized. The composition of leachate is influenced by external factors such as rainfall, waste type, and landfill age. How these variables affect redox chemistry and element speciation is still not fully understood. This research focuses on improving our understanding of leachate chemistry with an emphasis on sulfur species. This project investigates the speciation of sulfur compounds to better understand redox potential in landfill systems and evaluates the presence of other inorganic species that may co-occur or interact with sulfur under different conditions. Samples of landfill leachate are being analyzed using ion chromatography to quantify both cationic and anionic inorganic species. Standard calibration curves are used to ensure data accuracy. Multiple samples have been collected across different periods and environmental conditions. While data collection is ongoing, the study will compare sulfur and inorganic ion concentrations across samples and assess trends related to redox-active processes. This includes identifying which forms of sulfur dominate under different conditions and exploring correlations between sulfur speciation and other ions. This research will contribute to a more comprehensive understanding of landfill leachate chemistry, inform potential strategies for sulfur and resource recovery, and help guide future efforts to promote sustainable waste management practices.

Keywords:

Landfill; Leachate; Resource Recovery; Speciation Analysis; Ion Chromatography

Mentor(s):

Amisha Shah (Engineering); Guanchun Wang (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Pranshul Sardana (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Agent-based computational modeling of the homeostatic cortical actin array in plant epidermal cells

STEM

Authors(s):

Srikushal Muthamsetty† (Engineering)

Abstract:

The homeostatic cortical actin array of plant epidermal cells plays an important role in fundamental processes, including intracellular transport, secretion, cell expansion, and cytoplasmic streaming. The array is consisted of single actin filaments, which can also be organized together with the binding of actin crosslinking proteins (ACPs) to form an actin bundle. In experimental studies, live-cell imaging has been used to track the dynamic properties of both actin filaments and bundles at high spatiotemporal resolution. With small molecule inhibitors and genetic mutations, prior studies have shown a robust dynamic steady state of the cortical actin array, with individual filaments showing stochastic dynamics while bundles remain relatively stable. Computational efforts focused on the plant actin cytoskeleton are lacking, however, as prior studies primarily focused on investigating filament or bundle dynamics in animal cells. Using an agent-based model, we reproduced the steady state condition of the cortical actin array in plant cells with both single filament and bundle dynamics, which can help illuminate a novel observation that may be difficult to do experimentally. We found that increasing the binding rate of ACPs, decreasing the unbinding rate of ACPs, and increasing the ACP density all promoted bundle formation. On the other hand, increasing the unbinding rate led to rapid bundle disassembly. This research tackles the challenge of computational modeling of both single filament and bundle dynamics in the homeostatic cortical actin array of plant epidermal cells.

Keywords:

Actin; ACP; Bundle; Filament

Mentor(s):

June Hyung Kim (Engineering); Tae Yoon Kim (Engineering)

Other Acknowledgement(s):

Emily R Jakob (HHS)

Presentation Time: Session 2: 12:00-1:00pm

Arc Welding Metal 3D Printing for Composite Tooling STEM

Authors(s):

Paul Kyu-Hwan Park† (Polytechnic)

Abstract:

Arc welding metal 3D printing, or Wire Additive Manufacturing (WAAM), offers a cost-effective, large-scale approach for producing metal parts. While WAAM has been studied for structural components, its suitability for creating composite molds with the required dimensional accuracy, surface finish, and thermal performance remains underexplored. Addressing this gap is crucial, as traditional methods for producing large metal molds are expensive, slow, and inefficient. This research focuses on establishing and optimizing the WAAM process for fabricating composite tooling, with an emphasis on machine setup, parameter calibration, and process planning to enable reliable deposition. The work involves configuring the WAAM system, selecting and validating appropriate process parameters, and preparing for fabrication of test geometries and tooling shapes. Plans for future work include systematic testing and characterization of printed samples for dimensional accuracy, surface roughness, porosity, hardness, and thermal conductivity. Data will be collected through 3D scanning, profilometry, metallography, hardness testing, and thermal property measurements. This study is designed to lay the groundwork for comparing metal 3D printed composite tooling with conventional machined molds in terms of accuracy, surface quality, and thermal performance. Ultimately, the project aims to provide recommendations on process parameter selection and design guidelines to enable more flexible, efficient, and sustainable production of composite tooling.

Keywords:

Metal 3D Printing; Composite Tooling; Additive Manufacturing; Mold Fabrication

Mentor(s):

Garam Kim (Polytechnic); Eduardo Barocio Vaca (Engineering)

Other Acknowledgement(s):

Emily R Jakob (HHS)

Presentation Time: Session 2: 12:00-1:00pm

Computational Validation of Localized and Concentrated Vaccine Delivery Eliciting Robust Antibody Responses STEM

Authors(s):

Sanjana Prashanth† (Engineering)

Abstract:

Vaccine design remains largely empirical with trial-and-error approaches, leading to inefficient development of effective administration protocols. Computational modeling has shown promise in elucidating immune dynamics, but current models lack validation with preclinical data. Improved predictive computational models can validate experimental data and inform variations in vaccine administration strategies, thereby reducing the number of iterations required to develop effective vaccine protocols. This study employs a mathematical modeling framework to simulate immunological responses to a localized, polymeric collagen vaccine delivery mechanism. By formulating differential equations representing key immune processes, initializing parameters based on antigen and adjuvant concentrations, and analyzing the resulting dynamics through graphs, the model's predictions are calibrated to experimental data to assess its ability to reproduce in-vivo vaccine responses. Previous preclinical rodent studies revealed that the collagen delivery vehicle localized antigen availability over an extended period, leading to enhanced germinal center (GC) activity and prolonged B cell maturation. The model captures the kinetics of antigen retention, GC formation, and antibody production, showing qualitative agreement with the in-vivo experimental data. By accurately reflecting experimental observations, the model provides a valuable tool for optimizing vaccine administration strategies and guiding rational design, ultimately reducing reliance on repetitive preclinical testing.

Keywords:

Computational Modeling; Vaccine Delivery; Differential Equations; Germinal Center Enhancement

Mentor(s):

Sushma Gude (Engineering)

Other Acknowledgement(s):

Rachel Alena Morrison (Engineering); Juan F Hernandez Franco (Vet



Presentation Time: Session 2: 12:00-1:00pm

Microstructural Control of HTPB-Based Energetic Materials STEM

Authors(s):

Varunavi Kaveri Raghuraman† (Engineering); Ryan J Turnbull*

Abstract:

Polymer-bonded explosives (PBXs) must be engineered to deliver high energy output while remaining stable and predictable under thermal, mechanical, and environmental stress. Inconsistencies in pellet microstructure, such as voids, nonuniform binder distribution, or porosity, can lead to unpredictable initiation, poor performance, or dangerous handling conditions. New hydroxyl-terminated polybutadiene (HTPB) molding powders reduce the need for toxic solvents in traditional manufacturing processes and cure thermally over time. Storing the powders at cold temperatures could extend the processing lifetime, yet the effect of storage on final pellet properties is not understood. This study aims to understand how storing partially cured HTPB molding powder at different temperatures and varying durations affects the microstructural and mechanical properties of the resulting PBX pellets. Molding powders were prepared using partially cured HTPB with a precure time of either 2 or 4 hours. Both powders were stored in refrigerator (0°C) or freezer (-17°C) conditions for 24, 48, or 168 hours. After storage, the powders that were precured for 4 hours were immediately pressed, while the powders that were precured for 2 hours were thermally cured for an additional 2 hours and then pressed. Optical profilometry, Archimedes density testing, and compression testing were used to assess surface uniformity, bulk density, and mechanical integrity, respectively. A rheometer with parallel plate geometry and temperature control was used to study the degree of crosslinking and processing time of HTPB. This research identified storage times and temperatures extending molding powder processability and investigated how precure interruptions affect final PBX properties.

Keywords:

[no keywords provided]

Mentor(s):

Monique Suzanne McClain (Engineering)

Other Acknowledgement(s):

Ismar Leonel Chew (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 2: 12:00-1:00pm

Multi Target Trajectory prediction with Non-Overlapping Cameras

STEM

Authors(s):

Aakarsh Nagendra Rai† (Science|Graduate)

Abstract:

Trajectory prediction in crowded environments has traditionally relied on single-view or overlapping multi-view setups. In this work, we explore a more challenging and realistic setting; forecasting the future trajectories of multiple agents observed by spatially distributed drones with nonoverlapping fields of view (FoVs). Each drone independently observes a subset of the scene through a circular FoV and encodes its local spatiotemporal observations into a compressed representation using lightweight CNN encoders. These representations are transmitted to a central fusion model that spatially aligns and aggregates the embeddings to construct a unified global context. A Transformer-based decoder then jointly predicts future heatmaps of agent positions, reasoning over interagent dynamics across disjoint views. Our method effectively addresses issues of spatial disjointedness, partial observability, and communication constraints. We evaluate on a synthetic drone surveillance dataset and demonstrate strong performance in predicting trajectories even when agent paths traverse across different FoVs, highlighting the model's ability to learn implicit spatial coordination without explicit overlap or shared views

Keywords:

Machine Learning; Trajectory Prediction; Non-Overlapping Field of

Views; Federated Learning

Mentor(s):

David Iseri Inouye (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

A Quantitative Comparison of Motion Blur Correction Methods: MCFI, Post-Processing, and a Preemptive Human-Perceptual Approach

STEM

Authors(s):
Juan Esteban Rios Gonzalez†

Abstract:

Motion blur is a visual issue caused by the fast movement of the viewer in relation to the display format. One approach collectively being developed is a preemptive motion blur method for human observation that also hides ringing artifacts. This method is contrasted against MCFI (Motion Compensated Frame Interpolation) and a state-of-the-art post-correction motion blur software using the GoPro dataset. These three approaches are compared by simulating motion blur with a PFS (Point Spread Function) with varying kernels that are generated to account for frame rate of the display screen and velocity of the moving image. The data presented shows how the methods adapt to across a range of velocities and frame rates to ensure consistent evaluation. Finally, the resulting images are measured in terms of PSNR and SSIM metrics, which show that the preemptive method is superior by both standards and more robust when evaluated against the two other solutions.

Keywords:

Motion Blur; MCFI; PSF; GoPro

Mentor(s):

Daniel G Aliaga (Science)

Other Acknowledgement(s):

Emily R Jakob (HHS)

Presentation Time: Session 2: 12:00-1:00pm

Characterization and Operation of Inductively Coupled Plasma Neutralizer for Electric Propulsion Applications STEM

Authors(s):

David Rubin† (Engineering|JMHC)

Abstract:

Hollow cathodes have long been used as the operation principle of neutralizers for electric propulsion but are expensive to replace if a failure occurs. Particularly in lab settings, they can be prone to poisoning which severely shortens their lifespan. This research seeks to propose a new system in place of the traditional hollow cathode neutralizer, operating with inductively coupled plasma to properly neutralize the thruster and allow steady operation. To evaluate this system, copper coils were wrapped around a glass tube and tested with varying parameters of power frequency and tube diameter. The system was connected to an external generator and amplifier and tested under high vacuum. Visual observations were collected about plume intensity and a bidirectional coupler was used in series to read the forward and reflected power. Initial measurements indicated that the neutralizer was generating enough power to adequately supply the thruster, but steady state running was not observed. It is believed that the voltage drop within the plasma was too high due to a small contact surface with the electrode. To overcome this, copper inserts were installed to extend the electrode contact area within the plasma. Similar visual results and power measurements were collected as the original design, but the new system allowed the thruster to achieve stable ignition and run for several seconds. This work tackles the issue of having reliable and easily replaceable neutralizers which will enable the operation of electric thrusters in lab settings.

Keywords:

Plasma; Electric Propulsion; Neutralizer; Hall-Effect Thruster; Radio Frequency

Mentor(s):

Kenneth Barton Reindersma (Engineering); Nicholas Vytautas Babusis (Engineering)

Other Acknowledgement(s):

Alexey Shashurin (Engineering); Pranshul Sardana (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 2: 12:00-1:00pm

Co-designing Student VR Experiences for Geology Course Fieldtrips

STEM

Authors(s):

Hiya Samanta† (Science|JMHC); Henry J Lee* (Science|JMHC|Graduate); Siya Chirag Jariwala* (Science|JMHC)

Abstract:

Field trips are an integral part of geoscience courses. However, locations, such as caves, are often unsuitable for field trips due to accessibility and safety concerns. Virtual reality (VR) can bridge this gap and fulfill educational goals without the challenges accompanying physical navigation through such areas. To support undergraduate learning about karst environments in an Earth, Atmospheric, and Planetary Sciences (EAPS) course, we are developing a cave exploration VR experience. This project integrates a high-fidelity virtual cave environment with collaborative design workshops, enabling students, postdoctoral scholars, and faculty to co-create and refine the VR prototype for the course. We have designed the workshops to consist of three main activities. First, participants reflect on past field trip experiences and connect them to caves and virtual reality. Second, they examine cave images and generate questions to explore the types of contexts relevant to a cave-based VR environment. The workshop concludes with a storyboarding session where participants visually map out their ideas for the VR experience. The workshops will be facilitated during the summer and fall and the ideas presented and collected during these workshops will be expanded upon to refine the design of the VR prototype that will be deployed during the EAPS course. This VR will serve as the gateway for future projects about virtually exploring similar high-risk zones such as volcanoes and glaciers.

Keywords:

Co-Design; Virtual Reality; Caves; Geoscience

Mentor(s):

Anastasia Kouvaras Ostrowski (Polytechnic); Caue Sciascia Borlina (Science); Ali Bramson (Science)

Other Acknowledgement(s):

Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Assessing Reconstitution of Lyophilized Formulations in Cake and Bead Forms using LED Light Transmission

Authors(s):
Mary Jane Sayler† (Engineering)

Abstract:

Reconstitution of lyophilized drugs is an essential step prior to administration. Accurate determination of reconstitution time is critical for supporting formulation development and ensuring patient safety. Traditional methods for measuring reconstitution time rely on visually identifying the endpoint, which can introduce variability and potentially harmful errors. In this study, a light emitting diode (LED)-based method is proposed as a more objective alternative. The method uses an LED whose signal is initially blocked by the intact sample. As the product dissolves with the addition of water, changes in light transmission through the vial are detected by a phototransistor. The endpoint is numerically defined as the point at which transmitted light reaches a maximum and its rate of change becomes zero. This study compares traditional lyophilized cakes and lyophilized beads to evaluate differences in their reconstitution behaviors. Early results show clear differences between the two forms. A better understanding of the reconstitution mechanisms of different solid forms can help inform future formulation design and optimization of the reconstitution process in industry settings.

Keywords:

Phamasuidicals; Freeze-Drying; Optical Transmission; Dissolution; LED

Mentor(s):

Jesus Adrian Meza Galvan (Engineering); Anthony G Cofer (Engineering)

Other Acknowledgement(s): Pranshul Sardana (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Cyclodextrin Derivative Synthesis for Use in Formation of Layer-By-Layer Elastin Like Polypeptide Nucleic Acid Self Assembling Nanoparticles.

STEM

Authors(s):

Hayden Schneider† (Science|JMHC)

Abstract:

RNA delivery requires a carrier to be safely transported to a target cell. In order to aid RNA transport, non-viral methods have been developed. This type of delivery does not suffer from a robust immune response, but current methods lack cell targeting and thus require a larger dose for effective delivery. They also face problems due to the cost of materials and their nonrenewable sourcing. The Thompson Group aims to create a non-viral RNA delivery approach having increased targeting abilities. stability, bio-renewability, and lower cost. Using this delivery system, known as layer-by-layer elastin-like polypeptide nucleic acid nanoparticles (LENN), the RNA can be safely encapsulated in a multilayer package. These LENN can be made with agents that target cancer cells. The innermost layer of our nanoparticle interacts with the RNA using beta-cyclodextrin, a cyclic oligomer of the natural sugar glucose; beta-cyclodextrin is generally regarded as safe and is found in many FDA approved drug formulations. The beta-cyclodextrin precursor is linked to a polyarginine chain to create a cationic cyclodextrin derivative that can electrostatically interact with negatively charged RNA. These charged derivatives will then be used to encapsulate RNA and used in LENN formulations. The purity of the cyclodextrin derivates are determined using mass spectrometry (MS) and nuclear mass resonance (NMR). Utilizing NMR, evidence for the formation of a pure betacyclodextrin-polyarginine derivative has been obtained. This research will enable the development of low cost, low toxicity, and renewably sourced non-viral RNA carriers with targeting capabilities in order to treat cancer and other human diseases.

Keywords:

Biochemistry; Chemistry; Cancer Research

Mentor(s):

David Thompson (Science); Marissa Elaine Henager (Science)

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Statistical Modeling of Interstage Outcomes in Infants with Single Ventricle Heart Disease Using Data from the SVR Trial.

STEM

Authors(s): Elliott Shi† (Science)

Abstract:

Single ventricle heart disease is a rare congenital heart defect where a child is born with only one functioning ventricle, the heart's pumping chamber, instead of two. Although previous research has shown no significant difference in mortality between the two primary surgical approaches, the Modified Blalock-Taussig (MBT) shunt and the Right Ventricle to Pulmonary Artery (RVPA) shunt, the factors that most influence survival remain unclear. The purpose of this study is to provide a better understanding of this heart defect and its treatment options. This research aimed to develop a statistical model to discern which components are influential in a patient's health status. Using data from the Pediatric Heart Network's Single Ventricle Reconstruction trial, we analyzed 447 infants who were randomized to one of the two shunt types and followed until approximately 14 months of age. Echocardiographic data and neurodevelopmental assessments were collected at the end of this period. We intend to examine composite outcome variables, initially focusing on death, and then augmenting this approach as we proceed. We expect to find, regardless of variable data streams, some predictors of outcome, and we will probe their statistical significance and importance in anticipating poor outcomes for patients during this interstage period. This research offers a more in-depth analysis of singleventricle heart disease and its adverse outcomes. Further study includes more advanced statistical modeling.

Keywords:

Health; Congenital Heart Defect; Echocardiography; Predictors; Composite Outcomes

Mentor(s):

Brett A Meyers (Centers & Institutes)

Other Acknowledgement(s): Emily R Jakob (HHS)

Presentation Time: Session 2: 12:00-1:00pm

Computational modeling to assess spatial Calcium signaling patterns and mechanisms during plant defense

STEM

Authors(s):

Kenneth David Siefken† (Engineering)

Abstract:

Intracellular calcium (Ca2+) signaling plays a vital role in coordinating tissue and organ-level responses to pathogens, wounding, and stress. These responses typically involve two phases; an initial Ca2+ signal and. in many cases, a subsequent wave-like propagation of Ca2+ across the tissue. In this work, we investigate how Ca2+-induced Ca2+ release (CICR) contributes to the propagation of these waves. Unlike previous models that treat tissue as a continuous medium, we develop a hybrid agent-based modeling framework that explicitly incorporates individual cell geometries and cell-cell communication mediated by gap junctions (GJ) in animals and plasmodesmata (PD) in plants. We also include a Ca2+-dependent sink to reflect physiological clearance mechanisms. In this study, we explore how varying model parameters influence the emergence of different Ca2+ wave patterns, including continuous waves, stop-and-go propagation, and complete failure of wave initiation. By performing systematic parameter screening using Latin Hypercube Sampling, we characterize how CICR-mediated signaling is regulated across different parameter regimes and how it affects wave speed and travel distance. We also focus on Ca2+-mediated regulation of cell-cell communication. Specifically, we examine how Ca2+ influences the closure of communication channels such as PD, known to be Ca2+sensitive in Arabidopsis thaliana and other systems. We test three models of PD permeability: constant, linearly Ca2+-dependent, and biphasic. We quantify the diversity of resulting Ca2+ wave patterns using entropy calculations and compare these findings with alternative models of wave propagation. Together, this work advances our understanding of Ca2+ wave propagation and intercellular communication in response to external stimuli.

Keywords:

Calcium; Plasmodesmata; Wave Velocity; Computational Model; Intracellular Communication

Mentor(s):

FNU Nilay Kumar (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
Elsje Pienaar (Engineering); Emily R Jakob (HHS)

Presentation Time: Session 2: 12:00-1:00pm

Precise Tuning of Multi-Cavity Microwave Devices STEM

Authors(s):

Wrigley Alan Starkweather† (Engineering)

Abstract:

The biggest problem faced when using resonators in a microwave device is the precision required to create the desired characteristics. Often, they, have to be constructed with sub-millimeter precision to prevent the resonant frequency from shifting beyond the design constraints. A common solution to this is to make the dimensions of the cavity adjustable, an exemplary solution that accounts for both manufacturing error and changing environmental conditions assuming it is properly tuned. For simple single-resonator systems, this is easily accomplished either by the diligence of a human operator or an automated frequency monitoring and adjusting system. However, this becomes far more complicated with the introduction of multiple resonators. Calibration becomes far more difficult, as changes in any one resonator can change the total output in unintuitive ways. This research is intent on the development of an automated system for tuning a multi-resonator device utilizing the s-parameters of the real device and a simulated version of the system to automate the tuning process and optimize the properties according to operator's specifications. The biggest part of this research is a microcontroller-driven control board for high-precision actuators. It was created in Altium Designer to interface a Raspberry Pi Pico with four actuators controlling the physical properties of the component cavities of the device. It does this with SPI or I2C which allows for quick, reliable adjustment of the actuators to under a micron of precision. Recent tests demonstrate the effectiveness of this system; even being adjusted manually, the ability to adjust the cavities in a more quantitative way than the set screws had allowed makes the tuning process not only easier, but also less necessary, as once a tuning is established it can be saved and repeated without having to go through the process again. The main purpose of this research is to develop a precise system for the tuning of a cavity-based quadrature filter. The eventual goal is to be able to tune the filter far more effectively and efficiently than was previously possible. possibly with the addition of computer-driven automated tuning.

Keywords:

Microwave

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Mentor(s): Dimitrios Peroulis (Purdue University); Alex David Santiago Vargas (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Hypersonic Wind Tunnel and Constrained Ballistic Model Design and Analysis

STEM

Authors(s):

Aaron Su† (Engineering); Kaitlyn Elizabeth Bird‡ (Engineering)

Abstract:

Accurately modeling aircraft in hypersonic flight demands simulating high-speed, quiet airflow free of perturbation and acoustic noise. Many existing hypersonic tunnels are predominantly noisy, obscuring important phenomena underneath turbulence and offering limited test flexibility. This research seeks to address the structural and aerodynamic challenges of using linear accelerators to drive test articles through conditioned, quiescent air to reduce noise and expand the range of test conditions. For test article mounting, alumina ceramic struts were chosen due to space limitations demanding accelerations of up to 30,000 G. Struts modeled using SolidWorks and manufactured using stereolithography 3D-printing and sintering were verified for structural integrity using finite-element analysis (FEA). Incorporating sharp features favorable for attached shock formation, strut FEA calculations indicated that alumina ceramic can withstand the mechanical and thermal loads anticipated during full-scale testing. Projectile assemblies were simulated for flow obstruction in ANSYS Fluent, modeling conditions in the Boeing/AFOSR Mach-6 Quiet Tunnel (BAM6QT) and the Auriga Space Linear Accelerator, varying tunnel wall clearances by estimated boundary layer thicknesses to predict bypass channel tolerances needed to avoid blockage and mitigate drag. Complete assemblies simulated in 1:1-scale from Mach 3 to 4.12, 10 to 1000 mbar pressurization, and 0.625 to 73.65 mm wall clearances displayed transient drag increases up to 12mm. Ongoing research seeks to better quantify minimum margins for sufficient flow bypass to prevent choking. Further investigation warrants full-scale data acquisition and comparison of real ballistic models in pseudo-free stream in the BAM6QT and enclosed flow in the Auriga Linear Accelerator.

Keywords:

Hypersonics; Computational Fluid Dynamics (CFD); Finite Element Analysis (FEA); Additive Manufacturing; Aerodynamics

Mentor(s):

Joseph S Jewell (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Parth Uday Kelkar (Engineering); Abigayle Elaine Moser (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Provably Correct Quantum Circuit Cuttin STEM

Authors(s): Sarthak Tandon† (Engineering)

Abstract:

Quantum circuit cutting—decomposing large quantum programs into smaller subcircuits—has emerged as a key technique for scaling computations beyond current hardware limitations. However, ensuring the correctness of such decompositions under realistic noise remains an open challenge. This research presents ZX-Checker, a formal verification tool that extends the ZX-calculus to reason about circuit cutting in the presence of global noise models. The approach embeds ZX-diagrams into the category CPM(Qubit) using a double-wire construction, enabling symbolic modeling of completely positive tracepreserving (CPTP) maps. ZX-Checker implements a modified ZX-calculus, expressing noisy circuit fragments as linear combinations of enriched ZX-diagrams and simulating their reconstruction via algebraic rewriting. By integrating categorical quantum mechanics with automated rewriting and simulation, ZX-Checker offers a mathematically rigorous framework for verifying noise-aware circuit decompositions. This enables scalable, provably correct compilation pipelines for near-term quantum devices, advancing the formal methods toolkit available for noisy intermediate-scale quantum (NISQ) computing.

Keywords:

Quantum Computing; Quantum Error Correction; ZX Calculus; Quantum Verification

Mentor(s):
Jingbo Wang (Engineering)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Synthesis of Cationic Alpha-Cyclodextrin to Aid in Layer-by-Layer Elastin-like Polypeptide Nucleic Acid Nanoparticle Materials

STEM

Authors(s):

Peyton E Tanoury† (HHS)

Abstract:

Alpha-cyclodextrin is a natural sugar made of 6 glucopyranose molecules in a ring known for its hydrophobic inner cavity and a hydrophilic exterior. This project focuses on synthesizing cationic alphacyclodextrin derivatives with polyarginine chains for nucleic acid delivery. These products are formed by reacting the peptides with cyclodextrin by a carbonyl coupling agent. Though the reaction has been proven with other cyclodextrins, purification remains challenging. The importance of synthesizing a pure cationic alpha-cyclodextrin is to aid in layer-by-layer elastin-like polypeptide nucleic acid nanoparticle (LENN) as targeted RNA carriers for non-immunogenic cancer therapy. The initial phase involves creating alpha-cyclodextrin amine derivatives through several steps that allow for selective activation of a hydroxyl group on the cyclodextrin ring. The intermediate is then reacted to form the amine starting material necessary for linking to the chosen peptides. Preliminary work has established that dialysis can be used to separate the product based on molecular mass differences, which has been successful for beta-cyclodextrin-polyarginine-10-mer, though other derivatives have yet to be purified using this method. This project will highlight synthesis of cationic alpha-cyclodextrin molecules that are used to formulate LENN. By developing reliable methods for synthesizing and purifying this molecule we can help aid in the development of targeted RNA delivery. Continued work in purification will be essential for producing a high-quality product.

Keywords:

[no keywords provided]

Mentor(s):

Marissa Elaine Henager (Science); David Thompson (Science)

Presentation Time: Session 2: 12:00-1:00pm

Characterizing explosion asymmetry in the Cassiopeia A supernova remnant using JWST light echo observations STEM

Authors(s):

Madeline G Taylor† (Science)

Abstract:

Supernovae (SNe) are stellar explosions that occur at the end of a massive star's life (at least ~8 - 10 solar masses in size). Cassiopeia A (Cas A) is an instance of the debris field left behind by a SN that exploded 350 years ago. As light from the SN travels in all directions, photons reflect off the interstellar medium (ISM), which causes the light from the initial explosion to arrive hundreds of years after the original light reaches Earth. With this delay in time for light traveling, called a light echo (LE), we observe the SN at an earlier point in its evolution. This property of LEs enables researchers to observe the evolution of the SN and provides different viewing angles. We determine the characteristics of nearby dust, such as density and distance from remnant, by measuring across different filters and building a spectral energy distribution (SED) of emission. Our work makes it possible to model the composition of the ISM as well as the geometry and emitting properties of the explosion. Since interstellar dust plays a critical role in the formation of new stars and planetary systems, understanding its behavior and lifecycle is essential. Our analysis can also provide new insights into the shock breakout phase of a SN.

Keywords:

Supernova; SED; Infrared; Light Echoes; Cassiopeia A

Mentor(s):

Danny Milisavljevic (Science); Danielle Dickinson (Science); Noah William Zimmer (Science)

Presentation Time: Session 2: 12:00-1:00pm

Characterizing Proteoform-Drug Interactions by Reactivity-Driven Top-down Mass Spectrometry

STEM

Authors(s):

Olivia B Williams† (Science)

Abstract:

Despite its infrequent occurrence in the proteome, cysteine is the most nucleophilic amino acid. Its involvement in numerous biological processes makes it extremely prominent in covalent therapy research. Cysteine's pKa is known to shift dramatically with changes in its microenvironment, ranging between 3-10, which presents an opportunity to target specific cysteines in the proteome for covalent drug development. This can be achieved by identifying novel proteoforms; these are the unique proteins that can arise from the same gene through post-translational modifications (PTMs), alternative splicing events, and mutations. Currently, cysteine reactivity profiling is studied through bottom-up proteomics, but this approach suffers from a loss of structural information, causing the loss of the connection between reactivity and PTMs, and making it difficult to localize differentially reactive cysteines. In this study, we aim to better characterize proteoforms with differentially reactive cysteines using a combination of protein-level enrichment and top-down mass spectrometry. To test this, we will use activity-based protein profiling coupled with top-down liquid chromatography-mass spectrometry. These techniques allow us to isolate, label, identify, and characterize proteoforms containing reactive cysteines in complex samples. Preliminary experiments were analyzed via in-gel fluorescence and Coomassie stain and demonstrated comparable labeling efficiency between iodoacetamide, the standard for cysteine labeling, and a cellpermeable maleimide derivative. Future experiments will aim to evaluate the enrichment method for efficiency before moving into competitive experiments to determine the presence and placement of reactive cysteines within more complex samples.

Keywords:

Cysteine Reactivity; Proteomics; Activity-Based Protein Profiling (ABPP); Proteoform; Post-Translational Modifications (PTM)

Mentor(s):

Bryon Shane Drown (Science); Teagan Louise Campbell (Science)

Other Acknowledgement(s):
Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Direct servo-driven actuation strategy for an avian-inspired flapping-wing aerial vehicle

STEM

Authors(s):

Sota Yanagisawa† (Engineering|DSB); Abdullah Mouaffaq S Albaghdadi‡ (Engineering)

Abstract:

Flapping-wing aerial vehicles (FWAVs) inspired by avian flight offer advantages in maneuverability and endurance over traditional fixed-wing aircraft. However, FWAVs with rigid wings typically employ brushless DC motors, resulting in mechanically complex actuation systems involving multiple moving parts such as gearboxes and multi-bar linkages. In contrast, existing servo-driven flapping mechanisms are largely limited to FWAVs with membrane wings that rely on passive aeroelastic deformation, which is less ideal as it is difficult to control. This study presents the development and prototyping of a novel, direct servo-driven actuation strategy for an FWAV with airfoil-sectioned rigid wings. Each wing is actuated by two servos, enabling active control of the wing's angle of attack throughout the flapping cycle to generate thrust. This direct servo approach permits independent wing motion for complex maneuvers and supports an enhanced gliding mode with variable dihedral control. In addition, the precise angle control allows for further understanding of the thrust generation process. A modified aircraft design methodology is implemented to design the FWAV. The design process incorporates sizing studies, servo torque calculations, correlation analysis, and stability evaluations using software such as XFLR5 and OpenVSP. Wind tunnel testing is performed to quantify the lift, net thrust, and pitching moment under three operational modes: flapping, gliding, and a gliding-to-flapping transition. Free-flight tests were conducted to validate flight capability. The findings establish a foundation for future servo-driven FWAV innovations by demonstrating a mechanically simpler, modular, and upgrade-friendly design architecture.

Keywords:

Flapping Wing; Avian-Inspired Aircraft; Mechanism Design; Wing Kinematics; Aerial Robotics

Mentor(s):

Abhijnan Dikshit (Engineering); Pavankumar Channabasa Koratikere

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

(Engineering); Spencer Dean Jones (Engineering); Leifur Thor Leifsson (Engineering)

Other Acknowledgement(s): Varun Aggarwal (Engineering); Thomas Robert Bietsch (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Optimization of Large-Scale DNA Tetrahedral Nanostructure for Enhanced Drug Delivery Across the Blood-Brain Barrier STEM

Authors(s): Keith S Yung† (Engineering)

Abstract:

A major limitation for delivering therapeutics to the brain to treat neurodegenerative diseases is the Blood-Brain Barrier (BBB), a highly selective permeable layer of cells. While the BBB is effective in achieving brain homeostasis, it remains an obstacle for many engineered nanoparticles to deliver cargo., Tetrahedral DNA nanostructures (TDNs) have demonstrated their potential for delivering across physiological barriers, including the BBB, due to their biocompatibility, stability, exact sizing, and simple assembly. In our work, we designed and optimized yield of a large-scale tetrahedral DNA nanostructure with two double helices per edge and six full turns between vertices as a drug delivery vehicle. The enlarged TDN allows for reliable and higher concentration drug loading, such as miRNA or doxorubicin, when compared to other commonly used smaller TDNs. Yield optimization was achieved through testing different buffers, annealing regimes, DNA concentrations, circularized vs uncircularized strands, and molar ratios using native polyacrylamide gel electrophoresis. Our results indicate that the largescale TDN assembles at approximately 25% yield using 500 nM DNA, 12.5 mM magnesium acetate in 1× TAE buffer, and a 1:4:3 ratio of the circularized strand to strands 2 and 3 mixed and slow annealed over two days. These findings establish a strong foundation for the use of these TDNs in targeted neurological drug delivery.

Keywords:

DNA Nanomaterials; Drug Delivery; Blood-Brain Barrier; Nanoparticle Assembly; Neurodegenerative Disease

Mentor(s):

Grigorii Aleksandrovich Rudakov (Engineering)

Other Acknowledgement(s): Emily R Jakob (HHS)

Presentation Time: Session 2: 12:00-1:00pm

XRF-Based Identification of Buried Lead Service Lines: A Non-Destructive Alternative to Excavation

STEM

Authors(s):

Kaden Bowers†; Michael K Lau† (Engineering)

Abstract:

Lead service lines (LSLs) remain a widespread source of drinking water contamination yet replacing them is proven to be a challenge due to poor infrastructure records and costly identification methods. Current techniques involve excavating pipes to measure composition. Additional methods to identify lead using water testing do not differentiate between pipes, fittings, or connections made of lead. In this project, we propose using X-ray fluorescence (XRF) to detect buried LSLs non-invasively without excavations and minimizing disruption to residents. Unlike conventional XRF setups, we deploy a 140 kV X-ray tube directed into the ground with a cadmium zinc telluride (CZT) detector to capture Kshell lead fluorescence signals from the buried LSLs. However, soil causes significant signal attenuation and scattering, which greatly reduces the ability of our detector to get a signal deep in the soil. To address this, we investigated a series of spectral analysis and physical modifications such as beam collimation and noise filtering to reduce unnecessary signal detections. Our findings show that this technique greatly increases our detection depth below 12-15 inches which is well below buried depth of water service lines for most of the southeastern United States allowing for rapid, cost-effective detection of buried LSLs. Future efforts include further optimization of the system to extend our detection depth.

Keywords:

X-Ray Fluorescence; Lead; Non-Invasive Detection; Soil Attenuation; Instrument Optimization

Mentor(s):

Thomas Ray Grier (HHS); Aaron James Specht (HHS)

Other Acknowledgement(s):

Radhika Arvind Bhopatkar (Engineering); David Matthew Czerwonky (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Extending Generalized Space-Charge-Limited Current to Multi-Region Systems

STEM

Authors(s): Ziara Cato†

Abstract:

Space Charge Limited Current (SCLC) models of electron transport in vacuum, gas, and solid systems are governed by Mott-Gurney or Child-Langmuir. Mott-Gurney (MG) describes the maximum current for a gap filled with a solid material, whereas vacuum gaps use Child-Langmuir's (CL) Law. These models can be applied to a wide range of devices, from semiconductors and transistors to spark gap switches and other plasma devices. In previous works, a generalized SCLC (GSCLC) model with collisions and nonzero velocity demonstrated that there was no clear transition between CL and MG when one region is considered. Practical devices may be manufactured imperfectly or degrade from long-term use, which can introduce a change of material across the gap. This necessitates the analysis of a multi-region structure and the electron emission laws that govern it. The work here extends previous analysis to a gap with two distinct regions varying in collision frequencies. The equations governing how electrons move after they are emitted into the first region are solved analytically to capture how material differences affect space charge limited current behavior. We recovered GSCLC from a single material gap and analyzed the trends for different types of materials in the two regions by performing an asymptotic analysis of various collision frequencies for the two regions. For a gap between two different regions, the spatially varying collision frequency will cause complexities in the solution for the SCLC. This work provides a deeper view on how electron emission is impacted by material inhomogeneities within one electrode gap.

Keywords:

Space Charge Limited Emissions; Child-Langmuir; Mott-Gurney

Mentor(s):

Cameron James Buerke (Engineering); Allison M Komrska (Engineering); Lorin Irene Breen (HHS); Allen L Garner (Engineering)

Other Acknowledgement(s):

David Matthew Czerwonky (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 2: 12:00-1:00pm

Designing a Compiler for a Heterogeneous Digital Compute-In-Memory Transformer Accelerator

STEM

Authors(s): Evelyn Colon†

Abstract:

Transformer models, as the backbone of Large Language Models (LLMs), have complex and energy-intensive computing requirements. Optimizing the efficiency and latency of Transformer AI hardware is essential for reducing costs, improving sustainability, and democratizing access to powerful LLM technology.

While previous research has yielded significant advances in computing-in-memory (CIM) technology to make running Transformer models more efficient with reduced data movement, these projects often lack a robust Instruction Set Architecture (ISA—the set of commands a processor can execute) and, critically, a compiler that allows programmers to execute high-level code (especially Python) on the CIM chips. This research aims to bridge the gap between high-level code and NanoX's innovative CIM chip by designing a compiler that translates high-level code into the chip's custom ISA.

The compiler development process began from a hardware-independent perspective. The first task was to write an application that breaks down a given transformer model into matrix computations. Next, the compiler must select which of these computations the chip can execute. Finally, the compiler will be developed from a low-level, hardware-specific perspective, translating the identified computations into commands that the chip can execute directly. The compiler's functionality will be verified by executing high-level instructions on the chip and analyzing the system's performance through metrics such as computational accuracy and latency.

Keywords:

Transformer; Computing-in-Memory; Artificial Intelligence; Accelerator; Compiler

Mentor(s):

Haitong Li (Engineering); Luqi Zheng (Engineering); Shuting Du (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
David Matthew Czerwonky (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

OpenMC-Based Analysis of Neutron Radiation Effects on Microcontrollers in lightweight NTP systems STEM

Authors(s): Ritveek Govardhanam†

Abstract:

Compact, lightweight nuclear thermal propulsion (NTP) systems have recently regained interest due to their potential to reduce travel time for deep space missions, particularly crewed missions to Mars. The latest iteration of the Miniature Reactor Engine (MITEE), MITEE-C, is a promising candidate for such applications. The updated core geometry aims to match the reactor criticality trends observed in validated Monte Carlo N-Particle simulation benchmarks, specifically the effective multiplication factor (Keff) as a function of pitch-to-diameter ratio. In the MITEE system, Proportional-Integral-Derivative (PID) microcontrollers used to rotate control drums during reactor startup and shutdown are vulnerable to radiation-induced failure in the high-flux environment near the core. To assess and mitigate this risk, a neutron transport simulation was conducted using the community-developed Monte Carlo neutron and photon transport code, OpenMC, to determine the reactivity worth associated with the number of control drum failures and to evaluate the spatial distribution of neutron flux in the vicinity of the MITEE-C reactor. The results provide Keff at various selected failure modes and will provide voxel-level tallies of radiation exposure, informing the probability of radiation effects and the safest optimal positioning of microcontrollers in NTP systems.

Kevwords:

Nuclear Thermal Propulsion; Microcontrollers; Radiation Hardening; Monte Carlo Simulations; Reactor Physics

Mentor(s):

Jonah Li Xuan Lau (Engineering); Stylianos Chatzidakis (Engineering)

Other Acknowledgement(s):

David Matthew Czerwonky (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

High Temperature Solders for Aerospace and Defense STEM

Authors(s):

Rachel Christine Quisil Ordiales† (Engineering); Diego Jimenez Rivera†; lan Strachan† (Engineering)

Abstract:

Lead (Pb)-based solders had traditionally been used in the microelectronics and defense industries due to their favorable melting temperatures, wettability, and low cost; however, as increasing studies highlight lead's detriment on public and environmental health as well as supranational legislation restricting the use of lead-based materials in electronics, industry and research shifted towards lead-free solders, with Sn-Ag-Cu and Sn-Bi alloys rising in prominence. Concerns over high melting temperatures in Sn-Ag-Cu-based alloys and high strain rate dependence on flow strength in Sn-Bi-based alloys with respect to modern microelectronic applications prompted research into higher order elemental additions to further improve material properties. While mechanical testing of SAC 305 (Sn-Ag-Cu based) shows that the alloy exhibits decreased strength when aged when compared to asreflow,?Innolot?(enhanced Sn-Aq-Cu based) contrastingly exhibits increased strength when aged. Such behaviors may be attributed to differences and evolution of microstructures during reflow and aging. This work seeks to link microstructure evolution to mechanical properties in these solders and improve performance through tailored aging heat treatments. CALPHAD simulations were conducted using Thermo-Calc(R) software to determine equilibrium phase fractions and precipitation behavior?and were compared to experimental results obtained from? Differential Scanning Calorimetry (DSC) and Scanning? Electron Microscopy (SEM) image analysis. This combination of thermal and microstructural analysis revealed microstructural evolution of the as-reflow structure and evolution of precipitates as a function of temperature and composition. The results of this and subsequent projects will ultimately contribute to a guide?for solder selection in aerospace and defense.

Keywords:

[no keywords provided]

Mentor(s):

Michael Titus (Engineering); Ching-Chien Chen (Engineering); Lijia Xie

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

(Engineering); John E Blendell (Engineering); David Bahr (Engineering); Ganesh Subbarayan (Engineering); Carol A Handwerker (Engineering)

Other Acknowledgement(s):
David Matthew Czerwonky (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Testing the capabilities of two-step absorption nanolithography for meta-lens structures

Authors(s): Evan E Tuckley†

Abstract:

Microscale 3D printing has many applications in biomedical, computer, aerospace, and other fields of engineering. It shows promise to produce a meta-lens, which is made of sub-diffraction sized pillars to manipulate light in a smaller volume than traditional curved lenses. We plan to use a method called two-step absorption which utilizes a nonlinear response in the printing materials to reach nanoscale accuracy. The current mainstream method is two-photon absorption that utilizes expensive femtosecond lasers. There is need for using a low-cost method in metalens construction. We seek to prove that two-step absorption is a feasible low-cost alternative to the two-photon method for the printing of a metalens. The quadratic nonlinearity utilized by two-step absorption allows for the necessary spatial accuracy to replace two photon absorption at multiple magnitudes smaller in space and price. To test this, we have created a resin using Benzil as a photo initiator and an acrylate monomer to create nano-pillar structures to prove potential use in a meta-lens constructure. Our system utilizes a continuous-wave 405-nm laser, with a working power of approximately 100 µW. Additionally, results of resolution size and pitch (spacing between pillars) were compared with the Nanoscribe system that utilizes two-photon absorption. We hope to find a similar feature size of about 100 nm laterally and 300 nm axially.

Keywords:

Nano Scale 3D Printing; Optics; Meta-Lens

Mentor(s):

Jinwoo Kim (Engineering); Venkata Kalyan Vadlamudi (Engineering)

Other Acknowledgement(s):

David Matthew Czerwonky (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Hybrid metamaterial designs with tunable physical properties via laser patterning

STEM

Authors(s): Jianing Xue†

Abstract:

[Abstract Redacted]

Keywords:

Metamaterials; TiN-Au; Laser Patterning; Vertically Aligned

Nanocomposites; Silicon Integration

Mentor(s):

Allison Nobuko Scher (Engineering); Claire Amelia Mihalko

(Engineering); Haiyan Wang (Engineering)

Other Acknowledgement(s):

Jialong Huang (Engineering); David Matthew Czerwonky (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Simulation of a Low-Power PLL for Clock Generation in SoC AFTx07+

STEM

Authors(s):

Chao Min Chung† (Engineering)

Abstract:

[Abstract Redacted]

Keywords:

Phase Loop Locker; PLL

Mentor(s):

Seyedehmarzieh Rouhani (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Reinforcement Learning Environment for Finding Counter-UAV Surveillance Strategies

STEM

Authors(s):

Connor Bradley Frey† (Science)

Abstract:

Unmanned Aerial Vehicles (UAVs) are becoming more widely used around the world for attacks against infrastructure. The use of a network of surveillance cameras allows for a simple and cost-effective method to prevent these attacks by using the cameras to spot the UAVs. Reinforcement learning is a method that can allow agents controlling the cameras to find the optimal policy for detecting UAVs. A way to simulate this is by developing a multi-agent reinforcement learning (MARL) environment. A MARL environment would allow each camera and UAV to be controlled by a separate agent which significantly reduces the size of the local action space for each agent. This reduced action space makes it easier for the agents to make decisions and can speed up the runtime when using parallel processing. The use of agents to simulate the attacker and defender is so that we can find the Nash equilibrium strategy such that when the defender employs this strategy the attacker will only have one combination actions that will not hurt their position. This MARL environment would further support research in reinforcement learning algorithms for counter-UAV surveillance.

Keywords:

[no keywords provided]

Mentor(s):

James Michael Goppert (Engineering); Jaehyeok Kim (Engineering); Kylie Sommer-Kohrt (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

10,000,000x Increase in Electrochemiluminescence Lifetime through Parasitic Pathway Suppression

STEM

Authors(s):

Daniel Michael Carrel† (Science)

Abstract:

[Abstract Redacted]

Keywords:

Electrochemiluminescence; Microscopy; Crystals; Radicals; Precipitation

Mentor(s):

Brady Robert Layman (Science); Megan Leigh Hill (Science); Jeffrey Edward Dick (Science)

Other Acknowledgement(s):

Andy Berbille (Science)

Presentation Time: Session 2: 12:00-1:00pm

Epithelial Membrane Disruption Drives Vaping-Induced Lung Injury

STEM

Authors(s):

Seth Crisologo Gozo†; Alexander Josef Shemen†

Abstract:

Introduction. E-cigarette use has surged dramatically, with over 2.25 million U.S. middle and high school students reporting usage in 2024 (CDC). Cases of e-cigarette or vaping-associated lung injury (EVALI) have highlighted immediate risks, however the chronic effects of vaping aerosols on lung epithelial cells remain poorly understood. This study investigates the dose- and time- dependent impacts of e-cigarette aerosol exposure on human lung epithelial cells (A549), focusing on cellular morphology, membrane integrity, and wound healing capacity.

Methods. Using in vitro models, A549 cells were exposed to varying concentrations of e-cigarette aerosol over different durations. Scratch assays were used to examine wound healing related to dose and time. Cell morphology was quantified using Image J software (NIH). Index ranges from 0 to 1; a value of 1 indicates a round shape, 0 indicates an elongated morphology. Cell membrane integrity was quantitatively analyzed by measuring cytosolic levels of lactate dehydrogenase (LDH) using CyQUANT LDH Assay (Invitrogen).

Results. Scratch assays revealed retarded wound healing in a doseand time-dependent manner, suggesting impaired regenerative capacity. Morphological analysis showed a loss of the classic cobblestone appearance of epithelial cells, quantified by a significant reduction in circularity index. Furthermore, LDH assays indicated epithelial membrane damage, with LDH release increasing proportionally to aerosol concentration and exposure time.

Conclusion. The observed cellular damage adds to mounting evidence that chronic exposure to e-cigarette aerosols compromises pulmonary health. This study underscores the urgent need for further research into the molecular mechanisms driving vaping-induced lung injury. Understanding these processes, is essential to public health policies and the development of targeted interventions to mitigate the adverse effects of chronic e-cigarette use.

Keywords:

E-Cigarette; Vaping; Epithelial Cells; Wound Healing; Lung

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Farai Colin Gombedza (Purdue Northwest)

Presentation Time: Session 2: 12:00-1:00pm

From Circuits to Code: Inspiring Young Minds with Microelectronics

STEM

Authors(s): Ediz Guzey†

Abstract:

Many K-12 students from rural schools lack access to resources such as materials and equipment needed to engage in quality STEM activities. Providing these students with opportunities to learn more about STEM can enhance their understanding of STEM concepts and increase their interest in pursuing STEM careers. Purdue University's Center for Advancing the Teaching and Learning of STEM (CATALYST) offers a no-cost, online STEM program for over five hundred upper elementary students each year. The program takes place twice annually. Professors and graduate students from Purdue design and deliver STEM activities in which elementary students design, build, and test simple robots or structures, write code, or construct models. In this poster, I share a new activity I developed to help 5th grade students learn about electronics, particularly microelectronics. Students first learn about circuits and conductors using simple circuit kits. They then use different materials to see which conduct electricity. Next, they are introduced to microelectronics and complete a basic coding activity using a micro:bit. Together, we program the micro:bit to display a random emotion icon and the students perform a matching movement. This hour-long activity will be implemented in the upcoming CATALYST program. Students will also complete a brief survey to share their ideas about the activity and learning of the concepts. This activity will be posted on the CATALYST website and will be adaptable for use in classrooms, after-school programs or summer school settings.

Keywords:

Microelectronics; Elementary Education

Mentor(s):

Siddika Selcen Guzey (Education)

Presentation Time: Session 2: 12:00-1:00pm

Post-Pandemic Cardiology: Exploring The Association Between History Of Covid-19 Infection And Cardiovascular Conditions

STEM

Authors(s):

Huu Tuan Kiet Hoang† (Tan Tao University)

Abstract:

Introduction

Recent studies showed a history of COVID-19 infection may increase the risk of various conditions. This study aims to investigate the impact of post-COVID-19 infection on several cardiovascular conditions.

Methods

A retrospective study was conducted including adult admissions from the National Inpatient Sample (NIS) database of 2020 and 2021, excluding cases with acute COVID-19 infection. Logistic regression models were meticulously designed to assess the relationship between post-COVID-19 and cardiovascular conditions, with adjustments for hospital-related variables, patient demographics, common comorbidities, and both the Charlson and Elixhauser Comorbidity indices. A refined statistical technique was utilized during the entire analysis process to implement propensity score matching and to preserve the survey-weighted structure of the NIS database.

Results

The study included matched cohorts of 926,669 admissions with a history of COVID-19 infection and 926,670 controls. The analysis revealed a significantly increased adjusted odds ratio (aOR) for myocarditis (aOR 5.90, 95% CI: 3.94-8.30, p<0.001), pulmonary embolism (aOR 1.89, 95% CI: 1.80-1.98, p<0.001), and venous thromboembolism (aOR 1.33, 95% CI: 1.27-1.39, p<0.001). There were modest increases in arrhythmia (aOR 1.07, 95% CI: 1.04-1.10, p<0.001) and pulmonary hypertension (aOR 1.07, 95% CI: 1.03-1.12, p=0.001). Notably, there was no significant change in the risk for acute ischemic heart disease (aOR 0.99, 95% CI: 0.95-1.02, p=0.419).

Conclusions

A history of COVID-19 infection was associated with significantly increased risks for myocarditis, pulmonary embolism, and venous thromboembolism. There were also modest elevations in the risks of arrhythmia and pulmonary hypertension. Intriguingly, no statistical association was found between a history of COVID-19 infection and the risk of acute ischemic heart disease.

Keywords:

COVID-19; Cardiovascular Conditions; Post-Pandemic Cardiology; Myocarditis; Pulmonary Embolism

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine); Loc Vu (Tan Tao University)

Presentation Time: Session 2: 12:00-1:00pm

Combined Microbial Fuel Cell–Hydroponic System for Renewable Energy Generation and Wastewater Treatment

Authors(s):

Nachiket Magesh† (Engineering|JMHC)

Abstract:

As the global population grows at a rapid rate, the need for effective wastewater management and food production has become increasingly urgent. Conventional treatment processes are energy-intensive. increasing the demand for fossil fuels that produce greenhouse gases (GHGs). Mainstream agriculture is contingent on seasonal weather patterns and also strains water-scarce regions. Microbial Fuel Cells (MFCs) offer promising advantages by simultaneously treating wastewater and producing renewable electricity. In this study, a combined MFC – hydroponic system treats municipal wastewater from the Portage Treatment Plant (Indiana) in the anode chamber via an energy-positive process while supporting lettuce growth in the cathode chamber. This is compared to a standard MFC with an air cathode. Both employ 1000-ohm resistors, cation exchange membranes (CEMs), and distilled water and wastewater as catholyte and anolyte, respectively. Plant growth in the integrated design is monitored and compared to a traditional hydroponic setup. Coulombic efficiency, chemical oxygen demand (COD) and total nitrogen removal efficiency, and power generation of both configurations are evaluated. Additionally, nutrient transport pathways across the membrane are analyzed. The findings of this study provide insights into the potential of MFCs for both wastewater treatment plants and agricultural settings in a circular economy framework.

Keywords:

Microbial Fuel Cell; Wastewater Treatment; Hydroponics; Renewable Energy; Nutrient Removal

Mentor(s):

Veera Gnaneswar Gude (Purdue Northwest)

Other Acknowledgement(s):

Khin Thandar Tun (Purdue Northwest)

Presentation Time: Session 2: 12:00-1:00pm

Superior of Arterial Phase Frame Count in Quantifying the Restoration of Coronary Blood Flow of the Right Coronary Artery in Acute Coronary Syndrome by a Dynamic Angiography and Machine Learning Analy STEM

Authors(s):

Duong Hoang Anh Nguyen† (Tan Tao University)

Abstract: Background

In percutaneous coronary intervention (PCI), the Thrombolysis in Myocardial Infarction (TIMI) Myocardial frame count (TMFC) is frequently used to estimate coronary flow and assess post-PCI restoration. However, it is dependent on the contrast injection force. Hence, how can we quantify the coronary flow in an independent, realistic situation?

Methods

Patients with acute coronary syndrome (ACS) and a single lesion were selected and compared to a control group having non-significant coronary lesions, a normal ejection fraction, and no valvular disease. Angiographic recording began with contrast injection and continued until all contrast was flushed from the arteries. The arterial phase (AP) was calculated from the start of blood movement until the contrast cleared the distal arterial vasculature. Meanwhile, machine learning (ML) models were built based on an architecture combining U-net and Densenet-121. A segmentation model was then used to identify the AP's starting frame (with complete contrast) and ending frame (without contrast).

Results

The study included 30 cases (10 from the control group) with a mean age of 64.4±12 years (24 males). In the control group, the AP was 25±2.6 frames compared with 33±3.3 frames for the study group before they underwent PCI (p<0.05). After PCI, the AP was restored to 25.3±2.4 frames. The ML model was successfully developed with a root mean square error 5.4.

Conclusion

The AP calculated by the dynamic angiogram review technique is a potential marker for evaluating coronary flow and restoration besides the TMFC.

Keywords:

Acute Coronary Syndrome; Percutaneous Coronary Intervention; Thrombolysis; Myocardial Infarction; Machine Learning

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine); Loc Vu (Tan Tao University)

Presentation Time: Session 2: 12:00-1:00pm

The correlation between osmotic adjustment and yield stability in drought-stressed corn (Zea mays L.)

STEM

Authors(s):

William Lee Patton† (Agriculture|JMHC)

Abstract:

[Abstract Redacted]

Keywords:

[no keywords provided]

Mentor(s):

Michael V Mickelbart (Agriculture)

Other Acknowledgement(s):

Emily Spray (Agriculture)

Presentation Time: Session 2: 12:00-1:00pm

Three Months Follow-up Patients After Acute Coronary Syndrome

STEM

Authors(s):

Dang Pham† (Tan Tao University)

Abstract:

Background:

With improved quality of life, Vietnam's life expectancy has increased to 75.38 years (World Bank, 2020). Consequently, the national disease burden is shifting from infectious diseases to cardiovascular and metabolic disorders, particularly atherosclerotic cardiovascular disease. Managing acute coronary syndrome (ACS) in elderly patients presents growing clinical challenges. This study evaluated the presentation, treatment strategies, and short-term outcomes of ACS in older adults at a geriatric center in Vietnam.

Methods:

A prospective study was conducted at a single center, enrolling 90 elderly patients diagnosed with ACS. Upon admission, all patients underwent comprehensive assessments, including electrocardiography (ECG), Killip classification, GRACE score, cardiac biomarkers, lipid profile, and echocardiography. Treatment decisions were made through multidisciplinary consultation with patient and family involvement. Data on demographics, past medical history, management strategy, laboratory results, and length of hospital stay were recorded. All patients were followed for three months post-discharge.

Results:

Among 90 patients (mean age 75.2 \pm 7.7 years; 51 males), 40 had ST-elevation myocardial infarction (STEMI) and 50 had non-STEMI. Inferior infarction was observed in 21 STEMI cases, anterior in 17. Primary percutaneous coronary intervention (PCI) was performed in 55 patients—90% of STEMI and 34.5% of non-STEMI patients (p < 0.05). Patients with left main disease had longer hospital stays (13.7 vs. 10.6 days; p < 0.001). At discharge, 9 patients had heart failure with reduced or mildly reduced ejection fraction. All were clinically stable at three-month follow-up.

Conclusion:

Personalized, multidisciplinary care enables effective short-term management of ACS in elderly Vietnamese patients. Further research is warranted to assess long-term outcomes.

Keywords:

Acute Coronary Syndrome; Geriatric; Echocardiography; Long-Term Outcomes

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine); Loc Vu (Tan Tao University)

Presentation Time: Session 2: 12:00-1:00pm

Development of Particle-Jet-Based Calibrations for Diffuse Back-Illumination Extinction Imaging

STEM

Authors(s):

Yash Ajay Shah† (Engineering|JMHC)

Abstract:

Diffuse Back-Illumination Extinction Imaging (DBI-EI) has emerged as a promising technique for concentration measurements due to its resilience to beam-steering and its compatibility with harsh flow environments. However, quantitative interpretation of results is hindered by the current lack of comprehensive studies comparing measurement accuracy under well-controlled illumination and collection conditions, as well as across a range of known particle concentrations. This work aims to assess the performance of DBI-EI using both collimated and diffuse illumination schemes, with a particular focus on quantifying extinction across a range of particle loadings. Extinction measurements will be acquired under controlled conditions using silicon dioxide (SiO2) particles with known size distributions, measured by a Malvern Mastersizer 3000, enabling precise comparison between theoretical predictions and experimental results. Through this work, we aim to determine the variance in measured line-of-sight optical depth associated with particle field conditions. Ultimately, this study will support the development of calibrated, high-speed extinction diagnostics for application in transient, harsh, and optically challenging environments such as spray combustion and post-detonation fireballs.

Keywords:

[no keywords provided]

Mentor(s):

Daniel Robert Guildenbecher (Engineering)

Other Acknowledgement(s):

Cohen Thomas Ves Nunes (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Principles of Fluid Mechanics Applied to Dynamic Angiography in the Investigation of Cavitation in Coronary Arteries - New Discoveries and Perspectives

STEM

Authors(s):

Jacob Christophe Sues†; Sarah Louise Sues†

Abstract:

Purpose: Investigators have long been puzzled by the mystery of what initiates plague formation and then the development of coronary artery disease (CAD), a disease in which there is a narrowing or blockage of the coronary arteries. Coronary arteries have turns and ostia where plagues seem to form, yet peripheral vessels only develop plagues near ostia. In the heating and air conditioning industry (HVAC), similar damage to the inner coating of pipes is observed near bends and pumps. This is termed Cavitation Phenomenon. This investigation applied the principles of fluid dynamics from the HVAC industry to the blood flow in coronary arteries to explore the origin of CAD.

Methods: Approval was obtained from the hospital Internal Review Board. Patient consent was obtained. Coronary angiograms (CAGs) of 200 patients with stable CAD were selected and de-identified. CAGs were analyzed using the novel technique of dynamic coronary angiography and observing the flow of contrast media against background blood flow.

Results: Laminar flow was characterized by organized fluid layers with steady velocity and minimal/absent boundary layers in areas lacking plague development. Lesions were seen in areas of turbulent flow (near ostia): helical flow (at curves) and collision lines (areas of water hammer shock). In patients with anatomy restoration, CAD failed to worsen.

Conclusion: The results suggest that damage to the intima occurs from separation flow that becomes turbulent leading to Cavitation Phenomenon. This approach allows for mechanistic explanation of lesion formation and growth. These data bring a provocative new approach not only to the identification and prediction of lesion formation, but also to possible restorative interventions that might prevent or minimize lesion formation in what could be revolutionary in interventional cardiology.

Keywords:

Cavitation; Coronary Arteries; Fluid Dynamics; Water Hammer Shock;

Coronary Angiography

Mentor(s):

Ernest Francis Talarico (Purdue Northwest)

Presentation Time: Session 2: 12:00-1:00pm

Origins of Second Harmonic Generation Circular Dichroism / Circular Intensity Difference (SHG-CD) Microscopy STEM

Authors(s):

Declan Harrison Vasil† (Science); Alexander Higgins* (Science|JMHC)

Abstract:

Chirality, or the inability of an object to be superimposed onto its mirror image, is a key property in the characterization of many molecules and biological systems. However, traditional methods of chiral characterization have suffered from poor signal-to-noise ratios and low spatial resolution. Second Harmonic Generation Circular Dichroism (SHG-CD) offers up to three orders of magnitude increased sensitivity in chiral measurements over conventional absorbance circular dichroism and works label-free in both chiral structures and disordered media. Many different factors can contribute to SHG-CD based on physical conditions, and based on these conditions, many different models have been proposed to describe various contributions to SHG-CD. This research focuses on the collection of these models, as well as the proposal of new theoretical structures, in order to provide a comprehensive framework for the determination of dominant driving interactions and quantitative evaluation.

Keywords:

Second Harmonic Generation; Circular Dichroism; Linear Birefringence; Hyper-Rayleigh Scattering; Nonlinear Optics

Mentor(s):

Garth J Simpson (Science)

Presentation Time: Session 2: 12:00-1:00pm

Impact of Body Mass Index on Clinical Outcomes of Myocardial Infarction in Elderly Vietnamese Patients STEM

Authors(s): Cao Danh Vo†

Abstract:

Background:
Vietnam has exper

Vietnam has experienced remarkable socioeconomic growth, with GDP rising from \$31.2 billion (2000) to \$410 billion (2022), and life expectancy reaching 75 years. However, the Healthy Life Expectancy (HALE) remains at 65.4 years, with ischemic heart disease and diabetes now ranked second and fifth, respectively, among leading causes of death. Concurrently, obesity is rising, with adult BMI ?30 kg/m² increasing from 0.3% (2000) to 2.02% (2021). These trends present new challenges in managing acute coronary syndrome (ACS), particularly in elderly patients with comorbidities. This study aimed to compare clinical outcomes of myocardial infarction (MI) in elderly patients by BMI status.

Methods:

A prospective study was conducted from June to December 2023 on patients aged ?65 years diagnosed with MI. Patients were evaluated based on 2021 AHA/ACC/ASE/SCMR guidelines. Data collected included demographics, clinical history, comorbidities, ACS type (STEMI/Non-STEMI), revascularization strategy, echocardiographic findings, and discharge prescriptions. Patients were stratified into normal BMI (18.5 - 24.9) and overweight (?25) groups.

Results:

A total of 135 patients (mean age 74.0 \pm 7.4 years; 52 males) were included. STEMI occurred in 71 patients, and 117 underwent PCI. The overweight group had significantly shorter hospital stays (7.4 \pm 5.0 vs. 9.3 \pm 4.5 days; p = 0.023) but lower LVEF (49.4 \pm 13.5% vs. 54.5 \pm 12.5%; p = 0.026) and higher rates of heart failure (p = 0.03). Killip class on admission correlated with heart failure at discharge.

Conclusion:

Overweight elderly MI patients had higher heart failure incidence, but shorter hospital stays, suggesting nutritional and physiological status

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

may influence recovery and outcomes. Further investigation is warranted.

Keywords:

Body Mass Index; Myocardial Infarction; Clinical Outcomes

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine); Loc Vu (Tan Tao University)

Presentation Time: Session 2: 12:00-1:00pm

No Glovebox? No Problem. Accessing Hypoxic Electroanalysis Using Dense Gases in a Fish Tank STEM

Authors(s):

Amber K Wang† (Science)

Abstract:

For many years, traditional deoxygenation methods, including gloveboxes and inert gas purging systems, have been essential for airand moisture-sensitive electroanalysis. These techniques have offered opportunities to make discoveries in systems that are not naturally accessible in ambient conditions. However, these methods are costly, require diligent maintenance, and pose contamination risks that limit accessibility. Here, we propose an alternative and cost-effective approach to creating and maintaining a hypoxic environment for electroanalysis by taking electrochemical measurements in a fish tank filled with a dense gas blanket. Sulfur hexafluoride (SF6), butane, and argon gases were investigated by collecting a series of cyclic voltammograms to study the oxygen reduction reaction over an extended period under a blanket of each gas. We show that the oxygen reduction reaction peak returns significantly slower in the presence of SF6 than in systems with less dense gases like argon or butane. Our results support the effective use of a dense gas blanket to prevent atmospheric oxygen diffusion, conserving hypoxic conditions suitable for oxygen-sensitive electroanalysis that mitigate the need for costly equipment.

Keywords:

Hypoxic Environment; Electroanalysis; Sulfur Hexafluoride; Cyclic Voltammetry; Fish Tank

Mentor(s):

Patrick James Herchenbach (Science); Jeffrey Edward Dick (Science)

Other Acknowledgement(s):

Presentation Time: Session 2: 12:00-1:00pm

A Case of Jimson Weed Poisoning in a 15-Year-Old Boy STEM

Authors(s):

Mateusz Wlodarczyk†; Dhruva Magesh†

Abstract:

Purpose: Jimson Weed (Datura stramonium) is a poisonous flowering plant in the Daturae tribe of the nightshade family Solanaceae. It has become widely naturalized as a wild herb across most warm and temperate regions worldwide. All parts of Datura plants contain dangerous levels of the tropane alkaloids, classified as deliriants or anticholinergics. This study investigates the neurophysiology of Jimson Weed poisoning in a boy secondary to deliberate ingestion.

Methods: A 15-year-old boy was brought to the ED by his mother, who said he may have ingested a wild plant. He demonstrated bizarre behavior, mumbling and hallucinations. Vital Signs (VS) were obtained, and Physical Examination (PE), Neurological Examination (NE) and laboratory workups were done. Appropriate medical management was given.

Results: VS were T 37.2°C (98.9°F), BP 117/72 mm Hg, HR 103/min, and RR 24/min. PE demonstrated that he was awake, alert, but restless with agnosia. Mucous membranes were dry, and bowel sounds were decreased. Pupils were dilated, symmetric, and minimally reactive to light, but NE was otherwise within normal limits. Blood glucose, complete blood count, chemistry panel, and urinalysis were normal. Rapid toxicology screen was negative for alcohol and common psychoactive drugs. The plant specimen was positively identified as Datura stramonium. The patient suffered from depression of the parasympathetic nervous system involving cranial autonomic ganglia and enteric ganglia of the gastrointestinal (GI) tract.

Conclusion: Jimson Weed is a plant best known among adolescents and young adults for its hallucinogenic properties. The active ingredient in Jimson weed is a cholinergic blocker acting at synapses between autonomic neurons and target organs. Understanding and recognizing the classic signs and symptoms of anticholinergic intoxication can help clinicians evaluate patients presenting with Jimson Weed poisoning resulting in rapid life-saving treatment with physostigmine.

Keywords:

Jimson Weed; Sympathetic Nervous System; Toxicology; Neurology; Anticholinergic

Mentor(s):

Ernest Francis Talarico (Purdue Northwest)

Presentation Time: Session 2: 12:00-1:00pm

Traction Force Microscopy to Study Mechanosensing of Neuronal Growth Cones

STEM

Authors(s):

Gaurangi Yadav† (Science|JMHC)

Abstract:

The neuronal growth cone is a highly motile structure that aids growing axons by mechanically and chemically sensing the environment that the neuron is growing in and guiding the axons towards favorable conditions. Growth cones also aid neuronal outgrowth by generating traction forces via substrate-cytoskeletal coupling and actin filament retrograde flow. Previous literature has shown that growth cones from central nervous system (CNS) neurons and peripheral nervous system (PNS) neurons have different preferences for substrate stiffness and subsequently, generate different traction forces. However, the relationship of traction forces and neurite growth on substrates of different stiffness is not fully understood.

In this project, in order to further understand the mechanisms of mechanosensing during adhesion-mediated growth cone advance on substrates of preferred stiffness, we cultured Aplysia Californica bag cell neurons, on polyacrylamide hydrogels of preferred stiffness. We performed traction microscopy, where we used the displacement of fluorescent beads in the hydrogels to quantify the traction force as well as the stress fields generated by the growth cones. Currently, we are working on the analysis of the images in order to calculate these traction forces and stress fields generated by the growth cones on hydrogels of different stiffness. We hope that this work will provide a better understanding of the mechanosensing by neuronal growth cones.

Keywords:

Traction Force Microscopy; Fluorescent Bead Microscopy; Growth Cone; Mechanosensing; Neuronal Development

Mentor(s):

Daniel Suter (Science); Laura Pulido Cifuentes (Science)

Presentation Time: Session 2: 12:00-1:00pm

Investigations of Proton-Coupled Electron Transfer in Uranium-Nitrogen Complexes

STEM

Authors(s):

Tate Michael Quinn† (Science)

Abstract:

Proton-coupled electron transfer (PCET) is an important fundamental process in biological systems utilized in energy production, oxygen formation, as well as various other enzymatic functions. Beyond biological systems, synthetic chemists have long attempted to mimic this strategy for chemical transformations including water and ammonia oxidation, both for applications in clean energy as well as creating reactive species which can initiate challenging chemical reactions. In the field of molecular inorganic chemistry, transition metals have been heavily studied in their ability to facilitate PCET reactions. In contrast, research regarding the ability of actinides to facilitate similar PCET reactivity has been underdeveloped.

Our lab has demonstrated the ability for uranium(III) anilido complexes to undergo PCET to form uranium(IV) imido complexes utilizing an oxidant and a base. Further work from our lab showed the ability to undergo similar reactivity with net Hydrogen Atom Transfer (HAT) reagents. The presented work highlights the ability of various uranium(III) anilido complexes of differing electronic character, to undergo PCET reactions to form their respective uranium(IV) imido complexes. Additionally, current work shows progress towards synthesizing an ammonia-derived uranium(IV) parent imido, and even maybe an elusive uranium(V) nitrido, using traditional HAT reagents. By exploring the PCET chemistry of these species, we have been able to observe a significant metal-induced bond weakening effect determined through evaluation of the bond dissociation free energies (BDFE) of the respective N–H bonds.

Keywords:

Inorganic Chemistry; Actinide; PCET; Uranium

Mentor(s):

Suzanne C Doucette (Science); Ivan Jacob Huerfano (Science)

Presentation Time: Session 2: 12:00-1:00pm

PREVIEW: Purdue Rocket Experimental Video in Educational Work

STEM

Authors(s):

Thendral Kamal† (Engineering); Kevin Patrick Corrigan† (Engineering); Haoyu Zhang† (Engineering)

Abstract:

PREVIEW is a student-led project to develop an onboard video payload for hypersonic flight, aimed at capturing high-resolution footage of rocket exterior surface conditions during extreme thermal and aerodynamic loading. In collaboration with Pluto Aerospace and an external manufacturing client, the payload is integrated into a system designed to withstand relevant hypersonic conditions and support the visual evaluation of material behavior and surface finish response in flight.

Designed, built, and tested by students over two semesters, PREVIEW features a custom-machined aluminum wedge test section housing a Raspberry Pi Zero microcontroller, a high-speed Pi Camera Module 3, and sensors monitoring pressure and acceleration. Over Summer 2025, our team led end-to-end testing of all flight electronics, including breadboard prototyping, sensor calibration, power validation, and system-level integration. We simulated expected flight conditions to evaluate robustness during launch. Alongside these efforts, we finalized the circuit layout and completed the full CAD model, with flight hardware currently in production. The payload is scheduled for launch in late August 2025.

PREVIEW will demonstrate the viability of compact, student-engineered payloads for high-speed data collection. The successful integration of video capture and sensor systems will provide valuable insights into the effects of hypersonic flight on surface finishes. The PREVIEW platform also offers a cost-effective model for integrating diagnostic payloads into commercial and experimental flights, supporting materials testing and accelerating innovation in thermal protection systems across the aerospace industry.

Keywords:

Hypersonic Flight Testing; Rocket Payload Design; Flight Electronics Testing; Thermal and Structural Flight Testing; Aerospace Instrumentation

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Mentor(s): Steven H Collicott (Engineering); Christopher D Nilsen (Engineering); Monish Mahesh Lokhande (Engineering)

Other Acknowledgement(s): Adarsh Agrawal (Engineering)

Presentation Time: Session 2: 12:00-1:00pm

Vision Transformers for Style Classification STEM

Authors(s):

Aryan Shahu† (Science); Alzahraa Ahmed† (Engineering); Aarsh Nishant Dave‡ (Engineering)

Abstract:

The purpose of this study is to find better ways to test and improve image classification accuracy with different image styles (ink wash, oil paint, water paint). Our work aims to create a tool that is an evaluation framework for image generation models. This tool is meant to analyze various image generation models and benchmark them based on various image accuracy criteria. One of these criteria is the image style, which have been broken up into three specific styles: ink wash, oil paint, and water paint. The purpose of this sub-team is to increase the accuracy at which the image classification model categorizes generated images. We are working on testing generative models (text to image) and evaluating its performance through quantitative metrics. Current generative models still fail to respond to complicated prompts and could deliver inaccurate results. Our goal is to reach a better accuracy in predicting the performance of these models by applying multiple methods such as hyper parameter optimization. Also, we are planning on using other versions of the Vision Transformer. One version we already applied is Compact Convolutional Transformer and we are aiming to apply more models. Another idea to improve the accuracy is to use more training data. After applying the Compact Convolutional Transformer, we were able to get 93% total accuracy. We aim for a better accuracy after applying the other methods discussed in this research.

Keywords:

Vision Transformer; Style Classification; Compact Convolutional Transformer; Hyper Parameter Optimization; Model Accuracy

Mentor(s):

Yung-Hsiang Lu (Engineering); Le Mao (Engineering); Zihao Ye (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Symplectic Geometry: A Bridge between Classical Mechanics and Modern Field Theories

STEM

Authors(s):

Diana Carolina Camargo Barajas†

Abstract:

In classical physics, many systems can be better understood through a geometric perspective. In this approach, the phase space-which describes all possible positions and velocities of a system-is modeled using structures called Lagrangian submanifolds. These are special regions where a key geometric property of the system-the symplectic form-vanishes. This form encodes the coupling between positions and momenta, so its vanishing implies there is no Hamiltonian evolution within these regions. As a result, they can be interpreted as stationary configurations, or time-independent states, within the framework of classical dynamics.

Graphs of closed 1-forms, which can be visualized as geometric surfaces, are key examples of Lagrangian submanifolds. These graphs can often be generated locally by symplectomorphisms-transformations that preserve the symplectic structure of the system. This construction connects naturally with the Hamilton-Jacobi formulation, one of the most powerful methods in classical mechanics. In this setting, one seeks a generating function-namely, the action-whose differential defines a Lagrangian submanifold. Solving the Hamilton-Jacobi equation thus amounts to finding a surface along which the system evolves without deviation, reducing the dynamics to direct integration.

This geometric framework not only clarifies the behavior of conservative systems but also reveals underlying structures that hint at broader theoretical landscapes. By studying critical points through Morse theory, one begins to see how certain mathematical patterns-initially grounded in classical dynamics-can evolve into the kind of structures that later appear in modern approaches such as topological quantum field theory (TQFT).

Keywords:

Symplectic Geometry; Lagrangian Submanifolds; Hamilton–Jacobi Theory; Morse Theory; Topological Quantum Field Theory (TQFT)

Mentor(s): Manuel Luis Rivera (Science)

Presentation Time: Session 3: 1:30-2:30pm

Is there a more effective design for quadrat to increase ease of use and vegetation density?

STEM

Authors(s):

Scott Michael Burke† (Engineering); Faith Elizabeth McPhee* (Science); Sierra Hunnicutt* (Science|JMHC); Keith Kiragon Moreno* (Agriculture|JMHC)

Abstract:

Quadrats are a special tool in the ecology field that allows the measurement of vegetation density for further data analysis of a habitat. The larger the quadrat cross-sectional area, the better the results of the data, which in turn can make the quadrat hard to carry through the field. In wildlife corridor research, quadrat surveys provide a quantitative metric for habitat suitability. In this work, we consider the efficiency and ease-of-use benefits for field work in the design of a collapsible version of a quadrat using a House of Quality (standard metric for new design requirements) to assess the customer and engineering requirements along with benchmark and patented designs. Using SolidWorks (a CAD software), we constructed a minimum viable product for a small-scale, single prototype creation with bill of materials for lab scalability. The aim of the new design is that it can be utilized by other research groups across the country. Future enhancements for this design could automate the vegetation density calculation by combining the physical guadrat with software from a photo taken at the site. The precision of density calculation can be improved by creating smaller cross-sectional areas of webbing on the detachable net. We will create a House of Quality that will help measure our design requirements, assess customer satisfaction through surveying, and compare old to pilot product effectiveness through time trials and botanist evaluation. We predict that this design will prove more effective saving time as well as measuring vegetation with an increase in customer happiness.

Keywords:

Quadrat; Design; Corridor Ecology

Mentor(s):

Kristen Marie Bellisario (JMHC)

Presentation Time: Session 3: 1:30-2:30pm

Unveiling Food Waste Patterns at Purdue University

Social Science

Authors(s):

Katherine Sophia Chiparus† (Science)

Abstract:

Ever wondered how much food waste is generated at Purdue University—or how we compare to other Big Ten schools? This project aims to both evaluate existing practices and behaviors across major universities, and administer a survey to collect data on Purdue's campus. Al-assisted photo deconstruction and demographic data collection is used to analyze Purdue's food waste composition and behavior patterns. Concurrently, a comparative analysis of food waste strategies - including categorization of effectiveness, reach, and transparency of waste management efforts while focusing on composting, diversion programs, and dining hall operations - across Big Ten institutions was conducted. To date, the project has consisted of gaining survey approval and report compilation. Future goals include deploying the survey once approved and applying insights from both facets of this project to reduce Purdue's environmental footprint through improved food waste handling and policy recommendations.

Keywords:

Food Waste; Survey

Mentor(s):

Abigail Engelberth (Engineering); Valentina Negri (Centers & Institutes)

Other Acknowledgement(s):

Louis Tay (HHS)

Presentation Time: Session 3: 1:30-2:30pm

Methodology for Environmental Toxicology: Assessing Feeding and Rearing Strategies in Largemouth Bass (Micropterus nigricans) Larvae

STEM

Authors(s):

Amber Grace Hitchins† (Science|JMHC)

Abstract:

Poly- and perfluoroalkyl substances (PFAS) are an anthropogenic group of chemicals known for their persistence in the environment and their potential to bioaccumulate. PFAS can bioaccumulate in largemouth bass (Micropterus nigricans), yet the effects of exposure on bass larvae are unknown. While largemouth bass are commonly raised for aquaculture, techniques for rearing bass which enable controlled experiments at known densities, a necessity for toxicity studies, are poorly understood. Furthermore, the live prey typically used in existing approaches are not suitable for PFAS studies due to high background concentrations. The objective of this project was to assess different venues (indoors vs. outdoors) and feeding regimes to determine how to raise healthy larvae conducive to PFAS exposure studies.

Four treatment groups were used to determine the success of different combinations of venue and food: (1) indoor tanks with live zooplankton only, (2) indoor tanks with zooplankton and powdered Otohime A fish food, (3) outdoor tanks with a single zooplankton addition, and (4) outdoor tanks with zooplankton replenished daily. Live zooplankton samples were collected from the treatment groups and analyzed under a microscope to assess community composition, relative abundance, and to classify them by size. Larval survival, growth, and body condition were assessed with respect to observed densities of zooplankton across treatments.

Ongoing analyses will evaluate which practices maximized performance and the importance of food availability as a driver of these differences. By linking rearing approaches to larval success, this study will enable PFAS exposure studies with reliable and meaningful results.

Keywords:

Ecotoxicology; Largemouth Bass; Larval Survival; PFAS; Zooplankton

Mentor(s):

Tyler D Hoskins (Agriculture); Maria Soledad Sepulveda (Agriculture); Andrew Charles Todd (Interdisciplinary & Special Programs)

Other Acknowledgement(s):

Deise Cruz Santos (Agriculture); Hannah Casey McNeese (Agriculture)

Presentation Time: Session 3: 1:30-2:30pm

Al assisted Electromechanical Impedance for Civil Infrastructure Monitoring

STEM

Authors(s):

Xiangrui Kong† (Engineering)

Abstract:

This research aims to develop a non-destructive method for monitoring and predicting the strength of mortar during the curing process, which is crucial for ensuring structural safety and quality in civil infrastructure projects.

The experimental approach utilizes ultrasound testing, piezoelectric impedance sensors (PZT sensors), and machine learning techniques. The PZT sensors detect changes in electromechanical impedance that correspond to the evolving mechanical properties of the mortar. Simultaneously, ultrasound testing captures internal microstructure that reflects material integrity. Al models were trained to analyze the PZT sensor data and estimate mortar strength continuously throughout the curing process.

The developed models demonstrated decent predictive performance, showing high correlation with standard compressive strength tests across various curing durations and mixture designs.

This method has significant implications for the construction industry, enabling continuous and real-time strength monitoring. It reduces reliance on traditional destructive testing and supports more informed decision-making during the construction process. The integration of smart sensing and AI has the potential to enhance quality control, safety, and efficiency on future job sites.

Keywords:

PZT Sensor; Electromechanical Impedance(EMI); Strength; Air-Entraining

Mentor(s):

Rui He (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

How do acoustic indices serve as proxy of temperate forests and in relation to presence of bobcat (Lynx rufus) in central Indiana habitats

STEM

Authors(s):

Faith Elizabeth McPhee† (Science); Scott Michael Burke* (Engineering); Keith Kiragon Moreno* (Agriculture|JMHC); Yitian Zhu* (Science)

Abstract:

Central Indiana is largely dominated by agriculture which has led to numerous historical extirpations of mammals. The bobcat (Lynx rufus) is slowly re-establishing across northern Indiana after near extirpation in the early 1900s and utilizes corridors similar to extirpated mammals. Bobcats as a focal species can serve as an indicator for habitat quality for future designated wildlife corridors. New metrics have emerged from species monitoring through remote sensing technologies such as ecoacoustic indices which summarize sound profiles, are a potential proxy for biodiversity, and could be utilized in monitoring large mammals. Here, we investigate the relationship between Lynx rufu ?and acoustic indices in Indiana temperate forests. We deployed camera traps and acoustic recording units (ARUs) from May to July 2025 (n=9) to supplement collected data from 2023 to 2025 (n=24), collected habitat quality metrics using densiometers in a 30m grid, and computed distance metrics from sites to landscape features (e.g., water, human settlement, cropland). Then, from ARU recordings, we computed acoustic indices and created a bobcat prey presence ordinal scale. We ran non-parametric correlations (Spearman's Rank, Kendall's Tau) and Poisson regression to test the relationship between generated species and acoustic indices by daily mean. Then, we ran a distance-based redundancy analysis between bobcat presence and prey presence, habitat metrics, and highly ranked acoustic indices. We found that highly ranked acoustic indices had significant habitat metrics that represent bobcat habitat suitability. It is important to continue researching bobcats to understand how habitat suitability in wildlife corridors can be effectively indicated by acoustic indices.

Keywords:

Bobcat; Ecology; Corridor

Mentor(s):

Kristen Marie Bellisario (JMHC)

† Presenting Undergrad Author; † Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 3: 1:30-2:30pm

Application of Physics-Informed Neural Networks on crop yield prediction at multiple scales

STEM

Authors(s):

Aditya Pandurang Prabhu† (Engineering)

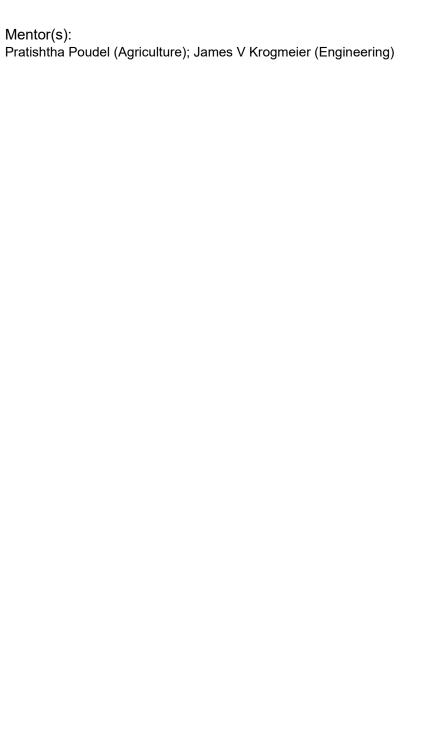
Abstract:

Accurately predicting crop yields is a critical challenge in sustainable agriculture, food security, and farm management. Traditional processbased models rely on agronomic domain knowledge, crop physiology and statistical approaches, while purely data-driven approaches leverage machine learning or deep learning models using meteorological and spatial data. Unfortunately, these black-box models(Data-drive approaches) often lack interpretability and fail to incorporate wellestablished physical principles. This project explores a hybrid approach by implementing Physics Informed Neural Networks, mainly, physicsbased recurrent neural networks (PI-RNNs) for time-series yield prediction. PINNs allow for the integration of scientific knowledge directly into the model by embedding physical laws as constraints in the loss function. This enables the network to learn from both data and domainspecific rules, improving generalizability and interpretability. In this study, we apply PINNs to predict winter wheat yield in the states of Kansas and Oklahoma. This is done by utilizing meteorological data, and remote sensing input taken from the Cybench dataset and AgERA-5 datasets. We attempt to mainly utilize Harvest Index, and Radiation use efficiency and constrain them in physical ranges obtained by previous domain knowledge. Furthermore, we penalize the machine learning model based on both a data loss and a physics based loss, which is calculated by the distance between the constrained variables and its set range decided based on domain knowledge. By combining these insights with machine learning, this research aims to apply a more reliable, interpretable, and scientifically grounded yield prediction framework. Future work in this area would involve trying to apply similar techniques to more complex models, including time-series transformers or applying established Differential Equations to ML algorithms and utilizing a similar loss scheme.

Keywords:

Physics Informed Neural Networks; Crop Yield Prediction; Meteorological and Spatial Data; Explainability and Interpretability

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment



Presentation Time: Session 3: 1:30-2:30pm

Al-Based Walkability Ecosystem: A Personalized, Social and Adaptive Solution to Urban Mobility and Public Health

Authors(s): Diya Singh† (Science)

Abstract:

Urban environments pose significant barriers to physical activity and public health, often due to a lack of motivation, insufficient adaptability to environmental factors, the uniformity of features in existing fitness apps, and limited opportunities for meaningful interpersonal interaction. This project proposes an Al-powered Walkability Assistant — a mobile application designed to foster healthier, more active lifestyles by addressing these challenges through personalized, adaptive, and community-oriented solutions.

This project adopts two research methods—text mining and open-ended surveys—to identify latent user needs and areas for improvement in walkability applications. We conducted large-scale text mining and analyzed over two million user reviews from 26 leading walking and fitness apps using Latent Dirichlet Allocation (LDA) topic modeling. This analysis revealed seven core themes in user review: gamification and incentives, general satisfaction, device sync and technical issues, motivation and activity tracking, features and integration, fun and social play, and support and troubleshooting. In addition, the ongoing results from the open-ended survey are expected to offer deeper qualitative insights that cannot be captured through large-scale data alone.

Building on these findings, the proposed prototype incorporates personalized route recommendations, real-time adaptation to environmental conditions, and gamified incentives to sustain user engagement. The Walkability Assistant aims to reduce sedentary behavior, enhance physical and mental well-being, and build inclusive urban communities through features that adapt dynamically to users and their environments. By uniting scalable AI analysis with human-centered design, this project contributes a robust, adaptive tool for promoting public health and sustainable urban mobility.

Keywords:

Artificial Intelligence; Walkability; Public Health; Urban Mobility; User-Centered Design

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Mentor(s):

Gaurav Nanda (Polytechnic); Elizabeth A Richards (HHS); Xinran Y Lehto (HHS); Mark R Lehto (Engineering); Jaeil Lee (HHS)

Presentation Time: Session 3: 1:30-2:30pm

Generation of Reference Data from BackPack LiDAR Point Clouds for Quality Control of Tree Inventory Products STEM

Authors(s):

Colton Gomoll† (Engineering)

Abstract:

Traditional methods for assessing tree inventories are time-consuming and as-such prove expensive and inefficient for large-scale applications. To address this issue. The Digital Photogrammetry Research Group (DPRG) is developing an automated tree inventory pipeline to segment individual trees within point cloud datasets and derive each tree's biometrics. In order to analyze pipeline results for quality control, reference maps are essential. However, reference maps based on manual measurements in the field can sometimes be inaccessible or non-existent. This project proposes an alternative method for generating reference maps for quality control based on reconstructed point clouds collected using BackPack systems. Horizontal slices were made from normalized point cloud data and refined through a semi-automated process to obtain stem and outlier (non-stem) clusters. Tree locations and DBH were then extracted from the reference maps using leastsquares circle fitting on stem clusters and compared to pipeline results. The method was tested on both natural forest and plantation datasets, collected at the University of Georgia's Whitehall Forest site using commercial (Hovermap) and in-house (KNAP) Backpack systems. For trees with DBH greater than 4 inches, comparison between pipeline and reference map results showed over 80% precision, 88% recall, and 86% F1-score amongst all datasets. Plantations showed higher precision, recall, and F1-scores when compared to natural growth forest. This approach offers a practical solution for quality control in the absence of field-based references, allowing for rapid feedback and iterative improvement of the tree inventory pipeline.

Keywords:

Reference Data; Quality Control; Tree Inventory; Point Cloud; BackPack LiDAR

Mentor(s):

Ayman F Habib (Engineering)

Other Acknowledgement(s): Sangyoon Park (Engineering); Hazem Khaled Hanafy (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Understanding the Role of Sugars in the Timing of Leaf Senescence in Urban Trees

STEM

Authors(s):

Emmeline Rose Seest† (Agriculture|JMHC)

Abstract:

For autumn deciduous tree species, leaf senescence marks the end of the growing season and the beginning of winter dormancy. The timing of this event has large implications for carbon assimilation, exposure to cold and freezing temperatures, and the allocation of resources for future growth and metabolism. However, the driving forces behind autumn phenology are less understood compared to the well-documented drivers of springtime phenology. Recent studies suggest sugars may play a significant role by advancing autumn leaf senescence. Our study aims to understand the impact sugars have on the timing of leaf senescence in urban deciduous tree species. To address this question, we selected Quercus rubra (n=5) and Liriodendron tulipifera (n=5) trees planted on Purdue University's campus (West Lafayette, IN, USA). Two branches were girdled, and two branches were non-girdled. Of these pairs, one branch was sampled weekly for stomatal conductance, greenness, chlorophyll content, bulk sugar content, and ABA concentration. The other branch was observed weekly for leaf count and phenology. Sampling will continue until total natural leaf senescence occurs. We hypothesize that 1) leaves on the girdled branches will senesce before the leaves on the ungirdled branches and 2) the girdled branches of the ring-porous red oaks will senesce before the girdled branches of the diffuse-porous tuliptrees. Overall, understanding the drivers of autumn leaf senescence will improve predictions of growing season length and the impacts of increasing drought, extreme weather events, and variable temperatures, thereby improving the ability of land stewards to manage our forests.

Keywords:

Leaf Senescence; Autumn Phenology; Nonstructural Carbohydrates; Girdle; Temperate Trees

Mentor(s):

Morgan Emily Furze (Agriculture); Mary-Margaret Brigette Benware (Agriculture)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 3: 1:30-2:30pm

Web Crawlers to Enrich Educational Content from External Sources

STEM

Authors(s):

Anna Ospina Bedoya†

Abstract:

This project explores ways to enhance Purdue University's AI chat assistant by enriching its knowledge base with structured educational content from external, high-quality sources, Specifically, it focuses on improving the assistant's ability to support programming-related gueries in digital forestry courses—such as Fundamentals of Remote Sensing by leveraging real-world examples and instructional materials beyond traditional curricula. The current implementation centers on developing custom web crawlers for YouTube and GitHub. These crawlers extract relevant content such as code repositories, README files, video transcriptions, and tutorial metadata. The gathered materials are processed through a semantic embedding pipeline and stored in a vector database to enable retrieval-augmented generation (RAG) when responding to user queries. While still in progress, this approach is showing promise in improving the contextual relevance and specificity of the assistant's responses. The system architecture is built on a modular FastAPI backend and includes domain-specific parsers, an embedding service, and a semantic search interface using ChromaDB. A functional prototype of an AI tutor is under development, and tools for expanding the dataset are also being designed. The framework is intended to be scalable and extensible, supporting future integration of additional content sources and customizable user agents.

Keywords:

Web Crawling; Retrieval-Augmented Generation (RAG); Semantic Embeddings; Domain-Specific Content

Mentor(s):

Gang Shao (Libraries); Baijian Yang (Polytechnic)

Presentation Time: Session 3: 1:30-2:30pm

Investigating Ti-based metal-organic frameworks for applicability in photoelectrochemical cells

STEM

Authors(s): Eva G Clancy†

Abstract:

Metal-organic frameworks (MOF) offer promising solutions for clean energy resources due to their photoactivity and ability to catalyze watersplitting reactions (WOR). MOFs can be implemented into photoelectrochemical (PEC) cells and manipulated for hydrogen fuel production. Primarily, those containing earth-abundant materials Fe, Ti, etc. are the most interesting for creating effective and economic energy production. Previous research has shown promising results for Fe-based MOFs such as MIL-126 and MIL-124 decorated with Ru-containing catalysts, Fe-triazolate (Fe(ta)2), but combined Ti and Fe MOFs have yet to be characterized for their catalytic and photoanode properties, particularly FeMIL-125-NH2. Building on the growing need for clean energy production, the characterization of MOF FeMIL-125-NH2 in a PEC cell is achieved. In acidic and neutral environments, 24-hour chronoamperometry is taken with periodic irradiation of the photoanode to observe oxygen and hydrogen production. Raman spectroscopy is used to investigate structural transitions in the MOF under test conditions. By investigating FeMIL125-NH2's activity, its potential as an effective photocatalyst is determined. This leads to illuminating results for FeMiL125-NH2's candidacy in the development of WOR-based clean energy resources.

Kevwords:

Chemistry: Biophysics: Metal-Organic Frameworks

Mentor(s):

Yulia N Pushkar (Science)

Presentation Time: Session 3: 1:30-2:30pm

Prospects for Quantum Entanglement at the High Luminosity Large Hadron Collider (HL-LHC)

STEM

Authors(s):

Madeline Anna Rehwinkel†

Abstract:

This project investigates the prospects of quantum entanglement in top quark pair production at the high-luminosity large hadron collider (HL-LHC). Utilizing generated Monte Carlo (MC) samples, we analyze the MC data to derive kinematic variables relevant to top-antitop quark production. Event selection criteria specific to top-antitop quark production and subsequent decay in the dilepton channel are applied, followed by a kinematic top quark reconstruction, which involves identifying the decay products of the top quarks and reconstructing their momenta and other properties. Uncertainties are then applied to the MC samples.

The focus is on measuring the normalized differential cross-section with respect to the opening angle, delta phi, between outgoing leptons in the transverse plane of the top quark center of mass frame. These leptons stem from the decay of the top quark into W boson, and W into a lepton and neutrino. Delta phi is sensitive to the extent of spin correlations between the produced top quark antitop quark pair originating from the colliding particles, quantified by the spin coefficient D. Entanglement is present in a certain phase space corresponding to -1 < D < -1/3. This study expands on previous work by implementing systematic uncertainties to the nominal analysis. On a broader scale, this method of data analysis can be used to probe the capabilities of the HL-LHC collider in future experiments and advance our understanding of quantum entanglement in particle physics, while contributing to the wider field of quantum mechanics through the potential application of Bell's inequality tests.

Keywords:

Quantum Entanglement; Spin Correlation Coefficients; Top Quarks; High Luminosity Large Hadron Collider (HL-LHC); Spin Polarization

Mentor(s):

Andreas Jung (Science); Osama Ragab Ahmed Dawood (Science)

Presentation Time: Session 3: 1:30-2:30pm

Graphene and hBN Encapsulation of 2D Fe(TeSe) for Superconducting Proximity Studies

STEM

Authors(s):

Madeleine Huang Spark†

Abstract:

Two-dimensional (2D) superconductors offer a rich platform for exploring exotic electronic phenomena, yet their electrical properties in the ultrathin regime remain largely unexplored due to fabrication challenges. In this project, we investigate the 2D limit of Fe(TeSe), a bulk iron-based superconductor, by isolating monolayers through gold-assisted mechanical exfoliation. Due to the air sensitivity and instability of Fe(TeSe) in its monolayer form, we are developing van der Waals heterostructures that cap the Fe(TeSe) with protective layers of graphene and hexagonal boron nitride (hBN). To achieve this, we test multiple dry transfer methods—including polycarbonate (PC) and polypropylene carbonate (PPC) film stamps—with a focus on minimizing thermal exposure to preserve the integrity of the Fe(TeSe) layer. Once fabricated, these heterostructures will allow us to probe potential superconducting proximity effects in graphene at temperatures below the critical temperature of Fe(TeSe). Our work aims to establish a reliable platform for measuring the electronic properties of fragile 2D superconductors and exploring their interactions with adjacent materials.

Keywords:

2D Materials; Dry Transfer; Mechanical Exfoliation; Superconductivity

Mentor(s):

Andres Eduardo Llacsahuanga Allcca (Science); Yong P Chen (Science)

Presentation Time: Session 3: 1:30-2:30pm

STARS MIM Characterization STEM

Authors(s)	١:

Tei Okamoto† (Engineering); Alexandre Chan Tome† (Engineering); Sophia Ho† (Engineering); Henry N Kuehl† (Engineering); Drew Thomas Novak† (Engineering|JMHC); Brendan V Espinola† (Engineering)

Abstract:

[Abstract Redacted]

Keywords:

Stars

Mentor(s):

David B Janes (Engineering); Rahim Rahimi (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Failure modes of thin film peeling under peridynamics and cohesive zone models

STEM

Authors(s):

Ben N Aaron†; Mike Xiao‡ (Engineering)

Abstract:

Peridynamics, a framework for non-local continuum mechanics, and the cohesive zone model (CZM), which characterizes fracture along a cohesive layer, have acted as important tools for modeling fracture mechanics of crack propagation. However, film peeling, a mechanics problem with appropriate constraints for a peridynamics and cohesive zone model, has been understudied despite relevance to a range of physical applications, including the everyday adhesive tapes or the laminates of structural materials. We aim to identify the conditions and failure modes under which a tear occurs when a thin film adhered to a rigid substrate undergoes bending while being peeled. This work also identifies parameters for which the film is peeled off cleanly without leaving residue. Using the PDMATLAB2D coding framework for peridynamics in 2D planes, we simulate peeling under plane strain and quasi-static loading conditions, allowing for the model to reach a steady state as loading is incremented to minimize inertial effects. Relevant tested variable parameters include the thickness of the adhesive film, the angle of loading, and the rigidity of the film. This study compares our results across levels of fineness in our simulations and in reference to the limited existing models to validate and verify our findings. This research addresses the film peeling problem with recommendations for parameters of interest in future modeling. Further testing of the findings could be achieved with experimentation with adhesives of known material properties, especially the adhesives used in tapes, stickers, and other products for which a clean peel is desired.

Keywords:

Peridynamics; Fracture Mechanics; Cohesive Zone Model

Mentor(s):

Ivan C Christov (Engineering); Ziyu Wang (Engineering)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Aerodynamic Analysis and Wind Tunnel Testing of an Avian-Inspired Flapping-Wing Aerial Vehicle

STEM

Authors(s):

Abdullah Mouaffaq S Albaghdadi† (Engineering); Sota Yanagisawa‡ (Engineering|DSB)

Abstract:

Bio-inspired flapping-wing aerial vehicles (FWAVs) offer agility and maneuverability advantages in environments where conventional UAVs struggle. However, their unsteady and nonlinear aerodynamic behavior introduces substantial complications in modeling and stability analysis, leading to challenges in early-stage design. This necessitates the need for experimental methods to elucidate the unsteady aerodynamics of FWAVs. Moreover, the static stability of such aircraft must be understood to inform further development of such unconventional platforms. This study investigates the aerodynamics and static stability of a customdesigned FWAV, BoilerBird 2, with flapping and gliding capabilities using both computational and experimental methods. The gliding characteristics are studied using computational methods and validated experimentally, while the flapping mode is studied solely through experiments. For the gliding phase, the aircraft geometry is modeled in XFLR5, and aerodynamic and stability parameters are predicted using panel and vortex lattice methods, informing the final aircraft configuration. Wind tunnel experiments are conducted to measure the aerodynamic and stability characteristics of the FWAV. Experimental data is gathered for the flapping stage and the gliding stage by mounting the model on a 3-component force balance and acquiring force and moment data over a range of angles of attack. The results are used to evaluate the reliability of XFLR5 for early-stage design of FWAVs in the gliding stage. This work contributes to the growing body of research in FWAV development and demonstrates a viable methodology for earlystage aerodynamics and static stability analysis. Future work will develop a computational methodology for dynamic and flapping flight modeling.

Keywords:

Flapping Wing Aircraft; Aerodynamics; Wind Tunnel Testing; Stability Analysis; Biomimicry

Mentor(s):

Abhijnan Dikshit (Engineering); Pavankumar Channabasa Koratikere
† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

(Engineering); Spencer Dean Jones (Engineering); Leifur Thor Leifsson (Engineering)

Other Acknowledgement(s): Radhika Arvind Bhopatkar (Engineering); Thomas Robert Bietsch (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

What Drives Pattern Formation in Ferns? A Mathematical Modeling Approach

STEM

Authors(s):

Isabel Sofia Bejarano Molina†

Abstract:

Understanding how complex tissues emerge during plant development is a central question in developmental biology. Ferns, as representatives of seed-free vascular plants, offer a valuable window into these processes due to their distinct life cycle. Unlike seed plants, they initiate and maintain groups of meristem cells (e.g., stem cells) that drive the formation of various organs and the overall shape of the plant tissue. Specifically, in the fern Ceratopteris richardii, cell behavior leads the tissue to transform from a round to a heart shape, with meristem cells located at the heart notch. Although recent studies have mapped cell division patterns, the mechanisms behind shape emergence remain unclear. The goal of our research is to address this gap by developing a mathematical model of cell dynamics during the gametophyte stage of the fern lifecycle. In this work, we introduce a Cellular Potts Model to describe cell division, growth, and shape in time using an energy-based framework. Initial conditions are established from experimental images, from which the spatial distribution of meristem and non-meristem cells was defined in a round shape. Then, we simulate cell behavior during a week of fern development in a computationally efficient manner. The results demonstrate that differences in cell proliferation and growth rates generate distinct spatial patterns over time. We make experimentally testable predictions about the behavior of meristem and non-meristem cells, thereby providing insight into the mechanisms that guide pattern formation and tissue morphogenesis in land plants.

Keywords:

Ferns; Cellular Potts Model; Mathematical Modeling; Tissue

Morphogenesis; Pattern Formation

Mentor(s):

Alexandria Volkening (Science); Nour Khoudari (Science)

Other Acknowledgement(s):

Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Exfoliating WSe2 in search of quantum phenomena in TMD Moiré superlattices

STEM

Authors(s):

William Christophe Bultman† (Science); Aditya Srinivasan* (Science); Vincent Cody Stavig* (Science)

Abstract:

Prior research has primarily focused on discovering quantum phenomena such as superconductivity and correlated insulating states in moire superlattices, those being twisted bilayer graphene and WSe2 of angles less than 5.0°. Much is yet to be discovered in regards to high twist angle bilayer WSe2, as well thicker layers of twisted WSe2, such as trilayer twisted WSe2 and its quantum properties. Further insights into the quantum properties of twisted bilayer and trilayer WSe2 puts research closer to understanding moire materials and their utility through superconductivity among other quantum phenomena. However, obtaining the large-area pristine monolayer WSe2- the key ingredient in our twisted layer device- deems challenging using the standard tape exfoliation method. We systematically study effect of a few tuning parameters on the yield of WSe2 exfoliation. We find maximized yield at a tape peel-off angle of 135° while the tension in transfer tapes minimized. The enhanced yield allows us to build twisted bilayer and trilayer WSe2 devices where we seek to detect superconducting and/or correlated insulating states through electrical transport measurement at low temperature.

Keywords:

2D Materials; Condensed Matter Physics; Materials Science; Quantum; TMD

Mentor(s):

Yihang Zeng (Science); Euihyun Jo (Science)

Other Acknowledgement(s):

Shuaiqing Zhang (Engineering); Nemanja Ninkovic (Science)

Presentation Time: Session 3: 1:30-2:30pm

Enhancing Synucleinopathy Detection in Preclinical Rodent Models using Surfactant-Modified Seed Amplification AssaysSTEM

Authors(s):

Amelia G Campbell† (HHS|JMHC)

Abstract:

Parkinson's disease (PD) is the second most common neurodegenerative disorder affecting approximately 10 million people worldwide. Hallmarks of PD neuropathology include the presence of Lewy body inclusions enriched with aggregated forms of alpha-synuclein (aSyn) and loss of dopaminergic neurons. In the diagnostic field, aSyn seed-amplification assays (SAAs), such as Real-Time Quaking-Induced Conversion (RT-QuIC), are tools that enable sensitive detection of aSyn aggregates in patient derived samples. In RT-QuIC, pathological ?Syn seeds catalyze the aggregation of monomeric ?Syn into fibrils, which bind to Thioflavin T, a dye that fluoresces when bound to amyloid structures. Multiple optimizations of RT-QuIC protocols using humanderived samples are reported in literature. However, there are a lack of studies examining rodent models of PD using SAAs. RT-QuIC is an attractive and underexplored candidate for examining the pathological mechanisms of synucleinopathies through in-vivo models of PD. In effort to improve this model, we aim to use surfactants to reduce spontaneous aggregation of mouse aSyn and accelerate seeded fibril formation. Previous reporting has shown that Triton X (TX-100) keeps aSyn in its monomeric form at the onset of the reaction in human samples. Sodium dodecyl sulfate (SDS) has been described to expose seeds in samples such as cerebral spinal fluid, reducing assay times. In a novel RT-QuIC optimization approach, SDS and TX-100 will be used at varying concentrations to optimize reproducibility and reduce the time of lag phase for rodent-seeded samples. This study aims to establish a rapid and reliable RT-QuIC protocol for preclinical rodent models of synucleinopathies.

Keywords:

Parkinson's Disease; Synucleinopathies; Alpha-Synuclein; RT-QuIC; Surfactant

Mentor(s):

Alicia Nicole Scott (Pharmacy); Jean-christophe Rochet (Pharmacy)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Emily R Jakob (HHS)

Presentation Time: Session 3: 1:30-2:30pm

Cardiomyocyte Differentiation of hiPSCs and 8p Chromosome Mutation

STEM

Authors(s):

Zhiyuan Chen† (Agriculture|Engineering)

Abstract:

Chromosomal disorders are genetic mutations that affect individual health on a cellular level throughout the body. Chromosomal 8p is a critical region that's crucial for physical growth and cognitive development. However, de novo 8p mutations which cause cancer, developmental delays, and malformations have been underexplored despite their clinical importance. Patient-derived human-induced pluripotent stem cells (hiPSCs) are valuable tools in drug and mutation screenings due to their ability to differentiate into various cell types, enabling the modeling of disease-relevant tissues and testing drug efficacy in vitro. Commercial media kits can provide insight into the process of differentiating iPSCs into neurons and cardiomyocytes, which can later help optimize small molecule-driven differentiation, offering more economical and batch-consistent results. This project aims to develop and optimize protocols for ventricular cardiomyocyte differentiation of 8p patient cell lines. Neurogenesis and ventricular cardiomyocyte generation of 8p patient-derived hiPSCs were tested for downstream studies. Cell viability, differentiation efficacy, and cell morphology were evaluated among various differentiation protocols for the cell lines tested. The differentiation timeline, predicted mechanism, and cell response were compiled for various protocols and target cell types. Fluorescent microscopy and cell painting were conducted for indepth screening of morphological differences. Results from cell painting provide quantitative data on cellular morphology and subcellular organization, setting a phenotype baseline for differentiation protocols on a molecular level. Future work may focus on mutation screening and drug testing for ventricular cardiomyocytes with unique types of 8p mutations.

Keywords:

Stem Cell; Chromosome; Mutations; Differentiation; Cardiomyocyte

Mentor(s):

Matthew Thomas Tegtmeyer (Science); Autumn Liberty Bandy (Science)

Other Acknowledgement(s):
Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Developing an In Vitro Tool to Study TDP-43 Pathology Using a DHFR-Dendra2-TDP43 Fusion System

STEM

Authors(s):

Wanming Dai† (Engineering); Kiersten Mackenzie Penquite* (Engineering|JMHC)

Abstract:

[Abstract Redacted]

Keywords:

TDP-43; Neurondegeneration; DHFR Degron; Synthetic Biology; HEK293T

Mentor(s):

Junkai Xie (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Mechanical analysis of the impact of bacterial growth on adherence to flat and nanopatterned surfaces

STEM

Authors(s):

Amelia G Eicher-Miller† (Engineering)

Abstract:

Some of the most advanced antibacterial technologies come from the most unlikely places: the wings of insects. Insect wings like those of cicadas or dragonflies have textured surfaces with features on the nanoscale, called nanopatterns. Medical implants such as catheters and dental or orthopedic implants offer bacteria a place to grow and form toxic biofilm communities that are antibiotic resistant. Current methods prevent biofilm growth by modifying implant surfaces to be antibiofouling or antiadhesive, but these coatings can cause inflammation and bacterial resistance due to their uneven and uncontrolled antibiotic release. Application of nanopatterns to medical implants creates a bactericidal surface that is also safe for the body. The physical properties of nanopatterns rupture bacterial cells, making them predictable and nontoxic. However, bacteria are not static. Their growth may influence their adhesion strength. This project will expand on an existing mathematical model to determine the effect of bacterial growth on surface adherence. By calculating how the free energy available to the bacteria changes as it grows on a surface, it will be revealed when the bacteria adhere most strongly. For modeling, I will expand the existing formulation to cylindrical cells, rather than spherical ones, since a significant fraction of infectious bacterium are cylindrical/rod-shaped. I will evaluate the free energy available to bacteria on both flat and nanopatterned surfaces, and analyze both situations using MATLAB. In the future, the results may be applied to developing more effective nanopatterned surfaces that target bacteria when they are most adhesive.

Kevwords:

Antibacterial Technology; Bacteria Mechanics; Nanopatterns; Biophysical Modeling; Mechanical Engineering

Mentor(s):

Ashwin Ramachandran (Engineering)

Other Acknowledgement(s):
David Matthew Czerwonky (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

An experimental method for exploring the linearity thresholds for electrochemical impedance spectroscopy of neural interfaces

STEM

Authors(s):

Deniz Eksioglu† (Engineering|JMHC)

Abstract:

Impedance evaluation is a critical tool to obtain detailed information regarding the functionality of neural interfacing electrodes. A key parameter during electrochemical impedance spectroscopy (EIS) is to ensure that the output of the system receiving the EIS stimulus signal is linear. Otherwise, the fundamental assumption of Ohm's Law in EIS is invalidated, leading to misrepresentation of the system, caused by the presence of harmonic responses to the input stimulus. Faradaic processes, such as the reduction and oxidation (redox) of chemical species at the electrode/electrolyte interface, occur at specific applied voltages that cause the system of interest to depict nonlinear behaviors. Moreover, as modern neural interfaces experience high impedance due to their small geometric surface area, it is crucial to deliver large amplitudes of stimulus signal during EIS experiments to drive sufficient measurement current, which can be distinguished from the background noise. Therefore, this project provides a verified systematic experimental plan for the determination of linear operation regions of neural interfaces. This study employs the use of Tafel and Lissajous plots to identify regions where the kinetics of redox reactions do not control the current at the interface. These experiments were conducted in a phosphate buffer saline solution with four different metal electrodes, all with the same surface area: platinum, tungsten, steel, and gold. By integrating Tafel and Lissajous analyses, the approach aims to distinguish regimes where electrode behavior remains governed by linear impedance principles rather than redox kinetics.

Keywords:

Electrochemical Impedance Spectroscopy; Linearity; Neural Interface; Tafel; Lissajous

Mentor(s):

Saeed Boroomand (Engineering); Kevin John Otto (Engineering)

Other Acknowledgement(s): Parth Uday Kelkar (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Development of a modeling tool for bulk particulate flows in large scale systems with complicated geometries STEM

Authors(s):

Emilio Yair Fonseca Puebla† (Engineering)

Abstract:

[Abstract Redacted]

Keywords:

PIVIab; Particle Image Velocimetry; Granular Flow; Hopper

Mentor(s):

Aaron B Morris (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Real-time System for Nurses Situation Awareness and Team Communication Assessment

STEM

Authors(s):

Hermes Heng-yu Fu† (Science|Graduate)

Abstract:

Situation awareness (SA) and communication effectiveness are two essential nontechnical skills (NTS) for healthcare providers. SA plays a vital role in enabling nurses to detect early signs of patient deterioration, while effective communication supports strong team performance. However, current assessments of NTS primarily rely on subjective evaluations conducted after the surgery, which limit their accuracy and timeliness.

This research proposes objective and real-time strategies to assess and predict NTS using physiological and communication data. These methods allow continuous monitoring, enabling the detection of changes in NTS and providing timely support to maintain safe and efficient clinical operations.

Building on previous studies that used physiological signals to predict cognitive load in surgical settings, this study introduces two real-time assessment systems. The first system analyzes heart rate variability and eye tracking data from wearable sensors to identify patterns linked to SA. These patterns can be used to estimate SA levels and offer immediate support when low SA is detected. The second system focuses on team communication, developing a machine learning model to predict team progress from sliding windows of sentences.

Together, these systems support objective and real-time evaluation of NTS, offering valuable feedback to enhance individual and team performance in healthcare environments.

Keywords:

Real-Time Analysis; Non-Technical Skills; Situation Awareness; Team Communication; Psychophysiological Assessment

Mentor(s):

Denny Yu (Engineering); Jingkun Wang (Engineering); Nicholas Eric Anton (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Predictive Maintenance of Vacuum Pump with Temperature and Sound Monitoring Using Deep Learning

STEM

Authors(s):
Austin H Gibson†

Abstract:

The dominant paradigm in manufacturing in the late 20th century was lean manufacturing, which emphasized minimizing costs through the elimination of waste. Since then, the invention and advancement of the Internet of Things (IoT), Big Data and Data Analytics, and Artificial Intelligence (AI) models have laid the foundation for the rise in Industry 4.0, where data generated in real-time is continually assessed by Al models for minimizing costs and maximizing operation efficiency. With modern technologies, the condition of machines can be continually assessed to determine the ideal time to perform maintenance on them. which is called predictive maintenance. The effective application of predictive maintenance can improve equipment longevity, reduce time wasted in needless inspections, and minimize needless expenditures by proactively repairing machines before they break. Sound and temperature data of three vacuum pumps in Birck Nanotechnology Center at Purdue were recorded over four years with low-cost sensors attached to them. The data was curated into an organized dataset and analyzed to build a model to predict maintenance-related outcomes of the vacuum pumps. Furthermore, deep learning models for vacuum pump health monitoring will be developed to support decision-making and reduce maintenance costs.

Keywords:

Artificial Intelligence; Predictive Maintenance; Machine Learning; Data Analytics; Internet of Things

Mentor(s):

Eunseob Kim (Engineering)

Other Acknowledgement(s): Parth Uday Kelkar (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Cellulose Cement Composite (C3) for Carbon Negative Construction

STEM

Authors(s):

Bryn R Goldstein†; Mahira Mim*

Abstract:

The challenge with current construction methodologies is their intense carbon emissions. Concrete, the world's second most used resource, is highly carbon-intensive due to the release of carbon dioxide in the cement manufacturing process. The 2" by 4" Dimensional lumber, a commonly used construction material, is also not carbon negative because of the eventual decay by biodegradation. By incorporating wood fibers in a compression-molded composite with cement, a new material is fabricated that is expected to be resistant to microbial decay and resistant to fire. This work focuses on the variation of wood content in the composite and its effects on the flexural strength of the composite. Volume percent of 25, 50, and 75 of wood were incorporated in the composite and aged for 7 days, 14 days, and 28 days. The wood-cement composites were cast on a hydraulic press and mechanical testing performed by three-point bending. Most cementitious composites undergo brittle failure, whereas high wood content composites undergo ductile failure. Ductile failure is preferred for construction materials since the material will not fail catastrophically so can be used in construction for safer buildings. This work also involves studying compression molding dynamics by understanding the duration of time needed for compression molding at a variety pressures. Overall, it was found that high casting pressure composites take more time for molding.

Keywords:

[no keywords provided]

Mentor(s):

Akshat Verma (Engineering)

Other Acknowledgement(s):

David Matthew Czerwonky (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

CADialogs: Empowering Precise Control for 3D Generation and Simplified Designing Processes

STEM

Authors(s): Yichen Hu† (Science)

Abstract:

In the field of mechanical design, there are many designers capable of creating innovative 3D models; however, unfamiliarity with computeraided design (CAD) applications can limit their creativity and efficiency. Previous systems, such as DeepCAD and CAD-Llama, generate 3D models for users, yet they may not produce results that satisfy users' needs. To overcome limitations in inefficient generation, we present CADialogs, a system that streamlines 3D design by guiding users through the model-building process step by step. Leveraging a GenAlbased framework, our system generates one component of the model at each step and allows users to modify parameters or add elements to match their expectations before proceeding to the next step. Users simply enter a text prompt describing their requirements, and our system generates an updated model component based on the prompt. We have completed significant preparatory work, including data preparation for model training, format conversions, and development of parts of both the frontend and backend interfaces. We plan to conduct a user study with 20 participants and gather feedback using a standard survey focused on simplicity, accuracy, and usability. We anticipate strong positive feedback, with average scores for each question showing improvement over previous systems, demonstrating that our system is more flexible and precise in generating models that meet users' needs.

Keywords:

[no keywords provided]

Mentor(s):

Karthik Ramani (Engineering); Yuzhao Chen (Engineering); Runlin Duan (Engineering); Mayank Harendra Patel (Engineering)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Ioanna Katsamba (Engineering)

Computational Analysis of Genetic Screens in Stem Cell-Derived Neurons Using MAGeCK

STEM

Authors(s): Qingyi Hu†
Abstract: [Abstract Redacted]
Keywords: MAGeCK; Neuronal Gene Regulation; Genome-Wide Screening; Normalization Methods; CRISPR-Cas9
Mentor(s): Junkai Xie (Engineering)
Other Acknowledgement(s):

Presentation Time: Session 3: 1:30-2:30pm

Design and Development of a Multimodal Underwater RobotSTEM

Authors(s): Sijie Huang†

Abstract:

Warming ocean conditions are accelerating the melting of polar ice shelves and driving global sea level rise. However, understanding the processes beneath these ice shelves remains a major challenge due to the inaccessibility and hazards of deep, confined sub-ice environments. This project addresses that gap through the development of a compact, multimodal underwater robot capable of operating in three modes: drifter, glider, and thruster. The long-term vision is to deploy a swarm of these vehicles from a mothership to enable distributed sensing in previously unreachable regions. The robot features a linear rail ball screw system for internal mass shifting to control pitch, a rotating gear mechanism for roll control via battery and electronics reorientation, and a tunable rudder for yaw control and directional stability. A foldable wing structure enables efficient forward motion in glider mode, while a soft ballast pouch allows real-time buoyancy adjustment for vertical sawtooth trajectories and seamless mode switching. Performance is evaluated through the robot's ability to dive, surface, pitch, roll, yaw, drift, glide, and propel. Integrated sensors measure underwater pressure, temperature, visual feedback, and proprioception via an inertial measurement unit. Data from test deployments will inform future improvements in mechanical design, locomotion transitions, and control strategies. This work highlights the feasibility of deploying small, low-cost underwater robots for scalable and safe sub-ice exploration. It offers a promising tool for monitoring climatedriven changes in polar environments, contributing to a deeper understanding of ocean-ice interactions under rapidly changing global conditions.

Keywords:

Underwater Robot (UR); Autonomous Underwater Vehicles (AUVs); Robotics; Multimodal Locomotion; Ocean Monitoring

Mentor(s):

Yu She (Engineering); Sheeraz Athar (Engineering)

Other Acknowledgement(s): Varun Aggarwal (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 3: 1:30-2:30pm

Degradation of Thermal Interface Materials in Submerged Conditions

STEM

Authors(s):

Xavier L Ish† (Engineering)

Abstract:

Thermal interface materials (TIMs) are commonly used in electronic systems to facilitate the dissipation of heat from heat sources like electrical components to outside heat sinks. TIMs consist of thermally conductive particles in a polymeric matrix that ensures high thermal conductivity along with the ability to adhere to the surface. However, typical thermal cycles associated with electronic systems can lead to the loss of thermal performance of TIMs over time. Several literature studies have reported the degradation in electronic packages in the ambient environment. As packages become power dense with time, improved thermal management is critical for healthy functioning of chips and immersion cooling is one of the possible strategies. This technique involves submerging the packages in dielectric fluids with relatively higher thermal conductivity than air. While the technology gains traction, there are major concerns with the reliability of the package, including the integrity of TIMs. This research aims to study the degradation of TIMs in submerged conditions and extend the current reliability studies to better predict the performance deterioration. The testing setup consists of a TIM sandwiched between two aluminum bars, which are connected to a heater and cooler to establish a temperature gradient across the TIM. The TIM and a portion of the aluminum bars are immersed in a dielectric liquid. Each aluminum bar has thermocouples inserted along its length so the temperature gradient can be measured. These temperature readings will allow for characterization of the thermal resistance of the TIM and allow in situ monitoring for degradation. This research will allow us to better understand the behavior of TIMs used in liquid immersion cooling and provide insight into their reliability in submerged conditions.

Keywords:

Al Chips; Thermal Interface Materials; Immersion Cooling; Thermal Management; Reliability

Mentor(s):

Amy M Marconnet (Engineering); Ritwik Vijaykumar Kulkarni (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Pranshul Sardana (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Implementation and Validation of a Robust HR-pQCT Time-Lapse Imaging Pipeline for Quantifying Bone Remodeling

Authors(s): Sidh Jain† (Engineering)

Abstract:

High-resolution peripheral quantitative computed tomography (HR pQCT) time-lapse imaging is emerging as a non-invasive method for assessing bone remodeling by capturing localized bone turnover, including formation and resorption, over time. However, reproducibility and parameter standardization are essential for broad adoption. In this project, we focused on implementing and validating a robust HR-pQCT image processing pipeline.

Using Python-based scripts, we successfully reproduced the time-lapse workflow, which included image registration to align 3D scans across timepoints, density thresholding to segment bone based on intensity values, and morphological filtering to refine and isolate meaningful remodeling regions. We confirmed the integrity of the pipeline by minimizing errors in same-day scan comparisons, consistent with the original study's findings. Key optimizations included the use of grayscale input images to preserve structural detail, 3D registration for precise alignment, and Gaussian smoothing to reduce noise and enhance consistency in detection.

With the pipeline now functional, the next phase involves applying this method to diverse research datasets, including studies on osteogenesis imperfecta and other bone pathologies. Ultimately, this work contributes to the development of a reliable, non-invasive biomarker for bone remodeling in both clinical and research settings.

Keywords:

HR-pQCT; Bone Remodeling; Time-Lapse Imaging; Image Registration; Non-Invasive Biomarkers

Mentor(s):

Rachel Kathleen Surowiec (Engineering); Wikum Roshan Ban Ranasinghe Mudiyanselage (Engineering); Christopher L Newman (Engineering); Noah A Jasinkiewicz (Vet Med)

Presentation Time: Session 3: 1:30-2:30pm

Interactive Handwriting-based Tutoring System Utilizing Large Language Models

STEM

Authors(s):

Haoyu Ji† (Science)

Abstract:

[Abstract Redacted]

Keywords:

[no keywords provided]

Mentor(s):

Karthik Ramani (Engineering)

Other Acknowledgement(s):

Ziyi Liu (Engineering); Yuzhao Chen (Engineering); Runlin Duan (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Utilizing Directed Evolution Techniques to Gain Insights into Factors Dictating the Substrate Scopes of Penicillin Binding Protein-Type Thioesterases

STEM

Authors(s):

Lucas O Johnson† (Science|JMHC)

Abstract:

Cyclic tetrapeptides (CTPs) are part of a diverse class of natural products that are especially promising in clinical applications. This is due to their broad range of biological activities and superior therapeutic properties, such as specificity and proteolytic stability, compared to their linear counterparts. While chemical methods exist to access CTPs, these methods often require the presence of certain amino acids in certain positions, thereby limiting their applicability. Because of these limitations, there has been great interest in a class of enzymes that have been shown to catalyze the head-to-tail cyclization of linear peptides, penicillin binding protein-type thioesterases (PBP-TEs). There has, however, been little insight gained into the properties of these PBP-TEs that determine their substrate scopes. This study is aimed at evaluating DNA shuffling mutants of two known PBP-TEs with differing substrate scopes, WP516 and Ulm16, and site-directed mutagenesis of Ulm16. DNA shuffling was completed between the genes for WP516 and Ulm16 and active mutants were expressed, purified, and tested with several peptide substrates. In Ulm16, three residues were selectively mutated to more closely mimic WP516. This Ulm16 triple-mutant was assayed with several linear peptides to assess the impact that each mutation has on the activity of Ulm16. From these mutants and their activities, we aim to pinpoint the residues and characteristics of PBP-TEs that are important in determining substrate scope, guiding future enzyme engineering efforts toward a broadly useful biocatalyst.

Keywords:

[no keywords provided]

Mentor(s):

Paisley Lilliana Jeannette (Science); Elizabeth I Parkinson (Science)

Other Acknowledgement(s):

Ioanna Katsamba (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 3: 1:30-2:30pm

Cellular Uptake of Functionalized DNA Tetrahedra for in vitro miRNA Drug Delivery

STEM

Authors(s):

Sreesha Vedavalli Kidambi† (Agriculture|Engineering)

Abstract:

Delivering miRNA therapeutics to the brain poses a challenge due to the low permeability of the Blood-Brain Barrier (BBB). Many drugs are unable to achieve sufficient concentration in the brain to mitigate the symptoms of Alzheimer's Disease. Tetrahedral DNA nanostructures (TDN) are drug delivery vehicles with high potential to facilitate the transport of these therapeutics across the BBB. However, TDN are not easily uptaken by BBB cells because of DNA's hydrophilicity and the negative charge of DNA's phosphate backbone. Cationic lipids and polymers have been shown to mitigate these properties of DNA nanostructures and plasmid DNA. Because of this, functionalizing TDN with cationic lipids or polymers such as DOTAP, DOTMA, or DEAE-Dextran may allow for easier uptake of TDN into cells. To begin, DNA strands functionalized with Cy3 dye were assembled into TDN and characterized using gel electrophoresis. TDN were incubated with either DOTAP, DOTMA, DEAE-Dextran. Lipofectamine3000 was used as a positive control. Functionalized TDN (fTDN) were then tested for uptake efficiency against naked TDN in human kidney HEK293 as well as breast cancer CA1A cells, which are a field-standard positive control. Confocal microscopy was used to observe the uptake of fTDN into cells. This research addresses the difficulty of delivering therapeutics across the BBB by using TDN and testing the cellular uptake of fTDN. Further improvements include finding optimal concentrations of DOTAP, DOTMA, and DEAE-Dextran, incubating TDN with miRNA before functionalization to observe the uptake of miRNA into cells, and using BBB cells to test uptake of fTDN.

Keywords:

Drug Delivery; DNA Nanostructures

Mentor(s):

Grigorii Aleksandrovich Rudakov (Engineering); Tamara L Kinzer-Ursem (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Emily R Jakob (HHS)

Presentation Time: Session 3: 1:30-2:30pm

Inducing Behavioral Choices in Mice by Selectively Stimulating V1 Neuronal Ensembles Using TRAP2 Mice

Authors(s): Sein Kim† (Science)

Abstract:

Learning and memory encoding have traditionally been attributed to higher-order brain regions such as the hippocampus and the prefrontal cortex. However, recent evidence suggests that early sensory cortices. including the primary visual cortex (V1), also play a role in these cognitive functions. While previous studies suggest V1 contributes to learning, the specific role of V1 neuronal ensembles in encoding taskrelevant stimuli and guiding behavior remains unclear. In this work, we sought to identify and target ensembles specifically during reward association. We then determined whether selective activation of these targeted ensembles during learning can alter memory formation and task performance. We hypothesize that behavioral responses can be evoked just by activating the V1 network. In order to label active neurons in V1, we used TRAP2/Ai32 mice and trained them to perform a visual Go/No-Go discrimination task. Once the mice learned the task, we labeled all active neurons during the Go stimulus and optogenetically activated them in V1 to induce reward behavior. We recorded behavioral performance across sessions and analyzed learning curves to assess the impact of the V1 network in memory encoding. Results from this study show that targeting neuronal ensembles in V1 is sufficient to induce behavioral responses in mice. These results support the idea that V1 is actively involved in learning and memory processes, and highlight the potential of cortical ensemble stimulation to influence learning behavior, providing a potential therapeutic avenue for neurological learning deficits.

Keywords:

V1 Neuronal Ensembles; Reward Association; Optogenetics;

TRAP2/Ai32 Mice; Memory Encoding

Mentor(s):

Sanghamitra Nareddula (Science)

Other Acknowledgement(s):

Lipi Roy (Engineering); Violeta Saldarriaga Ramirez (Science)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 3: 1:30-2:30pm

High-Resolution Zebrafish Nuclei Segmentation with Chunked Processing and NISNet3D

STEM

Authors(s):

Ian Kwan Yin Lam† (Science); Rachel M Rivera‡

Abstract:

As imaging equipment advances, the resolution of 3D images - such as those of zebrafish embryos - continues to increase, improving detail and accuracy but significantly inflating file size and processing time. NISNet3D, a neural network model optimized for performing image segmentation on 3D images of zebrafish embryos, struggles to handle these high-resolution images efficiently. This research develops a preprocessing and postprocessing pipeline that enables NISNet3D to handle large files more effectively. The preprocessing stage includes Gaussian filtering to suppress noise and Contrast Limited Adaptive Histogram Equalization (CLAHE) to reveal faint cellular boundaries. Large 3D images were handled by splitting them into overlapping chunks and batching them with folders. These folders were then evenly divided between two GPUs, which process their assigned folders sequentially starting the next one as soon as the current finishes. This balances load and maximizes output rate without exceeding memory limits. After inference, postprocessing stitches the predictions back into one large image. However, closely packed or touching cells in chunk border sections were often mislabeled as a single object. To address this, cell separation was performed using Euclidean distance transforms and watershed segmentation. This method locates each cell's centroid and separates overlapping cells along the line of minimal distance, preserving natural boundaries. Tests using older zebrafish embryo volumes confirm that preprocessing and chunk-based inference significantly reduce runtime while preserving segmentation quality. Visual inspection shows most cells are correctly labeled, though further automation is needed. Future work involves generalizing the pipeline to accommodate other datasets.

Keywords:

Zebrafish; Image Processing

Mentor(s):

Linlin Li (Engineering); Nissa Jo Larson (Engineering)

Other Acknowledgement(s): Emily R Jakob (HHS)

Presentation Time: Session 3: 1:30-2:30pm

CogniPilot Autopilot Development STEM

Authors(s): yahor lechanka† (Engineering)

Abstract:

With the growing development of advanced UAVs for air mobility and transportation, the demands for robustness and safety in autopilot firmware are increasing. To address these needs, a new autopilot system called CogniPilot is being developed at the Purdue UAS Research and Test Facility (PURT). CogniPilot leverages Lie Algebra and CasADi for implementing advanced control algorithms. This summer, Research and Development Drone 2 (RDD2) is being tested at PURT to validate real-world flight performance using estimation algorithms such as the attitude estimator. The development pipeline begins with a custom RViz-based simulation of RDD2, where all control algorithms are first validated. The system is then tested in Gazebo, which introduces more realistic physics and simulates RDD2's embedded hardware. Finally, the firmware is compiled for the NXP Real-Time Vehicle Management Unit and deployed on a physical guadrotor for indoor flight testing. The Qualisys Motion Capture System is used to track the drone's position and orientation, effectively emulating GPS indoors and providing ground truth for comparing against onboard estimates from the flight controller. The attitude estimator will utilize an Invariant Extended Kalman Filter. Additional modules—such as magnetometer attitude-free auto-calibration and a Wi-Fi-to-serial communication bridge—are also under development. The primary goal is to conduct successful test flights at PURT using the latest firmware. ensuring system stability. This framework will serve as a foundation for future contributors to develop their own modules and algorithms for machine learning, path planning, and more.

Keywords: Autopilot; UAV

Mentor(s):

James Michael Goppert (Engineering)

Other Acknowledgement(s): Parth Uday Kelkar (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Bi-directional Robotic Integration with Digital Twin for Generalized, Efficient, and Safe Automation in Manufacturing (BRIDGES)

STEM

Authors(s):

Kristine Yoonseo Lee† (Engineering)

Abstract:

Advancements in manufacturing industries have led to a growing demand for robots due to the need to improve productivity and operational accuracy. Currently, the role of robots in manufacturing mainly focuses on automation, being only capable of performing preprogrammed tasks in structured environments. However, real-world manufacturing sites using legacy machines are often unstructured and dynamic, increasing the need for robot autonomy which allows robots to interact with their surroundings and make decisions independently. The safety of previous autonomy frameworks is usually guaranteed through strict rule-based control, but these approaches inherently limit their adaptability. We aim to tackle this problem by developing a comprehensive framework that can handle various tasks in unstructured environments. This paper proposes a consolidated framework that integrates safe-set generation and optimal path planning. Initially, safe sets are generated based on the robot's perception of its surroundings via RGB-D camera. By leveraging Implicit Neural Representations (INR) and mapping functions, our safe sets ensure complete obstacle avoidance at a collision rate of 1%. Subsequently, an optimal trajectory to the target is generated using a modified RRT* algorithm that integrates a goal-biased random sampling and a heuristic-guided rewiring process. Comparing our proposed path planning algorithm with the conventional RRT algorithm, our path possesses 21% shorter jointspace length than the original path. In parallel, a grid-based A* algorithm is also proposed for comparison. This framework successfully performs obstacle avoidance and optimal path planning while taking real-time changes into account. BRIDGES will help roots achieve full autonomy in manufacturing sites.

Keywords:

Digital Twin; Robotics; Manufacturing; Automation

Mentor(s):

Hojun Lee (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Parth Uday Kelkar (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Video Analytics and Texture Analysis for Assessing Feed Mix Uniformity

STEM

Authors(s): Han Li† (Science)

Abstract:

Achieving uniformity in total mixed rations (TMR) on dairy farms is crucial for optimizing digestive function, enhancing nutrient utilization, and maintaining overall animal health. However, there remains a lack of automated, real-time systems for monitoring the preparation of TMR. This study explores the use of textural feature extraction from RGB images as a tool for assessing TMR uniformity. Cameras were mounted above a mixer wagon to record the mixing process of poorly-mixed and well-mixed lactating cow diets. Both diets were composed of the same ingredients, with the poorly mixed diet having a larger load size and shorter mixing time compared to the well-mixed diet. From each batch, the initial, middle, and final frames of the mixing process were extracted. In each frame, 100 regions of interest (ROI) were randomly selected, and various handcrafted textural features were computed, such as those derived from the Gray Level Co-occurance Matrix, Gabor filters, and Local Binary Patterns. Each feature was tested for robustness against variations in rotation, lighting, and camera distance to identify those that are most generalizable across different feed mixing conditions. Features were also tested for sensitivity to mix uniformity by calculating the coefficient of variation for each feature across all ROIs within a frame, and comparing the distribution of poorly-mixed and well-mixed groups. Features that effectively differentiated between groups showed statistically significant differences in their distributions, demonstrating the potential that textural analysis has in assessing diet uniformity as part of an automated system for real-time monitoring.

Keywords:

Video Analytics; Computer Vision; Texture Analysis; Feed Mix

Uniformity; Dairy Feed Management

Mentor(s):

Amy R Reibman (Engineering)



Presentation Time: Session 3: 1:30-2:30pm

Development of a sustained-release respiratory naloxone formulation using Flash NanoPrecipitation

STEM

Authors(s):

Lana Malek† (Agriculture|Engineering)

Abstract:

Yearly, thousands of fatalities occur due to drug overdose, more than two-thirds of which are caused by synthetic opioids such as fentanyl and heroin. Naloxone, the only existing FDA-approved treatment for opioid overdose, has a much smaller therapeutic window than the duration of time fentanyl is at toxic levels in the body. Therefore, multiple consecutive applications of naloxone are often necessary to effectively prevent a fentanyl overdose, which can lead to harmful side effects, such as pulmonary edema and tachycardia. The aim of this research was to develop a sustained-release respiratory naloxone formulation with a longer therapeutic window than the existing commercial formulation using Flash NanoPrecipitation (FNP). FNP produces nanocarriers through the rapid mixing of an organic solution containing hydrophobic materials with an antisolvent, such as water, to create supersaturation conditions that lead to the precipitation and encapsulation of the materials. Naloxone is not hydrophobic enough to precipitate in water on its own; thus, a method of hydrophobic ion pairing (HIP) was used to increase its hydrophobicity. HIP is the preferred method of increasing an active ingredient's hydrophobicity, as the paired complex is not considered a new molecular entity and therefore does not require additional FDA approval. The initial characterization of the formulations includes measuring the size and zeta potential using dynamic light scattering (DLS). Then, the colloidal stability and encapsulation efficiency (EE) of the best formulations were determined. Finally, the best formulations will be tested in vitro to determine their release patterns.

Keywords:

[no keywords provided]

Mentor(s):

Kurt Ristroph (Engineering); Caleb Frederick Fretz (Agriculture)

Other Acknowledgement(s):

Radhika Arvind Bhopatkar (Engineering)

[†] Presenting Undergrad Author; † Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 3: 1:30-2:30pm

Evaluating Tactile Perception in Freely Moving Mice Through Paw-Based Texture Discrimination

STEM

Authors(s):

Hannah Jordan Margulis† (Engineering|JMHC)

Abstract:

Our perception of touch is utilized every day to make decisions relevant to our functioning. We rely on texture to determine what clothes to wear or the safety of surfaces we walk on. Previous research has proven mice are able to discriminate between textures using their whiskers. However, these studies rely on head-restrained mice for neural recordings and ignore tactile information from the paws, which limits the clinical translatability of results. To address these limitations, we developed a behavioral task that allows freely-moving mice to discriminate textures through their paws. Mice were trained to walk over two different textures and report which texture is rougher by navigating to the reward port on the corresponding side. The textures consist of 16 sandpaper of varying grits as well as a smooth acrylic that acts as a baseline. We hypothesize that mice will guickly and accurately discriminate between texture pairs utilizing their paws for tactile input. These behavioral results will be later paired with neural recordings utilizing a multi-channel neural electrode array on the same behavior task to identify texture representation and discrimination thresholds in sensory brain areas. Together, this data will allow for a stronger understanding of naturalistic, mutli-feature texture encoding in the brain. Knowledge of this representation of texture information will contribute to the development of next generation prosthetics which aim to replicate the naturalistic sensation that is required for everyday functioning.

Keywords:

Neuroscience; Somatosensory; Texture; Neural Networks

Mentor(s):

Megan Hope Lipton (Science); Maria Cristina Makin (Engineering)

Other Acknowledgement(s):

Lucy Anne Jurow (Engineering); Varun Aggarwal (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Expanding Specification Capabilities of a Gradual Verifier with Pure Functions

STEM

Authors(s):
Doruk Alp Mutlu†

Abstract:

Static program verification is a crucial process in software development, particularly for safety-critical systems. Unfortunately, static verification tools require precise and complete program specifications from users. which is burdensome and slows down the verification process. Gradual verification eases the software verification process by seamlessly combining static verification and dynamic verification allowing imprecise (partial) specifications. The only sound implementation of a gradual verification system is Gradual C0, which targets the C0 programming language (a safe subset of C). Gradual C0 supports recursive heap data structures such as linked lists, trees, etc. However, Gradual Co's specification language is lacking in expressibility, missing key features such as pure functions and quantifiers. Extending Gradual C0 with pure functions allows specifications on the values stored in data structures while hiding implementation details. To address these limitations of Gradual C0, we introduce pure functions to Gradual C0. First, we provide formal rules for pure functions in Gradual C0's Intermediate Verification language. Then, we plan to implement these changes in Gradual C0. Our design follows from the design of Viper, also using an axiomatization strategy as part of the pure function verification. Extending Gradual C0 with pure functions will allow rich functional specifications. Future work will explore the extension of Gradual C0 with quantifiers and a soundness proof for both extensions.

Keywords:

Gradual Verification; Static Verification; Pure Functions; Implicit Dynamic Frames

Mentor(s):

Jenna L Wise DiVincenzo (Engineering)

Other Acknowledgement(s): Pranshul Sardana (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Light Scattering Simulation using RCW GratingSTEM

Authors(s): Laksh Nagpal† (Engineering)

Abstract:

Simulating the scattering of polarised light is a critical tool in optics. nanofabrication, and materials characterisation. The SCATMECH C++ library and its Python wrapper, pySCATMECH, provide a comprehensive suite of models for simulating surface and volume scattering. However, the current command-line interface and documentation complexity present a steep learning curve for new users and researchers outside optics-specific fields. This project addresses the accessibility barrier by developing an interactive graphical user interface (GUI) for pySCATMECH, which enables users to configure models, input parameters, sweep angle ranges, and visualise results in both 2D and 3D. The interface dynamically queries model parameters and enables nested submodel setup. Key features include user-defined angular sweeps, real-time plotting of BRDF intensity, and CSV export of simulation results. Currently, the GUI would support several surface and particle scattering and grating intensity models and provides autoparameter completion based on documentation parsing. The tool has been tested across multiple scattering configurations and is able to reproduce results from existing command-line scripts with a simplified user experience. Future work will integrate parameter presets for common materials and automate simulation comparisons across wavelength ranges. By streamlining access to pySCATMECH's powerful scattering models, this GUI lowers the barrier for interdisciplinary applications of polarized light simulation in both research and education.

Keywords:

Optics; Light Scattering; Grating; Simulation; Python

Mentor(s):

Euiwon Bae (Engineering)

Other Acknowledgement(s):

Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Fabricating Nanoparticle Enhanced Membranes for Passive Membrane Dehumidification

STEM

Authors(s):

Ishan Gopu Nair† (Engineering); Lily Avery Waterman‡ (Engineering); Isaac Parks‡ (Engineering)

Abstract:

Dehumidification technologies are used to reduce humidity in many different contexts, ranging from residential applications to industrial applications. However, conventional condensation dehumidification technologies are energy intensive as they need to go through a phase change procedure to remove moisture. Membrane-based dehumidification is considered a top alternative. In passive membrane dehumidification (PMD), dehumidification occurs solely through the water vapor pressure partial pressure differences between two flow streams and eliminates the need for energy-intensive rotary components like compressors or vacuum pumps. This provides significant savings in energy use and cost. However, for an efficient operation, a membrane with high water vapor permeance and low thermal conductivity is desired for PMD. As reduced graphene oxide (rGO) granule foam is known for its lower thermal conductivity, a support layer of polyvinylidene fluoride (PVDF) and rGO was fabricated using the casting and phase inversion method. For high vapor permeation and selective gas permeation, graphene oxide (GO) with PEBAX-1657 was used to fabricate the active layer of the membrane. The use of hydrophilic nanoparticles improves dehumidification performance when compared with a control membrane without rGO filler. These results yield positive prospects for further application of nanoparticle-enhanced membranes for passive membrane dehumidification.

Keywords:

[no keywords provided]

Mentor(s):

Md Ashiqur Rahman (Engineering); David Warsinger (Engineering)

Other Acknowledgement(s):

Lipi Roy (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Human Body Communication IC & System Design STEM

Authors(s):

Khanh Nam Nguyen† (Engineering)

Abstract:

[Abstract Redacted]

Keywords:

[no keywords provided]

Mentor(s):

Shreyas Sen (Engineering); Lingke Ding (Engineering); Zhengbin Chen (Engineering)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Innovative Immunotherapy for Glioblastoma using hPSC-derived CAR-Neutrophils

STEM

Authors(s): Cillian Norton† (Engineering)

Abstract:

Glioblastoma (GBM) is a highly aggressive and malignant brain tumour with poor prognosis. While Chimeric Antigen Receptor (CAR) - T cells have demonstrated effective results in targeting certain forms of cancer. their success in treating glioblastoma tumours is greatly restricted by the Blood-Brain Barrier and Blood-Brain-Tumour Barriers. Neutrophils, which are innate immune cells capable of penetrating these barriers, already possess tumour-killing capabilities in the form of cytotoxic granules, reactive oxygen species and Neutrophil Extracellular Traps. As such. CAR-engineered neutrophils offer a potential new strategy for overcoming the limitations associated with CAR-T Cell Therapies. The clinical application of neutrophils has been limited due to their short lifespan and resistance to genetic modification. However, human pluripotent stem cell lines (hPSCs) offer a renewable source for generating neutrophils in vitro, allowing for genetic engineering and controlled differentiation. In this project, CAR-neutrophils were derived using engineered H9 hPSC lines using a chemically-defined cytokinedriven protocol. The resulting cells were characterised using molecular and cellular assays including flow cytometry analysis to confirm neutrophil-specific surface markers. Functional assays demonstrated that these CAR-neutrophils exhibit potent anti-tumour activity against GBM in-vitro. These findings suggest that CAR-neutrophils may provide an effective immunotherapy for the treatment of glioblastoma and potentially other severe diseases.

Keywords:

Neutrophil; Immunotherapy; Glioblastoma; Pluripotent Stem Cells

Mentor(s):

Jingqiao Shen (Engineering); Xiaoping Bao (Engineering)

Other Acknowledgement(s):

Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

A Systematic View of Extant Material Sustainability STEM

Authors(s):

Aarav Pasad† (Engineering)

Abstract:

Building materials are critical inputs to construction processes and can substantially impact sustainability outcomes. The considerable consumption of energy and resources from building construction, as well as the projected growth rate of the construction industry, makes material sustainability assessment an emerging necessity. A proliferation of approaches is in use today, such as Life-Cycle Assessment and Green Building rating systems. However, these assessments consider varying definitions and disparate criteria, preventing consistent interpretation of results. This provides an opportunity to unify current sustainability methods into a self-consistent and holistic material sustainability framework. To this end, this paper identifies and interprets extant material sustainability approaches through a systematic literature review (n = 1650) in accordance with PRISMA guidelines. A structured Scopus search is used to curate a credible and extant body of knowledge on material sustainability assessment. A hybrid thematic analysis supported by Natural Language Processing and clustering techniques is employed to distill recurring sustainability themes and develop a structured taxonomy. Metrics spanning technical, economic, and socio-cultural dimensions are extracted from certifications, standards, and peerreviewed literature, and mapped onto the identified taxonomy's thematic categories, highlighting critical gaps and inconsistencies in current sustainability assessment. The research identifies opportunities to advance material sustainability assessment practice by enabling a more rigorous and comprehensive evaluation of sustainability. It also provides an opportunity to localize assessment measures, offering valuable insights for building designers, researchers, and standards organizations.

Keywords:

Sustainability; Material Selection; Life Cycle Assessment; Green Building Rating System; Systematic Review

Mentor(s):

Joseph V Sinfield (Engineering); Jenna Nicole Palka (Engineering)

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Heterogeneous Integration/Advanced packaging STEM

Authors(s):

Son Quoc Son Phan† (Engineering); Timothy P Malloy‡ (Engineering|JMHC)

Abstract:

Solder joints play a crucial role in the structural and electrical interconnection between the semiconductor components within electronic assemblies. However, due to their micro-scale, structural complexity, and complex viscoplastic mechanical behavior, it is a challenge to maintain these expectations. For proper inspection and analysis, the reflow process—a thermal soldering technique used to make solder joint samples—and mechanical tests are implemented. The success of the reflow process depends heavily on proper flux control, solder ball alignment, and reflow temperature management, with common defects arising from poor glue application or uneven reflow conditions.

By implementing a closed-loop capacitively controlled sub-micron precision mechanical tester, nine monotonic tests and nine creep tests were conducted for 42SnBi-1Sb-1Ag solder alloy at three different temperatures, 30°C, 37.5°C, and 45°C. Monotonic tests were performed at three different strain rates, from 7.7 * 10^-5s^-1 to 7.7 * 10^-3s^-1, while creep tests were run at three stress levels, 5.17MPa, 10.35 MPa, and 15.52 MPa. The results from nine monotonic and nine creep tests are used to fit well-established viscoplastic constitutive models, including the Anand model and the Time hardening creep model, to predict monotonic and creep behaviors. The material parameters extracted from these constitutive models describe properties such as strain rate sensitivity, activation energy, and they can be used in future FEA simulations.

Keywords:

[no keywords provided]

Mentor(s):

Sean Yenyu Lai (Engineering); Ganesh Subbarayan (Engineering)

Other Acknowledgement(s): Parth Uday Kelkar (Engineering)

[†] Presenting Undergrad Author; † Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 3: 1:30-2:30pm

Epidemic Spike Prediction Using Networked Compartmental Model Dynamics and LASSO/Ridge Regression Estimation

Authors(s):

Juan Andres Puyo Montealegre†

Abstract:

The COVID-19 pandemic underscored the critical importance of timely preventive action in stopping the spread of infectious diseases. A central challenge in shaping effective policy responses is predicting when and how infection spikes will occur. Although agent-based models and neural network approaches have been widely employed for this purpose, their high computational demands and complexity can hinder rapid or largescale application. To explore a more computationally efficient alternative, we first implemented a networked classical compartmental model (SIRS) to assess its potential in predicting infection outbreaks. Epidemic spread was simulated over a large network, and dynamical parameters for the networked SIRS model were estimated using LASSO regression. We evaluated the robustness of this framework under varying noise conditions and small perturbations to the underlying network contact structure. Our results reveal that while the model is sensitive to noise and structural changes, often struggling to fully recover the system's true dynamics (with variable deviations of up to 30%), it consistently captures the timing of infectious peaks with reasonable accuracy. Moreover, a modified SIRS model (SVUIRS) was implemented, together with Ridge regression estimation, for comparability with an Agent-Based simulation. Despite presenting the same sensitivity and deviation problems as before, it was able to capture the influence of vaccination on the magnitude of infectious peaks. In conclusion, this study highlights the promise of using networked compartmental models combined with sparse regression techniques for rapid epidemic spike prediction. While further validation is needed, particularly in comparison to real world data and other established agent-based simulations, the approach offers a practical and light-cost foundation for scalable epidemic forecasting.

Keywords:

Infection Spikes; SIRS; SVUIRS; Agent-Based; Deviation

Mentor(s):

Shreyas Sundaram (Engineering); Philip Eugene Pare (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
Justin Linus Ren (Engineering); Varun Aggarwal (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Biphoton generations & Quantum optics STEM

Authors(s): Zheng Qing† (Engineering)

Abstract:

This project explores both experimental hardware design and theoretical quantum optics. In the first phase, I designed and fabricated a current control module for magneto-optical trap (MOT) applications. This task involved schematic and layout design of a custom PCB, mechanical fabrication of an aluminum enclosure, integration of thermal management using fan-assisted cooling, and low-noise circuit testing to ensure robust current stability for magnetic coils. The second phase focuses biphoton generation via four-wave mixing in cold atoms. Using perturbation theory and nonlinear susceptibility analysis, I modeled the biphoton wavefunction as a convolution of the system's optical responses. I analyzed its time-domain form to understand how phasematching, detuning, and nonlinear coupling shape the two-photon correlations observed in experiments.

Keywords:

[no keywords provided]

Mentor(s):

Xuanying Lai (Science); Christopher Hou Li (Science); Adi Bhatnagar (Engineering)

Other Acknowledgement(s):

David Matthew Czerwonky (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Lightsheet Imaging for pSmad in Zebrafish Epiboly with Optocontrols of BMP Receptors

STEM

Authors(s):

Rachel M Rivera†; Ian Kwan Yin Lam‡ (Science)

Abstract:

Bone Morphogenetic Protein (BMP) signaling plays crucial roles in diverse biological processes, including bone formation, tissue regeneration, and it has been identified as a major contributor in developmental biology. In Danio rerio (zebrafish), the BMP pathway is essential for establishing the dorsoventral axis during early embryogenesis. While many molecules within this pathway are known, the mechanisms by which they attenuate noise remain undefined. This research investigates noise attenuation and recovery using optogenetic control of BMP receptors during zebrafish embryonic dorsoventral patterning. We will employ light-induced dimerization of LOV domains fused to intracellular regions of BMP receptors. This optogenetic approach will enable us to have control over cellular differentiation and explore the complexity of systems in a reversible manner. Our primary tool for data collection will be light sheet imaging, which will allow us to visualize pSmad protein gradients under various conditions and the necessary data will be quantified from the images with computational collaboration. We anticipate observing increased pSmad activity corresponding to a greater number of signaling complexes, induced by the optogenetic activation of receptors. Light sheet imaging will also be used to monitor the embryo's recovery following optogenetic stimulation, providing insights into pSmad dephosphorylation rates under different light conditions. Data will be collected from both wild-type and optogenetically controlled embryos to compare pSmad levels. Future directions include quantifying images obtained from the light sheet and the data will contribute to analyzing noise origins in the BMP pathway, ultimately enhancing our understanding of this fundamental developmental process.

Keywords:

Bone Morphogenetic Protein (BMP) Signaling; Danio rerio (Zebrafish); Optogenetic Control; Light Sheet Imaging; pSmad Protein

Mentor(s):

Nissa Jo Larson (Engineering); Linlin Li (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Emily R Jakob (HHS)

Presentation Time: Session 3: 1:30-2:30pm

Material Characterization of Lithium-Ion Batteries and Fire Suppression in Thermal Runaway Events

STEM

Authors(s):

Alexander Rizk† (Engineering)

Abstract:

Lithium-ion batteries are valued for their high energy density, longer lifespan, and faster charging times compared to other batteries, including lead-acid and alkaline batteries. However, upon experiencing physical damage, exposure to excessive heat, or being overcharged or overdischarged, the batteries are prone to undergo thermal runaway: a self-sustaining cycle of heating which can lead to harmful gas production, ignition, and detonation. This research aims to develop a fire suppressant that can be dispersed upon a battery undergoing thermal runaway to halt the reaction and prevent the dangerous effects. The first phase of the research focused on various analysis techniques on charged and discharged batteries of varying number of cycles, including gas chromatography, fourier transform infrared spectroscopy, differential scanning calorimetry, and thermogravimetric analysis. These tests collected data such as onset temperature of thermal runaway and infrared spectra for material analysis. The second phase of the research will deal with producing fire suppressants out of foaming agents, phase change materials, and encapsulation agents. These will be tested on batteries undergoing thermal runaway in a combustion chamber built by the research group. Our analysis techniques from the first phase demonstrated that the volatility of a battery generally increases with each cycle and as a battery's state of charge increases. The combustion chamber tests will determine the effectiveness of our developed fire suppressants. This research addresses the issue of thermal runaway in lithium-ion batteries. Further research into suppression techniques is crucial to make lithium-ion batteries safer for use.

Keywords:

Lithium-Ion Batteries; Thermal Runaway; Fire Suppression; Material Characterization

Mentor(s):

Matthew William Vaughn (Engineering); Robert Edwin Ferguson (Engineering); Steven F Son (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Pranshul Sardana (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Constructing Spacecraft Trajectories in the Earth-Moon Region using Adaptive Trajectory Design Software

Authors(s):
Javier S Robinson†

Abstract:

Designing spacecraft trajectories in the Earth-Moon region requires complex models that accommodate the constantly shifting influence of both gravitational forces. Adaptive Trajectory Design (ATD) is a software package for constructing spacecraft trajectories – and transfers between them – using simplified models such as the circular restricted three body problem (CR3BP). It also includes a database of reference trajectories with existing real-world applications. Access to ATD is often requested by researchers in federal, industry, and educational settings. However, ATD's documentation is only suitable for users who already understand three body dynamics, severely limiting its accessibility. In particular, it lacks sample problems that would provide critical context for a wider range of users. Major additions to ATD's documentation will make it available to space mission design experts that may not be familiar with three body mechanics. Additionally, new trajectories will be generated and several existing NASA missions will be added to the database. The trajectories will be converted into the higher-fidelity ephemeris model. The documentation for ATD will be updated to thoroughly describe the process of adding trajectories, constructing transfers, and creating satellite constellations, assuming background knowledge of two body dynamics. ATD will, consequently, offer a lower barrier to entry and be more accessible. Additionally, ATD will include more reference trajectories that commonly occur in real research applications. The expectation is that ATD will reach a far wider userbase of mission design experts, researchers, and students, allowing all of them to participate in the design of trajectories for three body systems.

Keywords:

Three Body Mechanics; Circular Restricted Three Body Problem; Space Mission Design; Earth Moon Region

Mentor(s):

Kathleen Howell (Engineering)

Other Acknowledgement(s):
Dale Andrew Pri Williams (Engineering); Jay Singh (Engineering);
Pranshul Sardana (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Interactions of High Repetition Rate Subthreshold Nanosecond Pulses on Biological Cells

STEM

Authors(s):

Francisco Sebastiano† (Engineering); Nicodemus M O'Brian‡ (Engineering)

Abstract:

Electric pulses of sufficient duration and intensity can permeabilize cells through electroporation or induce cell death through apoptosis. This study will investigate the biological response to electric pulses below this threshold at high repetition rates, on the order of kilohertz, and unlikely to noticeably heat immortalized human leukemia cells. Cell viability and mitochondrial function are measured using trypan blue exclusion and tetrazolium salt (MTT) proliferation, respectively, 24 and 48 hours after exposure. Experimental results for the minimum repetition rate and number of pulses necessary to induce bioeffects are compared to simulated membrane pore formation. These results will demonstrate the relationship between pulse repetition parameters and bioeffect thresholds for trains of short duration, low energy electric pulses.

Keywords:

Electroporation; Apoptosis; Pulsed Power

Mentor(s):

Cameron James Buerke (Engineering); Andrew Joseph Romes (Engineering); Allen L Garner (Engineering); Ignacio G Camarillo (Science)

Other Acknowledgement(s): Parth Uday Kelkar (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Improving Intelligent Tutoring System Responsivity to Humans through Haptic Feedback

STEM

Authors(s):

Yilin Shao† (Engineering)

Abstract:

Adaptive intelligent tutoring systems (ITS) adapt to a human learner's cognitive state, such as self-confidence and mental workload through choosing when to assist based on tutoring objectives. In prior work, a psychomotor ITS for a quadrotor simulator was designed to adapt to learners by choosing when to assist in drone landing attempts. However, participants are only given visual indicator when they are assisted in a drone landing, which offers little transparency in the quadrotor simulator. Communication between the human learner and the ITS is a key component in instructing the learner, and this can be improved upon via multi-modal feedback. In this work, we provide haptic feedback to the learner in addition to an existing assistance algorithm, which determines when to provide automation assistance and tone of feedback, trained using self-confidence, workload, and learning stage Markov decision process models. With the addition of multi-modal feedback to the ITS, an updated assistance algorithm can be trained to intelligently assist a user when learning to land a quadrotor in a 2D simulator and decide when to use different forms of feedback. We designed and incorporated haptics onto the physical controller via Arduino microcontroller employing actuators to create vibrational cues that enhance realism and instructional clarity for the user. Additionally, several LEDs were used to provide supplementary visual augmentation. Through this multimodal feedback approach, we aim to facilitate clearer, more intuitive instruction, thereby improving overall learning outcome.

Keywords:

Intelligent Tutoring Systems; Multi-Modal Feedback; Haptic Feedback

Mentor(s):

Madeleine Shuhn Tsua Yuh (Engineering); Neera Jain (Engineering)

Other Acknowledgement(s):

David Matthew Czerwonky (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

4D Echocardiographic Assessment of Regional Strain in Acute Doxorubicin Cardiotoxicity

STEM

Authors(s):

Wilhelm S Smith†; Anna Julie Astrid Webb‡ (Science); Aasish Chowdary Karuturi‡ (Science|JMHC); Bea Olivia Cabot‡ (Science)

Abstract:

Doxorubicin, a powerful anthracycline chemotherapy drug, has been linked to cardiac dysfunction in 50% of patients post-cancer treatment. Cardiac strain is a sensitive metric for detecting dysfunction, but limitations in its measurement with 2D speckle-tracking echocardiography prevent robust regional assessment. Here, we aim to characterize regional left ventricular strain in a murine model of acute doxorubicin-induced cardiotoxicity using a novel 4D image analysis MATLAB program. Seven male C57BI/6J mice were injected intraperitoneally with doxorubicin (DOX; 25 mg/kg body weight dosage); 3 control mice were injected with equal volumes of saline. Echocardiography was performed for all mice at baseline before DOX injection and 2 days after; control mice and 3 DOX mice were also imaged at 7 days. To assess cardiac performance under exertion, a dobutamine stress test was performed for all non-baseline timepoints, reacquiring select images after dobutamine injection. 4D ultrasound images were obtained using the Vevo 3100 and analyzed using a MATLAB program developed by the Cardiovascular Imaging Research Laboratory at Purdue. Metrics of interest include regional and global longitudinal and circumferential strain; ejection fraction, left ventricular mass, and E/A wave ratio were also measured. This research hopes to further characterize the acute changes in cardiac strain induced by DOX; future work includes histological assessment and mass spectrometry imaging of cardiac tissue to further characterize injury and a more clinically relevant chronic investigation of cardiotoxicity in mice.

Keywords:

Doxorubicin; 4DUS; Ejection Fraction; Echocardiography

Mentor(s):

Benjamin Zeidler (Engineering); Cortland Hannah Johns (Engineering); Craig Goergen (Engineering); Emily R Jakob (HHS)

Other Acknowledgement(s):

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 3: 1:30-2:30pm

Solution-processed CISe/CIGSe thin film solar cells by a lowcarbon synthesis route

STEM

Authors(s):

Paul Spitz† (Engineering)

Abstract:

Solar energy is an abundant and renewable source that offers a sustainable alternative to help meet global energy demands. Currently, most of the solar energy production relies on silicon solar cells, which require higher temperature processing conditions and a thicker absorber layer. CuInSe2/Cu(In,Ga)Se2 (CISe/CIGSe) chalcopyrite-based materials have been promising inorganic semiconductors due to their potential for lower production costs and ease of manufacturing by solution techniques. One of the main chemistries used in solution processing is the amine-thiol system, which has shown high performance and broad dissolution capacity of binary and pure metals, but still limited power conversion efficiency. Typically, a sulfide precursor film is coated and subsequently annealed at high temperature in the presence of a chalcogen element to create a selenide film. However, this ion exchange mechanism is not fully completed and could lead to sulfur residue alongside carbon impurities, which hinders the possible further improvement in performance. Here, we explore a different method for creating selenium-containing sulfur-free precursor inks using selenourea as a selenium source and primarily using dimethyl formamide as a solvent. The selenourea forms adducts with the metal precursors in the solution, forming our desired CISe/CIGSe phases. These phases, obtained by molecular processing conditions of this chemistry, are more focused on the development of thin films and further applications in solar cell devices. Using Raman spectroscopy, x-ray diffraction, and scanning electron microscopy at multiple steps, we will analyze film morphology and molecular composition to obtain suitable absorber layers with decent opto-electronic properties.

Keywords:

Solar Cell; CIGS; Solar Energy; Selenourea

Mentor(s):

Jhoan Andres Ruiz Velasquez (Engineering)

Other Acknowledgement(s): Lipi Roy (Engineering); Shubhanshu Agarwal (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Examining Myh9a Function and Localization in Zebrafish Wound Closure Utilizing PhiC31-CRISPR-Cas9 Knock-In Line Methods

STEM

Authors(s):
Morgan Stephens† (Science|JMHC)

Abstract:

Would closure is driven by the actomyosin ring, through the recruitment of actin filaments and myosin motor proteins to the damaged site. Myosin itself is known to provide the contractive force behind this process. In our zebrafish model, we aim to observe this process in by targeting the nonmuscle myosin gene myh9a that is involved in tail contraction, as the mechanisms that are utilized by myh9a in the process of wound closure are not understood. This research aims to better understand these functions of myh9a. This study utilizes a two-step Knock In (KI) method with the PhiC31-CRISPR Cas9 recombination system in examining myh9a receptor interactions. The first step is the generation of an attp KI line, followed by the injection of an attB plasmid into the attp line. This integration is directed through site-specific attp-attB DNA recombination and is performed by inducing DSBs to the last few introns to lower disruption in the translation of the endogenous protein. Endogenous gene tagging can be used to examine these expressions and to study protein localization within a cell. Through utilizing myh9a that has been tagged with a green fluorescent protein (GFP) or red fluorescent protein (RFP), these interactions of myh9a with receptors and proteins can be tracked in the epithelial skin layers. Overall, the aim of this work is to observe and determine the roles of myosin gene myh9a in Zebrafish wound closure.

Keywords:

CRISPR-Cas9; Knock-In Lines; Myh9a; Wound Closure

Mentor(s):

Chang Ding (Science)

Other Acknowledgement(s): Emily R Jakob (HHS)

Presentation Time: Session 3: 1:30-2:30pm

Predicting St Joseph River Plume Behavior Using Satellite-Derived Observations and Hydro-Meteorological Measurements

STEM

Authors(s):

Ethan Scott Streckfuss† (Agriculture|Engineering|JMHC)

Abstract:

The Great Lakes provide drinking water and recreational use for millions of people, thus it is important to maintain high water quality. River plumes introduce new pollutants to the water, which can have implications for human health and the aquatic ecosystem. Despite the amount of research conducted on oceanic river plumes, plumes released into freshwater lakes are still not well-understood, and vary in important ways from their oceanic counterparts. This study aims to leverage highresolution satellite imagery and environmental data in order to characterize Lake Michigan river plumes and increase knowledge of plume boundaries, movement, and water quality. An algorithm was created to automate the detection and measurement of the St Joseph River plume from 3 meter spatial and 1 day temporal resolution satellite imagery. This algorithm utilizes Normalized Difference Water Index and Normalized Difference Turbidity Index spectral indices to separate land from water, then clear water from turbid water, creating clean boundaries of river plume presence. In addition to plume detection, data including river discharge, temperature, and wind were analyzed. These parameters, in conjunction with the satellite imagery, are incorporated into an empirical model to predict plume presence, size, and direction without satellite imagery input. The model demonstrates skill in capturing plume characteristics on environmental forcings. Combined results show that larger plume sizes typically occur with higher peak discharge events, as well as stronger wind speeds. It is concluded that satellite imagery can properly be used with environmental data to characterize and measure plume size and movements.

Keywords:

[no keywords provided]

Mentor(s):

Kendahl R Hejl (Engineering); Cary D Troy (Engineering)

Other Acknowledgement(s):
David Matthew Czerwonky (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Investigating the Response of Human Lung Fibroblasts to the Mechanical Strain of Respiration

STEM

Authors(s):

Eliza Louise Thurs† (Engineering); Angelica Sofia Gonzalez-Ng‡ (Engineering); Maria Macias‡ (Engineering)

Abstract:

The lung is one of the most common sites of metastatic spread across cancer types. Human lung fibroblasts (HLFs) play a pivotal role in metastatic disease progression by remodeling the extracellular matrix (ECM) to create a more favorable environment for cancer cell colonization. Although HLFs are known to aid metastasis, limited research has explored how cyclical mechanical strain from respiration affects their viability and ECM production, two factors that are closely tied to cancer progression and detection. This study uses fibronectin to simulate the in vivo metastatic lung microenvironment and enable a more physiologically relevant analysis of cellular response to mechanical strain. The goal is to assess how cyclical loading affects HLF viability and ECM output over time. HLFs were cultured and adhered to fibronectin-coated bands mounted on magnetic actuators capable of controlled deflection. At days 1, 3, and 6, subsets of cells were stained using a live/dead assay and imaged with BioTek and confocal microscopy where live cells fluoresced green and dead cells fluoresced red. Following imaging, each actuator is placed on a platform that continuously stretches the band until failure. Band deflection is measured using a high-precision laser to infer ECM production through mechanical resistance. Image analysis will quantify cell viability at each time point. Deflection data will indicate changes in ECM output due to cyclical loading. Together, these results will help characterize the mechanical sensitivity of HLFs and offer insights into how respiration dynamics may influence cancer cell colonization in the lung.

Keywords:

[no keywords provided]

Mentor(s):

Madison Mckensi Howard (Engineering); Luis Solorio (Engineering); Juan Camilo Mesa Agudelo (Engineering)

Other Acknowledgement(s): Parth Uday Kelkar (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Rheological Characterization of Fungal Mycelium Gels for Soft Electronics Technology

STEM

Authors(s):

Reece Avery Tippery† (Engineering)

Abstract:

Historically, electronic systems have been developed from rigid materials, limiting their use in certain applications, like healthcare and wearables which require soft materials that can more comfortably interact with biological organisms. While synthetic polymers have been used to fill these roles, they are often used in a disposable fashion and require the refinement of fossil fuels to produce. The electrical properties of fungal mycelium show promise in solving both of these issues, providing a renewable and soft material for use in electronics. However. their mechanical properties as bulk materials or with reinforcement remain to be characterized. In this study, shear rheometry was used to characterize the mechanical response of fungal mycelium in both small and large amplitude oscillatory shear and compression. Non-reinforced fungal mycelium showed a low degree of linear elasticity, and largely viscoelastic and poroelastic behavior under compression. Sodium polyacrylate reinforced mycelium gels showed improvement in both these areas, being more elastic and retaining water to a greater degree. These results indicate that while pure mycelium gels have the disadvantage of a small elastic regime and low water retention, these problems can be mitigated by polymer reinforcement.

Keywords:

Materials Science; Rheology; Gel; Wearable Technology

Mentor(s):

Matthew Kaboolian (Engineering); Kendra A Erk (Engineering)

Other Acknowledgement(s):

Emily R Jakob (HHS)

Presentation Time: Session 3: 1:30-2:30pm

Urban stressors and male-male interactions: The impact of ALAN and traffic noise on male Eastern Gray Treefrogs' phonotactic responses

STEM

Authors(s):

Susana Torres Gnecco†

Abstract:

Urbanization is one of the most significant threats to biodiversity and a primary source of sensory pollution. Artificial light at night (ALAN) and traffic noise affect the physiology, behavior, and reproduction of many species. Amphibians are experiencing global population declines, and previous research has shown that sensory stressors affect both female and male reproductive behaviors, but little is known about their effect on male-male interactions. We aim to determine how ALAN and anthropogenic noise affect males' phonotactic responses to acoustic stimuli. This behavior can be essential for territorial defense, breeding site selection, and reproductive success. We also aim to examine how the effects of these sensory pollutants are magnified when combined. compared to when presented individually. Eastern Gray Treefrog (Hyla versicolor) males were collected at different breeding sites in the Greater Lafayette area, IN. Phonotaxis tests consisted of recording the males' movement patterns and calling behavior in response to heterospecific and conspecific playbacks under four different treatments: control, noise (at 80dB level), ALAN (at 5 lux) and ALAN + noise. These intensities aimed to mimic real-life conditions that frogs experience as urban areas expand. We expect that the presence of stressors will increase response times and reduce the likelihood that a male approaches a caller, indicating a greater impact when the stressors are present together. This study contributes to our understanding of how sensory pollutants affect male phonotactic responses to acoustic signals and highlights potential effects of multiple stressors, resulting in beneficial information for habitat management and urban planning policies.

Keywords:

Sensory Pollution; Phonotaxis; Amphibian Behavior; Urbanization; Male-Male Interactions

Mentor(s):

Ana Maria Ospina Larrea (Science); Ximena Bernal (Science)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Building Model to Evaluate Multi-functional HVAC Platform with Modular Thermal Storage

STEM

Authors(s):

Allen Joseph Vidallon† (Engineering)

Abstract:

The temperature inside residential buildings can be predicted with existing software programs such as EnergyPlus and TRNSYS. While these programs provide highly accurate results, they are often unnecessarily complex for preliminary control synthesis and validation. This work aims to develop a low fidelity building model that runs faster than high fidelity models while capturing the dominant dynamics within a building. The model is intended to evaluate candidate control schemes based on energy consumption, HVAC operating cost, and temperature setpoint error. A grey box model is used that incorporates physics-based mass and energy balance equations that account for the various modes of empirical heat transfer within the zone. A residential house that consists of one floor and five rooms acts as the simulated building, where a zonal model approach treats each room as a control volume. The model considers the operation of the HVAC system, the ambient temperature, adjacent zones, and the number of occupants and of appliances within a zone when calculating the corresponding rates of energy transfer. The proposed building model is designed to deliver an accurate temperature prediction for each room in a timely manner. The implementation of the model enables rapid evaluation of HVAC control systems, facilitating reducing energy consumption and operating costs.

Keywords:

HVAC Control Validation; Grey Box Building Model; Transient Finite Volume Method

Mentor(s):

Demetrius Gulewicz (Engineering); Neera Jain (Engineering)

Other Acknowledgement(s):

David Matthew Czerwonky (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Computer Vision for Real-Time Cellist Postural Correction STEM

Authors(s):

Ziang Wang† (Science); Shrinand Perumal‡ (Science); Luke Jaehyeon Choi‡ (Science|JMHC); Michael X Zhang‡ (Engineering); Benjamin Joseph Taylor* (Engineering|JMHC); Jackson Patrick Shields* (Science); Ekaterina Tszyao* (Science); Atharv Kharbanda* (Science); Bisti Sunil Potdar* (Science); Sivamurugan Velmurugan* (Engineering|Science); Michael Alexander Ikriannikov* (Science); Joseph Issac Getachew* (Science); Mukund Sanjay Rao*

Abstract:

A significant proportion of musicians will sustain musculoskeletal injuries in their career, with suboptimal posture frequently cited as a primary contributing factor. To reduce the risk of injuries due to poor posture for practicing cellists, we introduce Cello Evaluator, a system designed to identify key errors in postural form, including the supination of the wrist, the height of the elbow and shoulder, and the placement of the bow relative to the strings of the cello. Our approach uses Google Mediapipe for tracking hand and shoulder locations of the user and YOLOv11 for tracking the bow and strings. The coordinate points generated by these models are then used for classification: 1) two deep neural networks assess the correctness of the wrist and elbow posture 2) linear algebra techniques are applied to evaluate shoulder height, bow positioning, and bow angle. Using these features, we present an application able to identify and correct cellist posture in both real time and pre-recorded videos, thereby reducing the risk of injury for practicing cellists using our system. Future improvements would include implementing the models into mobile for improved privacy and optimizing current models for faster and more accurate inference.

Keywords:

Computer Vision; Machine Learning; Music

Mentor(s):

Yung-Hsiang Lu (Engineering); Yeon Ji Yun (Liberal Arts); Zihao Ye (Engineering)

Other Acknowledgement(s):

Varun Aggarwal (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: Session 3: 1:30-2:30pm

Construction Worker Trajectory Modeling and Prediction for Workzone Safety

STEM

Authors(s):

Nathan Daniel Weston† (Engineering)

Abstract:

For over a decade, the construction industry has ranked the highest in the number of worker deaths among all industries. New technological developments prompt an opportunity for construction safety to be improved. This ongoing research aims to improve construction safety by incorporating technologies like real time sensors, digital models, and artificial intelligence (AI) models to predict and warn construction workers entering dangerous areas. To accomplish this, a custom GPS system is developed, including a camera, which can detect the location of workers, and a GPS receiver, which will be placed on the camera. The combined information from the camera and GPS receiver can determine the GPS coordinates of workers. These coordinates are uploaded to a digital model of the construction project, which models the workers' positions in real time. Furthermore, an Al model uses these coordinates in the digital model to predict the trajectory of the workers into the near future. Using risk analysis, another Al model determines if a worker might enter a dangerous area. If the model determines the worker is entering dangerous areas, a real time warning is issued to the workers. Early results show the GPS receiver measures coordinates accurately and the camera can detect humans. Also, the digital model can receive real time GPS coordinates. Future research will develop accurate AI models and improve the current GPS system. Also, future research will test on real construction jobsites. Although incomplete, this research shows safety improving technology is integrable on construction sites.

Keywords:

Construction; Safety; Artificial Intelligence; Digital Twin; Smart Workzone

Mentor(s):

Woei-chyi Chang (Engineering); sogand Hasanzadeh (Engineering)

Other Acknowledgement(s):

Radhika Arvind Bhopatkar (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Morphological Effects of Clozapine on Astrocytes STEM

Authors(s):

Lucille Mattingly Whyman† (Science)

Abstract:

Although psychiatric disorders are extremely prevalent in the population. pharmacological research in this field has been limited over the last several decades. One medication called clozapine, an anti-psychotic used to treat schizophrenia, was discovered in the mid-1960s, but it is still not well studied. Since clozapine is the most effective drug for many with treatment-resistant schizophrenia, it is crucial to learn more about its effects. This research aims to determine the morphological effects of clozapine on astrocytes. Astrocytes derived from human induced pluripotent stem cells (hiPSCs) were grown to maturity and treated with clozapine to see how the morphology changed. The three concentrations of clozapine used were 800ng/ml, 1600ng/ml, and 3200ng/ml in complete astrocyte media. These astrocytes were treated for 7 days and imaged on each of these days. Following treatment, cell painting was performed to see the effects more clearly. The following study compares the morphology of astrocytes before treatment with clozapine to those who have been treated for a week. This mimics clinical clozapine exposure to identify astrocyte-specific responses to this medication. This study may give insight into why clozapine is effective, and it could allow for further research into medications that are potentially safer and/or more effective.

Keywords:

Clozapine; Astrocytes; Schizophrenia; Cell Painting

Mentor(s):

Ayomide Olohigbe Unuigbokhai (Science); Matthew Thomas Tegtmeyer (Science)

Other Acknowledgement(s):

Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Synthesis of a Semiconducting Organic Conjugated Ladder **Polymer through Saponification and Lactonification**

Authors(s): Reed M Woolard† (Science)

Abstract:

Conjugated ladder polymers are distinct from conventional polymers as their repeating units are attached by two bonds to each other, giving them a double-stranded and ladder-like structure. When these polymers have uninterrupted conjugation in their backbone, they are categorised as conjugated ladder polymers. The polymers of this type have greater thermal stability and often give more delocalised polarons in their doped state, thanks to their rigid and planar structure. However, the design and synthesis of new conjugated ladder polymers are challenging because of their rigid fused backbone and double-stranded structure, which require harsh reaction conditions and result in mostly insoluble polymers. In this study, we investigated the degradation of the highly conductive polymer n-PBDF followed by reformation into a conjugated ladder polymer PCCD via UV-VIS-NIR photospectrometry, NMR spectroscopy, and mass spectrometry. Well-defined small molecule study confirms that under the same degradation conditions, BDF-based oligomers also degrade and reform into CCD-based ladder oligomers. Despite being a ladder-type conjugated polymer, PCCD showed fused ring opening and closing reversibility, which is also confirmed in CCD-based ladder oligomers. giving the polymer recyclability.

Keywords:

[no keywords provided]

Mentor(s):

Uttam Pal (Science); Jianguo Mei (Science)

Other Acknowledgement(s):

Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

QFedLib – A Quantum Federated Learning Framework with Fully Homomorphic Encryption for Efficient Data Privacy

Authors(s):

Alan S Yi† (Science); Daniel Anoruo†

Abstract:

The success of machine learning in healthcare relies on access to large, diverse datasets. Strict privacy and ethical regulations often hinder the ability to share data between different domains, such as manufacturing and drug design, which makes it difficult to train centralized machine learning models. To overcome this challenge, we propose decentralizing the data and training the models locally. This framework is known as federated learning (FL), where models are distributed and trained among multiple domains, and then each model is combined into a refined version (Dutta, 2024). In our most recent example of FL in hospital settings, each hospital trains models locally before their weights are sent to a server for aggregation between different clients (Bhatia, 2024). This research aims to build upon existing architecture by providing a federated learning framework for securing data between multiple clients through fully homomorphic encryption (FHE) and speeding up the process with quantum neural networks (QNNs). Enhancing federated learning with fully homomorphic encryption (FHE) ensures that even the model updates remain encrypted during transmission and aggregation. providing stronger end-to-end privacy protection (Bhatia & Bernal Neira, 2024). To simulate this process, we built a library that integrates the quantum-computing framework Pennylane (Bergholm et al., 2018) with the Pytorch-based federated-learning framework Flower (Beutel et al., 2020), all while utilizing fully homomorphic encryption to mask the data for further security. We benchmark FHE-QFL against centralized learning (CL) and traditional FL on various medical classification tasks, such as DNA and brain tumor MRI datasets. Our FHE-QFL models show AUC-ROC scores within 3% of traditional methods, demonstrating that quantum-enhanced federated models can enhance security while maintaining high accuracy.

Keywords:

Quantum Machine Learning; Federated Learning; Fully Homomorphic Encryption; Medical Classification

Mentor(s):

Yirang Park (Engineering); David Esteban Bernal Neira (Engineering)

Other Acknowledgement(s):

Parth Uday Kelkar (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Robust Message-Passing for Decentralized Machine Learning under Communication Constraints

STEM

Authors(s):

Peter Zakariya† (Science)

Abstract:

Sensor networks are systems that collaboratively monitor an area, collecting and processing data in harsh environments with limited communication. Integrating machine learning with sensor networks enhances real-world applications such as remote wildlife monitoring or anomaly detection for security around a building. The challenges of a harsh environment motivate the need for robustness under restricted bandwidth. To understand the effects of different approaches in this setting, we simulated sensor networks with an image segmentation task. where each pixel is a node and the communication topology is created through Erdos-Rényi or spatial grid generation to represent different network structures. During each communication round, nodes are constrained to send one message to one neighbor. Nodes are able to aggregate partial information to create a representation of their surrounding environment; in our simulation, nodes create a corrupted version of the original image. U-Net models were leveraged to predict the pixel's label at a node's location, and as expected, accuracy improves over communication rounds. Sending only one pixel in a message is inefficient, motivating the need for using techniques to encode more than just raw information in a message. One technique being explored is wavelet transforms, a signal compression technique commonly used in image compression. Further strategies are explored to prioritize selecting neighbors who would gain the most information from the message to increase the information exchanged per communication round. This research advances the application of decentralized learning to real-world scenarios with limited communication between devices, where maximizing the information of each message is crucial.

Keywords:

Machine Learning; Deep Learning; Decentralized; Networks; Sensors

Mentor(s):

David Iseri Inouye (Engineering); Mai Elkady (Science)

Presentation Time: Session 3: 1:30-2:30pm

The Effect of ADAMTS10 Mutation on IOP-Associated Optic Neuropathy in Canine Glaucoma

STEM

Authors(s):

Haley Jane Harmeson† (Agriculture); Liam Andrew Clarke* (Science)

Abstract:

Glaucoma is one of the leading causes of irreversible blindness in both humans and canines. Increased intraocular pressure (IOP) and its negative impact, such as apoptosis and degeneration on retinal ganglion cells (RGCs) and the optic nerve, is a primary risk factor for glaucoma. In comparison to dogs with other forms of glaucoma, clinical observations suggest that Beagle dogs that display ADAMTS10 mutations may exhibit more favorable visual outcomes despite elevated IOP. However, it remains unclear whether this clinical impression reflects an intrinsic effect of the ADAMTS10 mutation, the gradual elevation of IOP typically seen in this form of glaucoma, or other unknown factors. From previous studies, our group developed a canine ocular hypertensive glaucoma model with controlled IOP elevations, allowing consistent application of the same magnitude and duration of IOP elevation. In this model, the target IOP range of 36-45 mmHg can best resemble the human glaucomatous disease mechanism. Using this preliminary model, we induced controlled ocular hypertension to compare its effects on glaucoma progression between ADAMTS10-mutant (n=1) and nonmutant (n=1) dogs. The progression of glaucoma was evaluated based on optical coherence tomography (OCT), electroretinography (ERG), fundus photography (Retcam), maze vision testing, and histopathology. Preliminary in vivo results include (1) ADAMTS10-mutant dog showed dramatic fundus photography changes including altered tapetal reflectivity during IOP elevation. (2) The ADAMTS10-mutant dog showed decreased ERG values and decreased visual performance in maze vision testing. (3) In OCT, subjectively, the ADAMTS10-mutant dog appeared to have more retinal thinning. Unlike the clinical impression, when the same magnitude and duration of IOP elevation was induced. ADAMTS10-mutant dog might be more susceptible to IOP-induced optic neuropathy.

Keywords:

Glaucoma; Optic; Neuropathy

Mentor(s): Shin Ae Park (Vet Med)

Other Acknowledgement(s): Oluwabunmi T Oladele (Vet Med); Hyerim Ra (Vet Med); Andras Komaromy (Michigan State University)

Presentation Time: Session 3: 1:30-2:30pm

Immunolocalization of a Rhoptry Protein, SnROP21, in the Merozoite and Schizont Stages of Sarcocystis neurona STEM

Authors(s): NaLaya Lee†

Abstract:

Sarcocystis neurona, a protozoan responsible for a debilitating neurological disease called equine protozoal myeloencephalitis, undergoes asexual replication in the central nervous system of the horse. This replication involves two developmental stages: extracellular merozoites and intracellular schizonts. Interestingly, these stages in S. neurona lack a specialized apical secretory organelle called rhoptries, but several rhoptry proteins (ROPs), including SnROP21, were identified in the transcriptome and proteome of S. neurona. In related protozoans, rhoptry proteins typically localize to and are discharged by rhoptries to participate in host-parasite interactions. This prompted questions about rhoptry protein localization and their functional roles in S. neurona in the absence of rhoptry organelles. In this study, we have used a transgenic S. neurona line expressing a C-terminal hemagglutinin (HA)-tagged SnROP21 (SnROP21-HA) to perform immunolocalization assays. Bovine fibroblast monolayers on cover glasses were infected with S. neurona merozoites that transformed into schizonts upon invasion. Cover glasses with intracellular schizonts at four different timepoints over a 72-h period of development were collected. Merozoites on poly-L-Lysine-coated glass slides and intracellular schizonts were fixed and processed by probing with anti-HA antibodies to localize SnROP21. In extracellular merozoites, SnROP21 was localized predominantly to the apical pole. In the schizonts, SnROP21 showed temporal expression, with it being undetectable at the 48 h timepoint but showing granular cytoplasmic distribution at other timepoints. This dynamic expression of SnROP21 suggests a unique role that might be temporally regulated. Further studies on SnROP21 will enhance our understanding of its role in S. neurona biology and host-parasite interaction.

Keywords:

Horses; Equine Protozoal Myeloencephalitis; Sarcocystic Neurona; Rhoptries; Immunofluorescence

Mentor(s):

Sriveny Dangoudoubiyam (Vet Med)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Annapoorani Jegatheesan (Vet Med); Yaileen Eysmarie Aponte (Vet Med)

Presentation Time: Session 3: 1:30-2:30pm

Mechanical Testing of Equine Laminae Samples STEM

Authors(s):

Emily Elizabeth Rastovski† (HHS)

Abstract:

Equine laminitis is a condition that causes extreme pain, suffering, and can result in euthanasia of horses on humane grounds. Failure of the laminar junction, which connects the hoof wall to the distal phalanx, is the mechanism responsible for clinical manifestation of laminitis. However, there is limited data published comparing healthy and laminitic mechanical strength. Samples of laminae collected from euthanized horses can be mechanically tested in vitro using a materials testing system that measures maximum load supported by the laminae. Furthermore, the effects of storage conditions on the strength of lamina samples are unknown. This study includes two aims: 1) to determine if different storage conditions affect mechanical testing results and 2) to determine differences in load-bearing properties between healthy and laminitic tissue. We hypothesized that 1) there would be no difference in mechanical testing results among refrigerated, incubated, or frozen tissue and 2) laminar strength would be lower in laminitic tissue compared to healthy tissue. Here, we first examined the differences in laminar tensile strength over time in differing storage conditions. Then, differences in laminar strength between healthy and laminitic tissue were investigated. In the first phase of this study, hoof samples were collected after euthanasia and divided between refrigerator, incubator, and freezer storage (all within 2 hours post-mortem). Refrigerated and incubated samples were randomly chosen to be tested at n=8 time points over 72 hours following time of death. Freezer samples were thawed at room temperature for 6 hours, then tested at n=8 time points over the next 72 hours post-thaw. Mechanical testing involved incising samples to fit within a jig, which was placed onto the materials testing apparatus. Once testing began, the machine pulled the sample apart vertically at a rate of about 1mm/second until it reached a set displacement endpoint. Measurements of maximum force sustained by laminae over the testing period were recorded. Results from this study will provide a foundation for future research investigating laminitis in horses.

Keywords:

Laminitis; Mechanical Testing

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Mentor(s): Sandra D Taylor (Vet Med); Timothy B Lescun (Vet Med)

Other Acknowledgement(s):
Alexandra Ines Johan Usimaki (Vet Med)

Presentation Time: Session 3: 1:30-2:30pm

Investigating IL-17A-Driven Tertiary Lymphoid Structure Cytokine Expression in Canine Bladder Cancer Cells STEM

Authors(s):
Brayden Spurlock†

Abstract:

Tertiary lymphoid structures (TLS) are immune aggregates associated with improved prognosis in various human cancers, including invasive urothelial carcinoma (transitional cell carcinoma (InvTCC)) of the urinary bladder. TLS formation is orchestrated by chemokines such as CXCL13 and CCL21, typically induced by pro-inflammatory cytokines, including interleukin-17A (IL-17A), produced by stromal fibroblasts and immune cells. In human and murine models, IL-17A signaling promotes TLS development and enhances anti-tumor immune responses. However, the extent to which this pathway functions in canine tumors remains unclear. Here, we investigated IL-17A-induced expression of TLS-associated chemokines and angiogenic factors in five canine InvTCC cell lines (AxA, AxC, Nk, Original (K9TCC), and Sh) in vitro. Cells were treated with recombinant IL-17A, and quantitative PCR was used to assess expression of IL-17RA, CXCL13, CCL19, CCL21, CXCL12, and VEGF, normalized to 18S RNA. IL-17RA expression was low or undetectable in most lines. Neither CXCL13 nor CCL21 showed significant upregulation following IL-17A treatment, and CCL19 exhibited variable low-level expression. VEGF was consistently expressed, but was unaffected by IL-17A treatment. These findings suggest IL-17A alone is insufficient to induce TLS-associated chemokine expression in canine tumor cells under monoculture conditions, suggesting that stromal or immunederived signals are necessary for full TLS pathway activation. In contrast to established IL-17-driven TLS induction models, these results underscore species-specific or context-dependent differences in IL-17 signaling. Our study reveals a knowledge gap in canine cancer immunobiology, supporting the future use of co-culture models incorporating stromal and immune cells to more accurately model TLSinducing pathways in canine InvTCC anti-tumor responses in vitro.

Keywords:

IL-17; Canine; Cytokine; TLS; Cancer

Mentor(s): Meaghan M Broman (Vet Med)

Other Acknowledgement(s): Chennan Li (Science); Deborah W Knapp (Vet Med); Deepika Dhawan (Vet Med)

Presentation Time: Session 3: 1:30-2:30pm

Validation and Temporal Analysis of Differentially Expressed MicroRNAs in Horse Serum Following Intravenous Lipopolysaccharide Administration

STEM

Authors(s):

McKinley Kathryn Underhill† (Agriculture|JMHC)

Abstract:

Sepsis remains one of the leading causes of mortality in horses and presents significant diagnostic challenges, particularly in its early stages. MicroRNAs (miRNAs), small, non-coding RNA molecules that regulate gene expression, offer a promising avenue for early detection of sepsis before clinical signs become evident. However, limited research exists on the role of miRNAs in equine sepsis. Our preliminary analysis identified several miRNAs that were significantly upregulated or downregulated in response to the LPS challenge. Blood plasma samples were collected from horses before and after LPS administration, and digital PCR was used to quantify changes in specific miRNA expression. The aim is to identify miRNAs that are differentially expressed in horses during experimentally induced sepsis via lipopolysaccharide (LPS) infusion. These findings suggest that certain miRNAs may serve as potential biomarkers for the early detection of sepsis in horses. Further research is needed to validate these candidates in clinical cases. Ultimately, understanding miRNA dynamics in sepsis could contribute to faster and more accurate diagnostics, as well as improved outcomes, for equine patients.

Keywords:

[no keywords provided]

Mentor(s):

Andrea Pires dos Santos (Vet Med)

Presentation Time: Session 3: 1:30-2:30pm

Optimizing Data Corruption Sensing for MRAM STEM

Authors(s):

Andrew Yu-en Loh† (Engineering)

Abstract:

[Abstract Redacted]

Keywords:

[no keywords provided]

Mentor(s):

Isaac P Hagedorn (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Quantifying Musical Complexity for Automatic Music Transcription: A Correlation Analysis of Human Perception and AMT Performance

STEM

Authors(s):

Franklin Shang† (Science)

Abstract:

Automatic Music Transcription (AMT) systems face significant challenges when processing complex musical pieces, but the specific musical characteristics that contribute to transcription difficulty remain poorly understood. This research investigates the relationship between human perception of musical complexity and AMT transcription accuracy by correlating established complexity metrics with transcription performance across multiple AMT models.

We analyze three key dimensions of musical complexity: polyphonic (simultaneous notes), rhythmic (timing patterns), and harmonic (chord structures). For each dimension, we implement computational metrics validated in human perception studies, including maximum polyphony, inter-onset interval variance, and chord complexity measures. These metrics are applied to datasets, and their values are correlated with transcription accuracy scores from seven different AMT models (CREPE, Sound2MIDI, MT3, Transkun, Bytedance, Basic Pitch, and ReconVAT).

Our preliminary results show strong correlations between certain complexity metrics and transcription accuracy. This research contributes to understanding what makes music challenging for computational transcription systems and provides insights for improving AMT model performance. The findings can guide model selection for different types of music and inform the development of more robust transcription algorithms.

Keywords:

Automatic Music Transcription; Music Information Retrieval; Machine Learning

Mentor(s):

Yung-Hsiang Lu (Engineering); Ojas Chaturvedi (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Battle of the Scanners: Comparing QCT to the Volscan Profiler 300

STEM

Authors(s):

Neely JoAnne Brown† (Agriculture); Anna Rachelle Hardesty† (Agriculture); Emily Rose Mawhorter† (Agriculture|JMHC); Gabriella Anna Tysse Levine‡ (Agriculture); Olivia Katherine Sullivan‡ (Agriculture)

Abstract:

Quantitative computed tomography (QCT) has been widely used in keel bone research to assess fractures and deviations; however, its utility in producing complete quantitative surface measurements is limited. The QCT is a costly scanning option that is often inaccessible because it is commonly located in either hospitals or medical imaging centers. The Volscan Profiler 300, a tool previously applied for both the qualitative and quantitative analysis of food products, may offer a viable alternative. This study aimed to evaluate the Volscan's potential to become an alternative to QCT for generating quantitative keel bone surface data. Initially, the Volscan protocol was created by scanning a smooth oval object to confirm the system's functional capabilities. 3D-printed keel models were then scanned to establish optimal scanning parameters that would apply to an asymmetrical object. After trial and error, these parameters were then applied to organic keel bones to validate the Volscan's ability to produce accurate numerical data and a representable 3D image. Through manual verification, it was confirmed that the Volscan produced highly accurate quantitative measurements with minimal error margins. However, this accuracy came at the expense of the clear resemblance the QCT provided for the scanned keels. Despite the poor digital reconstruction of the keel supplied, the strong performance in quantitative data acquisition suggests the Volscan Profiler 300 is a promising alternative to QCT for keel bone analysis.

Keywords:

Keel Bones; Volscan; Poultry; QCT

Mentor(s):

Sara Elizabeth Cloft (Agriculture); Darrin M Karcher (Agriculture)

Presentation Time: Session 3: 1:30-2:30pm

Organic Synthesis of Halogenated Furanone Natural Products from Delisea Pulchra

STEM

Authors(s):

Olivia Rae Burton† (Science|JMHC)

Abstract:

Natural products (NPs) are an important source of bioactive compounds, with potential therapeutic applications in medicine, agriculture, and chemical biology. In addition to their practical applications, NPs often play key roles in signaling and defense mechanisms within the organisms that produce them. One group of compounds that reflects this purpose is the halogenated furanones known as fimbrolides, which are produced by the red seaweed Delisea pulchra. These molecules have been shown to interfere with bacterial quorum sensing by inhibiting acylhomoserine lactones (AHLs) from binding to LuxR-type receptors.

In our project, we are focused on looking into how these fimbrolides and their derivatives might interact with LuxR- type receptors such as TraR from Agrobacterium tumefaciens, the bacterium responsible for causing crown gall disease. Since this pathogen relies on quorum sensing to initiate infection and transfer DNA into host plant cells, blocking this pathway could offer a promising way to manage crown gall disease. These compounds are difficult to isolate from their natural source in large enough amounts, so it is necessary to chemically synthesize them in the lab. These molecules will be evaluated for their ability to inhibit quorum sensing using GFP reporter assays in collaboration with other members of the lab.

Keywords:

Natural Products; Quorum Sensing; Small Molecule Synthesis; Plant Pathogen

Mentor(s):

Elizabeth I Parkinson (Science); Namuunzul Otgontseren (Science)

Presentation Time: Session 3: 1:30-2:30pm

Spectral Characterization of Cardiac Tissue from Raw Ultrasound RF Signals Using Frequency-Domain Analysis STEM

Authors(s):

Yunyi Gao† (Science)

Abstract:

[Abstract Redacted]

Keywords:

Ultrasound RF Signals; Discrete Fourier Transform (DFT); Tissue

Recognition; Signal Processing

Mentor(s):

Marco Aurelio Conde Oliveira Prado (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

What are the ideal systolic and diastolic blood pressure which do not injure the intima of iliac and coronary arteries? STEM

Authors(s):

Chan Huy Ha† (Tan Tao University)

Abstract:

Background:

Hypertension (HTN) is a major risk factor for coronary artery disease. Previous research demonstrated that laminar flow protects the endothelium, whereas turbulent flow damages it and initiates atherosclerosis. This study aimed to determine the blood pressure (BP) threshold beyond which turbulence and retrograde flow develop, potentially triggering intimal injury and plaque formation.

Methods:

A total of 50 patients were divided into two groups: Group A with controlled BP (<120/75 mmHg) and Group B with uncontrolled BP (>160/105 mm Hg). Dynamic coronary and iliac angiography was performed with 15 frames per second (0.06 seconds per frame). Flow was visualized as white blood entering over a black contrast background. The duration of antegrade, retrograde, and turbulent flow (collision) was measured. Turbulence was defined as swirling or mixing of contrast and blood following retrograde-antegrade collision.

Results:

In Group A (n=20), 90% of patients showed no retrograde flow in iliac or coronary arteries, and collision duration was brief (<0.12 seconds). In Group B (n=30), retrograde flow in the iliac artery was observed with prolonged collision (>0.24 seconds), and coronary turbulence lasted up to 0.18 seconds (p < 0.05 vs. Group A). The sites of turbulence corresponded to known plaque-prone regions in previous studies.

Conclusion:

Uncontrolled HTN produces prolonged retrograde and turbulent flow, potentially injuring the endothelium and initiating atherosclerosis. Controlled BP (<120/75 mmHg) was associated with laminar flow and minimal collision. These findings suggest that lower BP may protect

against flow-related vascular injury. Larger clinical trials are warranted to define optimal BP targets for atheroprotection.

Keywords:

Atheroprotection; Hypertension; Coronary Artery Disease; Laminar Flow; Retrograde-Antegrade Collision

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine); Loc Vu (Tan Tao University)

Presentation Time: Session 3: 1:30-2:30pm

Two-phase Heat transfer Enhancement using Confined Multi-Jets

STEM

Authors(s):

Duc Minh Hoang† (Engineering)

Abstract:

The continuing miniaturization and high-density packaging lead to a significant rise in heat load of the high-performance GPU, reaching ~1000 W for NVIDIA B200. Liquid cooling with an efficient thermal management solution is required to maintain a lower operating temperature of such device. In this study, direct-on-chip cooling with multi-jets with distributed inlet and outlet is proposed for a 2.5D interposer package. Overall manifold height is kept at 5 mm with a lateral feeding of coolant to make it more appealing for data center cooling application. Also, special provision in manifold design is provided to ensure leak-tight solutions and to integrate with the stiffener of the NVIDIA V100 chip, making it a lid-compatible manifold solution. After the integration of the 3D printed manifold, thermo-hydraulic performance is tested for various coolant flow rates and GPU load. The thermal design power, TDP of this chip is 300 W. The working fluid R1233zd(E) is dielectric, and the tests are performed at a saturation temperature of 37.5°C. GPU temperature is measured using an embedded sensor within the chip. Heat transfer coefficient, vapor quality, and pressure drop across the manifold is additionally measured to have a detailed performance map of the system. Also, thermal performance is studied for a dynamic power load, by step varying from idle power (~42 W) to TDP, mimicking real-time conditions. Overall, the current manifold provides an excellent thermal management solution with a robust packaging solution for high-power AI chips.

Keywords:

Electronic Cooling; Jet Impingement; GPU; Thermal Management

Mentor(s):

Gopinath Sahu (Engineering)

Other Acknowledgement(s):

Tiwei Wei (Engineering); Ketankumar Jayantkuma Yogi (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Creating Safe, Supportive Places For Youth Learning After School

Social Science

Authors(s):

Taylor Marie Hollis†; Armando Del Tejo Armendariz†; Saw Shin Htwe‡; Bethy Natalia Avella‡; Ngoc Phan Khanh Nguyen‡; Jacob Peng‡

Abstract:

The purpose of this community-based research project is to understand the needs of youth that can be fulfilled with an after-school program. Although the afterschool program's founder identified a need to address a cardiovascular health epidemic in the community, there remains an opportunity to ask the community what they would want to see in afterschool programming. Thus, our goal is to assess the needs of the community's youth so we can make recommendations to the program leadership on what the community needs from after-school programming. We used transcripts from three focus groups to determine the needs of the community's youth. One transcript included three parents whose children are not enrolled in the after-school program, while two others included youth from kindergarten through twelfth grade who are enrolled in the program. We used thematic analysis to identify trends in the data, which revealed what the community wants fulfilled. Our results showed that youth have slightly different needs, ranging from boredom prevention, school help, mental health help, and a safe environment. Based on our findings, we recommend teaming up with a community partner that specializes in mental health, providing more engaging learning materials, and creating opportunities for more parent and Purdue student volunteers.

Keywords:

Afterschool; Youth; Development; Qualitative; Community

Mentor(s):

Temitope Folasade Adeoye Olenloa (JMHC); Hannah Renee Krouse (JMHC)

Presentation Time: Session 3: 1:30-2:30pm

The Coanda Effect Caused Turbulence and Damaged the Intima at the Middle Coronary Segment

STEM

Authors(s):

Do Phuong Vy Huynh† (Tan Tao University); Bao Lam Phan‡ (Tan Tao University)

Abstract:

Background

Coronary arteries are biological pipes. As such, the principles of fluid mechanics from industry can be applied to arteries to study the development and ruptures of coronary plaques. One principle, the Coanda effect, is defined as the tendency of a fluid jet to stay attached to a convex surface. Fluid jets are a type of turbulent flow that damage the intima triggering the atherosclerotic process. This study utilized dynamic angiography and a Deep Learning program to determine if flow at the mid-segment became slow due to the Coanda effect.

Methods

Patients with the acute coronary syndrome (ACS) underwent novel dynamic coronary angiography. The coronary artery was completely filled with contrast (black color), then blood (white color) moved in and displaced the contrast. All movements and interactions of blood flows were recorded at 15 frames/second. To analyze flow patterns, Deep Learning Models were trained based on a convolutional neural network. The U-net combined Densenet121 was used to train a model to recognize and detect the stenosis area. The CNN model was used to identify and classify the stagnant flow.

Results

In 50 cases (70% male) 76% of lesions occurred at the middle and distal segments. Stagnant flow was identified at the internal boundary layer in 68% of patients, and the duration of stagnant flow was 10.9 + - 0.7 frames (0.067 seconds per frame). The arterial phase (AP) was prolonged at 2.8 + - 0.7 seconds in patients with stagnant flow, while it was only 1.82 + - 0.5 seconds (P = 0.003) in patients without stagnant flow. The sensitivity in detecting stagnant flow by the Deep Learning model was 0.91; specificity was 0.96.

Conclusion

The Coanda effect was seen in the internal boundaries layer with a prolonged AP. This effect likely results in delayed the O2 delivery, chest pain, ischemia and atherosclerotic plaques in patients with ACS.

Keywords:

Fluid Mechanics; Coanda Effect; Acute Coronary Syndrome; Coronary Plaques; Stagnant Flow

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine); Loc Vu (Tan Tao University)

Presentation Time: Session 3: 1:30-2:30pm

The Role of Temporal Predictability in Sustained Attention Social Science

Authors(s):

Abstract:

Miho Kato†

Attention requires sustaining focus on information and goals over time. Sustained attention performance is affected by time and temporal predictability. Specifically, previous research showed that performance in sustained attention tasks decreases when the focus of attention is required to be sustained over a longer period of time, and performance increases when the duration to sustain attention is predictable (known as temporal predictability). The current research examines the relationship between the duration of sustained attention and temporal predictability with two cognitive tasks. In the Sustained Attention to Cue Task (SACT), participants were required to sustain their focus of attention on a cued location to detect a subsequent target. In the antisaccade task, participants were required to fixate on the center of the screen until a cue appeared either on the left or right side of the screen, and asked to immediately shift their attention to the opposite side to detect the target. In the data presented here, 29 young adults (13 in the unpredictable and 16 in the predictable group) completed 10 sessions with both tasks. We predicted that longer wait/fixation times would be associated with decreased accuracy, and that increased temporal predictability would enhance their sustained attention and lead to increased accuracy. Preliminary results showed that SACT performance decreased over longer wait times, regardless of temporal predictability. In the antisaccade task, performance decreased from medium to long fixation times only when the fixation duration was predictable.

Keywords:

Sustained Attention; Temporal Predictability

Mentor(s):

Thomas S Redick (HHS); Harun Yoruk (HHS)

Other Acknowledgement(s):

Madelyn Jo McVey (HHS); Amanda Lynn Fordyce (HHS)

Presentation Time: Session 3: 1:30-2:30pm

Development and Implementation of a Codebook in an Afterschool Research Team

Social Science

Authors(s):

Hannah Krouse† (Ivy Tech Community College)

Abstract:

Codebooks are an integral tool that are utilized during qualitative data analysis to determine themes or "codes" from data sources which help answer research questions. Research on afterschool programs. however, primarily rely on quantitative data, leaving few established codebooks that analyze findings from focus groups and determine themes from participants' experiences. The afterschool research team seeks to answer research questions related to parent and youth needs within the afterschool program, youth learning and development, and culturally relevant practices within the afterschool program through the construction and use of a codebook. To build a codebook, afterschool researchers reviewed cleaned focus group transcripts to identify specific categories mentioned by participants that relate to our research guestions (needs, learning and development, and culturally relevant practices). After the codebook was drafted, pairs of researchers used Microsoft Excel to pilot the codebook by assigning codes to relevant lines in the focus group transcripts. Pairs reconciled their codes by comparing their codes to determine which codes were most accurate. Final codebook revisions were completed by combining similar codes together and ensuring all parts of the codebook were complete. Co-developing and piloting our codebooks allowed us to conceptualize how the data impacts aspects of an afterschool program, plus helped make our codebook align with our research questions. Co-developing our codebooks also helped us minimize repetitive and overlapping codes that could be condensed together. Ultimately, building a codebook during the data analysis process of research is a valuable and accurate way to contextualize results in participants' voiced experiences.

Keywords:

Qualitative; Codebook; Afterschool; Methods

Mentor(s):

Temitope Folasade Adeoye Olenloa (JMHC)

Other Acknowledgement(s): Rose Mbewe (Education)

Presentation Time: Session 3: 1:30-2:30pm

Defect Prediction in Manufacturing Process Using Supervised Machine Learning Models

STEM

Authors(s):

You-Cheng Lay† (DSB)

Abstract:

This project aims to develop an effective method for predicting the performance of the manufacturing process and finding the factors that would affect the manufacturing outcome. The goal is to predict the performance and compare each model based on several statistical factors, including ROC, Entropy R2, AUC, RASE, and classification accuracy. The outcome is whether or not the manufacturing process has failed and what variables affect the outcome. Variable selection involved the use of stepwise selection (both backward and forward), p-value selection, BIC selection, and the contribution portion. The target variable is the defect status, which is indicated by 'YES' or '1' when the process has failed and by 'NO' or '0' when the process is in control.

Models constructed include: Bootstrap Forest, K-NN, Neural Boosted Network, Support Vector Machine, Naive Bayes, and Logistic Regression. The final model is the one constructed through the bootstrapped forest, which has the highest Entropy R2 score among all the candidate models. The bootstrapped model also has the highest AUC, accuracy rate, and the lowest RASE. The variables that affect the defect status are: Maintenance hours, Quality Score, Defect Rate, Production Volume, Additive Material Cost, Energy Efficiency, and Production Cost.

Keywords:

Machine Learning; Manufacturing Defects; Predictive Modeling;

Supervised Learning; Quality Control

Mentor(s):

Matthew Lanham (DSB)

Presentation Time: Session 3: 1:30-2:30pm

Prolonged Arterial Phase as a Cause of Chest Pain in Takotsubo Cardiomyopathy: A Dynamic Angiography and Artificial Intelligence-Based Analysis

STEM

Authors(s):

Phuong Anh Let (Tan Tao University)

Abstract:

Background:

Takotsubo Cardiomyopathy (TCM), also known as "Broken Heart Syndrome," is characterized by chest pain, ST-segment elevation, elevated troponin levels, apical ballooning, reduced ejection fraction (EF), and angiographically normal coronary arteries. While emotional stress is recognized as a trigger, the underlying mechanism of chest pain in TCM remains unclear. This study hypothesized that abnormal coronary flow - specifically, prolonged arterial phase (AP) -may contribute to chest pain in TCM.

Methods:

Fifteen patients with TCM were evaluated using dynamic coronary angiography and artificial intelligence (AI) analysis. Inclusion criteria included chest pain, ST-segment changes, elevated troponin, apical ballooning, and non-obstructive coronary arteries. Ten patients controls with minimal CAD lesion and no left ventricular dysfunction served as a comparison group. Coronary flow was recorded at 15 frames per second. An AI model was trained by combining U-net and DenseNet-121. The model identified AP onset and completion based on contrast washout. AP duration was calculated from the first frame of blood inflow to complete contrast clearance from the distal coronary tree. All TCM patients were followed for one year.

Results:

The mean AP duration was significantly prolonged in TCM patients (3.17 \pm 0.53 s) compared with controls (1.62 \pm 0.26 s; p < 0.001). Mean EF improved from 33.9 \pm 7.6% to 58.8 \pm 12.6% at two weeks. At one-year follow-up, all patients were asymptomatic, except one who died from sepsis unrelated to cardiac disease.

Conclusion:

Prolonged coronary arterial phase in TCM may underlie chest pain and transient myocardial dysfunction. Despite initial severity, patient outcomes were favorable.

Keywords:

Takotsubo Cardiomyopathy; Artificial Intelligence; Arterial Phase; Ejection Fraction; Chest Pain

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine); Loc Vu (Tan Tao University)

Presentation Time: Session 3: 1:30-2:30pm

Analyzing the Electric Vehicle Charging policies and incentives on effective rollout of charging stations in California

Social Science

Autho	ors(s):
Scott	Nguy†

Abstract:

The development process of EV charger permit and approval has helped to increase the coverage of EV cars and EV charger installation in public and in residential homes in California. However, administrative burden prevented local government officials and utility company providers from being able to assess the impact of their policies on the customers due to lack of coordination. This effect has resulted in less coverage in EV charger adoption not just in public businesses but also among consumers in homes. For this research, the question will ask the following: Which policy approach is more effective in driving out EV charger adoption? The purpose of the study is to compare and contrast the different EV charger policies adopted by local governments and utilities in California. One of the first steps in the research was that EV charger policies and incentives were collected in a spreadsheet. Next, the specific policies between the utility providers (IOU) and the local city governments (POUs) were collected. Third, the total number of EV chargers in the region are gathered from each program. Preliminary findings showed that utility companies such as Southern California Edison tend to offer more EV coverage than local-city government municipalities. Also, the coverage of EV chargers is more numerous in Southern California than in Northern California. Much of the difference is due to availability of local resources as well as law applicability in each county. Since the research has not been studied, the importance of looking into the connection makes this worthwhile.

Keywords:
[no keywords provided]

Mentor(s): Shan Zhou (Liberal Arts)

Presentation Time: Session 3: 1:30-2:30pm

Morphological Characteristics of Apical Left Ventricular Thrombi Associated with Embolic Risk and Stroke STEM

Authors(s):

Minh Thien Pham† (Tan Tao University)

Abstract:

Background:

Apical thrombi in patients with anterior wall ST-segment elevation myocardial infarction (AWMI) or dilated cardiomyopathy (DilCM) are associated with embolic complications, including stroke. The morphology and composition of these thrombi may influence embolic risk. This study aimed to determine which thrombus characteristics are associated with higher embolic potential and clinical outcomes.

Methods:

This retrospective study included 32 patients diagnosed with apical thrombus via echocardiography between 2010 and 2021. Twelve patients had AWMI and 20 had DilCM. Patients with atrial fibrillation were excluded. Data collected included time from thrombus detection to stroke, type of anticoagulation (i.e., vitamin K antagonists vs. NOACs), and clinical response. Thrombi were analyzed for size, shape, protrusion, and echogenicity. Chi square or Fisher's exact test was used to compare outcomes.

Results:

Three of 12 patients with AWMI (25%) developed stroke within a mean of 7.5 days. These thrombi were small, round, protruding, and heterogeneous in echogenicity. Stroke events in this group were generally mild, with good recovery after thrombolysis. In the DilCM group, 2 of 20 patients (10%) developed stroke at a mean of 21 days (p < 0.05). These thrombi were larger, flat, incorporated into the apical wall, and had homogeneous echogenicity. Strokes in this group were more severe and less responsive to treatment.

Conclusion:

Thrombi in AWMI patients, though more embolic, were associated with better outcomes due to favorable morphology. Thrombi in DilCM patients

were less embolic but led to worse clinical outcomes. Larger studies are needed to confirm these findings.

Keywords:

Dilated Cardiomyopathy; Anterior Wall St-Segment Elevation; Myocardial Infarction; Thrombi; Embolic Risk

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine); Loc Vu (Tan Tao University)

Presentation Time: Session 3: 1:30-2:30pm

Management of Left Main Coronary Artery Disease in Elderly Patients in Vietnam

STEM

Authors(s):

Truc Quynh Pham† (Tan Tao University)

Abstract:

Background:

Left Main Coronary Artery Disease (LMCAD) poses a significant therapeutic challenge in elderly patients due to elevated procedural risks and common comorbidities. In Vietnam, the aging population and limited access to advanced interventional therapies further complicates clinical decision-making. This study aimed to evaluate the current management strategies for LMCAD in elderly Vietnamese patients and identify clinical factors associated with treatment outcomes.

Methods:

A retrospective study was conducted on 48 patients aged ?60 years diagnosed with LMCAD at a geriatric tertiary hospital in Vietnam over a 6-month period. Patients with incomplete records or concurrent terminal illness were excluded. Data were extracted from medical records, including demographics, comorbidities, treatment modalities, echocardiographic parameters, and biochemical test profiles. Statistical analyses included descriptive statistics, paired t-tests for continuous variables, and chi-square or Fisher's exact test for categorical variables.

Results:

The mean age was 71 \pm 7.5 years; 58.3% were male. Common comorbidities included hypertension (95.8%), diabetes (47.9%), and chronic kidney disease (31.3%). Medical therapy was the most utilized approach. Primary percutaneous coronary intervention (PCI) was performed in 37.5% of cases, with 33.3% experiencing delayed presentation (>48 hours). The mean BCIS-JS score improved from 11.2 to 7.0 post-intervention. Mean LVEF at discharge was 56.6 \pm 14.4%. Significant correlations (p < 0.05) were observed between treatment decisions and factors such as prior stroke, mitral regurgitation, GRACE score, BCIS-JS, and LDL-c levels.

Conclusion:

Timely PCI and individualized medical therapy improve cardiac function in elderly LMCAD patients. Elevated LDL-c and delayed intervention predict poorer outcomes, highlighting the need for early risk stratification.

Keywords:

Left Main Coronary Artery Disease; Elderly Vietnamese; Interventional Therapies; Percutaneous Coronary Intervention

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine); Loc Vu (Tan Tao University)

Presentation Time: Session 3: 1:30-2:30pm

Defining Ideal Blood Pressure Thresholds to Prevent Retrograde Flow and Turbulence in Coronary and Iliac Arteries: A Dynamic Angiography and Machine Learning Study

STEM

Authors(s):

Bao Lam Phan† (Tan Tao University); Do Phuong Vy Huynh‡ (Tan Tao University)

Abstract:

Background:

Uncontrolled hypertension (HTN) is a major modifiable risk factor for coronary artery disease (CAD). Prior research demonstrated that laminar flow protects the endothelium, whereas turbulent flow—particularly from retrograde-antegrade collision—can injure the intima and trigger atherosclerosis. This study aimed to determine the systolic and diastolic BP thresholds that avoid reversed flow and turbulence in the coronary and iliac arteries.

Methods:

Fifty patients underwent dynamic coronary and iliac angiography. Following contrast opacification, blood inflow (white over black contrast) was recorded at 15 frames/second to assess flow direction (antegrade vs. retrograde) and type (laminar vs. turbulent). A machine learning (ML) model was developed in Python. Model 1, based on U-net and DenseNet-121, performed vessel segmentation. Model 2, a convolutional neural network, classified flow patterns.

Results:

Group A (n = 30) with uncontrolled systolic BP >160 mmHg and diastolic BP >110 mmHg exhibited retrograde flow and turbulence in both coronary and iliac arteries. In contrast, Group B (n = 20) with diastolic BP <75 mmHg showed no retrograde flow in the iliac arteries. Moreover, when systolic BP was maintained below 110 mmHg, no retrograde flow occurred in the coronary arteries.

Conclusion:

The absence of retrograde flow and turbulence was observed with systolic BP <110 mmHg and diastolic BP <75 mmHg, suggesting these thresholds may represent optimal hemodynamic conditions for vascular protection. These findings provide physiological insights for BP targets in CAD management.

Keywords:

Hypertension; Laminar Flow; Turbulent Flow; Retrograde-Antegrade Collision; Coronary Artery Disease

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine); Loc Vu (Tan Tao University)

Presentation Time: Session 3: 1:30-2:30pm

Effect of loss of hyaluronan synthases on glycosaminoglycan production in bone marrow derived cells

STEM

Authors(s): Christian A Roach†

Abstract:

Osteoarthritis is a highly prevalent musculoskeletal disease with negative consequences such as swelling of the joint, joint pain, joint stiffness, and decreased range of motion. Although this disease can be extremely debilitating for affected individuals, no cure currently exists. One therapeutic target for the disease is modulating the endogenous production of hyaluronan. As osteoarthritis progresses, hyaluronan content declines. Hyaluronan is a glycosaminoglycan (GAG) that is produced by hyaluronan synthases (Has) 1, 2, and 3. In this work, we utilized Has1 knockout (-/-) and Has3 knockout (-/-) mice to evaluate contributions of Has1 and Has3 to matrix production. Sulfated glycosaminoglycans (sGAG) are a key component of the extracellular matrix (ECM) and as osteoarthritis progresses sGAG production declines. Bone marrow derived cells release sGAG that can remodel the ECM which can correlate to regeneration of damaged tissue. Bone marrow derived cells were isolated from Has1-/- and Has3-/- mice and cultured for 24 hours. This was followed by media collection. Dimethylmethylene blue assay was conducted to measure the sGAG content released from cells into the collected media. On average, bone marrow derived cells isolated from Has1-/- mice released 7.12 ug/mL sGAG into media while bone marrow derived cells isolated from Has3-/mice released 7.60 ug/mL sGAG. Future work will involve the analysis of other matrix components such as hyaluronan. Understanding the relationship between hyaluronan synthases and GAG production can give us a better foundation for developing treatment options for osteoarthritis.

Keywords:

Glycosaminoglycan; Hyaluronan Synthase; Bone Marrow Stromal Cells

Mentor(s):

Deva Chan (Engineering); Mikayla Angelique Roach (Office of the Provost)

Presentation Time: Session 3: 1:30-2:30pm

Addressing 3D Printing Defects for Upgrades to CERN's Large Hadron Collider

STEM

Authors(s): Jalynn Sanders†

Abstract:

This research is done for the future high luminosity upgrades for the Large Hadron Collider (LHC) at CERN. Various 3D printing methods are tested to address defects in the Dry Gas Injection (DGI) tubes used in the Inner Tracker Support Tube (ITST) of the Compact Muon Solenoid (CMS) detector at the LHC. The DGI tubes will undergo immense radiation, heat, and pressure; therefore, structural integrity is vital. Currently, only 25% of our tubes per print are suitable for use at CERN. A review of 3D printing literature yielded several possible causes for the defects, including instability of the z-axis, layer separation, variations in lift and roller speeds, and more. These methods are still being tested to, hopefully, significantly reduce the time required for DGI printing and to increase the percentage of usable tubes per print.

Keywords:

[no keywords provided]

Mentor(s):

Sushrut Karmarkar (Science); Heather Nicole Martin (Science)

Presentation Time: Session 3: 1:30-2:30pm

Searching for novel quantum phase in TMD Moiré superlattice STEM

Authors(s):

Vincent Cody Stavig† (Science); Aditya Srinivasan† (Science); William Christophe Bultman* (Science)

Abstract:

In condensed matter physics, a moiré material is created by stacking two or more layers of two-dimensional (2D) materials with an interlayer rotation. The interference effect between atomic lattices of the constituent layers gives rise to a moiré pattern, an artificial and much larger lattice. The presence of the moire superlattice can strongly modify the electronic properties in the material, giving rise to novel quantum electronic phases, such as unconventional superconductivity, topological insulators etc. To search for new quantum phases of electrons in this platform, we designed devices consisting of moire transition metal dichalcogenide (TMD) as a core layer and other functional 2D material as supporting layers. Multiple devices were successfully fabricated using Van der Waals dry transfer technique and the following lithography steps. We will study the novel superconducting phase and fractional Chern insulators in these devices at an extremely low temperature of 250 mK.

Keywords:

Quantum; Condensed Matter Physics; TMD; 2D Material; Materials Science

Mentor(s):

Yihang Zeng (Science); Euihyun Jo (Science); Shuaiqing Zhang (Engineering)

Other Acknowledgement(s):

Nemanja Ninkovic (Science)

Presentation Time: Session 3: 1:30-2:30pm

Constraining potential helium sources in magnetite, with applications to helium-based geo- and thermochronology STEM

Authors(s):

Hannah Nicole Tharrington† (Science)

Abstract:

Magnetite (Fe3O4) is a mineral that is common in Earth's crust across a wide range of geologic environments. Geologists would like to utilize measurements of helium (He) isotopes in magnetite for geo- and thermochronology, i.e., to determine the timing and rates of geologic events and processes. In order to successfully use magnetite for Hebased chronology, we need to characterize and understand the different potential sources of He, which can include radioactive decay, cosmic ray interactions, and nuclear reactions within magnetite. This research uses various analytical techniques to characterize these different sources within magnetite samples that we will later use to measure helium diffusion kinetics and determine surface erosion rates. To account for extraneous radiogenic He from mineral inclusions, we used Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray Spectroscopy (EDS) to determine the presence, distribution, and composition of potential mineral inclusions. We also used X-ray Computed Tomography (XCT) data to map the spatial distributions of inclusions in 3 dimensions and referenced these data against the SEM/EDS data. To account for nucleogenic He produced by (alpha,n) reactions of lithium, we also measured lithium concentrations by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) analysis. The results of these analyses can be used to evaluate the potential sources of helium within the magnetite and its further applications with regards to geo- and thermochronology.

Keywords:

Magnetite; Thermochronology; Geochronology; Helium Isotopes

Mentor(s):

Marissa Tremblay (Science); Hongcheng Guo (Science)

Presentation Time: Session 3: 1:30-2:30pm

Genetic Divergence and Signatures of Selection Between Locally Adapted Ecotypes of Arabidopsis Thaliana STEM

Authors(s):

Stephanie Tirado Rojas† (Science)

Abstract:

Although A. thaliana ecotypes obtained from Italy (IT) and Sweden (SW) have been well-studied and shown to be locally adapted, we still do not fully understand the genetic variation underlying these adaptations. We may expect regions of the genome responsible for local adaptation to be highly divergent between ecotypes. To investigate this, we identified divergent regions using whole genome sequence data to calculate average nucleotide divergence between populations (Dxy) along with population differentiation (FST) in non-overlapping windows. We identified regions of interest by locating the most highly divergent windows and overlaying them with known fitness QTL. Notably, we identified a peak of Dxy at the end of the first chromosome within a QTL associated with fitness variation in Italy. A large putative deletion in IT and high sequence divergence between ecotypes provides good candidates for future functional validation. Additionally, we implemented population genetic analyses to detect potential loci under selection in these same regions. Overall, these analyses aid in understanding the genetic basis of local adaptation in this system.

Keywords:

Arabidopsis; Adaptation; Genetics

Mentor(s):

Samuel Joseph Mantel (Agriculture); Christopher G Oakley (Agriculture)

Other Acknowledgement(s):

Juan Diego Rojas Gutierrez (Agriculture)

Presentation Time: Session 3: 1:30-2:30pm

How Diet Changes in Older Hens Affect the Vitelline Membrane Strength

STEM

Authors(s):

Gabriella Anna Tysse Levine† (Agriculture); Olivia Katherine Sullivan† (Agriculture); Anna Rachelle Hardesty‡ (Agriculture); Neely JoAnne Brown‡ (Agriculture); Emily Rose Mawhorter‡ (Agriculture|JMHC)

Abstract:

Older laving hens are not typically kept in production because of declining egg quality and quantity but due to avian influenza hens are being kept in production. However, when nutritional changes are applied to older hens, it is possible to combat this quality decline, specifically vitelline membrane strength. High Vitelline membrane strength is essential during egg processing to prevent yolk breakage and preserve yolk properties such as emulsification, color, and flavor. It is also crucial during transport to ensure the survival of developing embryos and maintaining yolk integrity in eggs. The aim of this study was to measure vitelline membrane strength in eggs from older hens (> 100 weeks of age). The eggs were broken, and the yolk was separated from albumen and placed into a petri dish for analysis. If a yolk was broken prior to trial, that egg was removed. The probe on a Texture Analyzer machine was automatically lowered to break the yolk and observation of both the peak on the graph and the yolk's integrity confirmed when the yolk broke, and the maximum force of the vitelline membrane strength was recorded. When comparing data of mean forces from our older laying hens (140.918g to 187.088 g) with published data with younger hens (129.9g to 155.7g), the means from older laying hens are trending higher. Comparable findings in means of vitelline membrane strengths between groups of hens indicate that industry can utilize older hens and still be able to process, transport, and maintain egg quality.

Keywords:

[no keywords provided]

Mentor(s):

Sara Elizabeth Cloft (Agriculture); Darrin M Karcher (Agriculture)

Presentation Time: Session 3: 1:30-2:30pm

Blood Flow Heterogeneity and Plaque Eccentricity in Coronary Artery Disease: A Dynamic Angiography, Deep Learning, and IVUS-Based Study

STEM

Authors(s):

Ha Khanh Linh Vo† (Tan Tao University)

Abstract:

Background:

In coronary artery disease (CAD), despite whole coronary exposure to same risk factors, atherosclerotic plaques develop at selective arterial sites. Furthermore, intravascular ultrasound (IVUS) frequently reveals eccentric plaque morphology on horizontal sections. This study aimed to investigate the underlying hemodynamic mechanisms contributing to plaque localization and eccentricity using dynamic angiography, IVUS, and deep learning (DL) models grounded in fluid dynamics principles.

Methods:

Patients with unstable angina underwent dynamic coronary angiography combined with IVUS assessment. Initially, the coronary arteries were fully opacified with contrast. Upon cessation of injection, incoming blood (white) displaced the contrast (black). The arterial phase (AP) is defined as the time interval from complete contrast filling to full washout, recorded at 15 frames/second. DL models were trained on 225 independent angiographic videos. U-Net and DenseNet-121 architectures were used for vessel segmentation and frame detection.

Results:

Thirty-six patients (mean age 69.2 ± 9.1 years; 72.2% male) were analyzed. IVUS revealed eccentric plaque in 91.7% of cases (33/36). Among these, 81.8% exhibited persistent contrast "hangover" at the plaque site during angiographic washout (p < 0.05). Patients with eccentric plaques had significantly longer arterial phases compared to those with concentric lumens $(1.95 \pm 0.3 \text{ s vs.} 1.66 \pm 0.2 \text{ s, p} < 0.05)$.

Conclusion:

Local hemodynamic heterogeneity—reflected by prolonged arterial phase and contrast retention—may drive site-specific plaque

development and eccentricity in CAD. These findings highlight the potential of fluid dynamic insights to inform risk stratification and interventional planning.

Keywords:

Coronary Artery Disease; Plaque Eccentricity; Intravascular Ultrasound; Dynamic Angiography; Fluid Dynamics Principles

Mentor(s):

Ernest Francis Talarico (Purdue Northwest); Thach Nguyen (Tan Tao University School of Medicine); Loc Vu (Tan Tao University)

Presentation Time: Session 3: 1:30-2:30pm

CMMD-Based Evaluation of Generative Models

Creative

Authors(s):

Puruo Wang† (Science)

Abstract:

As part of the CVGM (Computer Vision and Generative Models) group's broader effort to develop a comprehensive evaluation framework for generative models, our sub-team focuses on measuring how well generated images align with their intended prompts. In this preliminary study, we implement a CLIP-based Cross-Modal Maximum Mean Discrepancy (CMMD) metric to assess image-text consistency. The pipeline computes feature embeddings for both prompts and generated images using CLIP, then calculates CMMD against real image references from the COCO-30K dataset. We benchmark four diffusion models—Stable Diffusion v1.4, Stable Diffusion 2.1, SDXL-Turbo. and aMUSEd—across six categories of prompts, including simple objects, complex scenes, and multi-object scenarios. This allows us to evaluate prompt fidelity and visual coherence in a standardized, reproducible manner. Our sub-team's work contributes one component of the larger CVGM initiative: building a reliable, modular evaluation system for generative model research. The methods and metrics established here will support other teams in the group and help guide future model development.

Keywords:

Generative Models; Evaluation Metrics; Model Benchmarking; Computer Vision

Mentor(s):

Yung-Hsiang Lu (Engineering); Le Mao (Engineering); Zihao Ye (Engineering)

Presentation Time: Session 3: 1:30-2:30pm

Patient Refused Doses of Critical Medications - St. Bartholomew

STEM

Authors(s):

Mia M Yates† (Pharmacy|JMHC)

Abstract:

Introduction: Medication safety (MS) is critical within healthcare systems to identify, mitigate, and prevent harm. St Bartholomew's Hospital (SBH) utilizes a MS dashboard to document missed or delayed medication doses for hospitalized patients.

Objective: To identify and describe missed doses of medication at SBH.

Methods: Data from the Qliksense® dashboard was evaluated from July 2023 to June 2025, based on the date a medication was first prescribed. A total of 78,435 missed medication doses were cleaned and analyzed. Microsoft Excel® formulas were utilized to identify patient refused doses of medications on the SBH Critical Medications List. All 'prn' medications were excluded. Data was further analyzed to evaluate 'habitually refused' medications. The definition of 'habitually refused' was a medication refused two or more times by a patient during their hospital stay.

Results: A total of 5,768 doses were identified as refused. The top three medications refused included enoxaparin, morphine, and oxycodone. Most patient refusals occurred in respiratory and oncology wards. There were 3,757 (65%) 'habitually refused' doses by a total of 410 patients. Enoxaparin was the most habitually refused critical medication, accounting for 1304 (35%) habitual refusals by 166 patients.

Conclusions: The characterization of frequently refused medications highlights the need to further examine the patient refusal reporting system, communication protocol between hospital staff when a patient refuses a critical medication, and patient education strategies to reduce refused doses. Future MS research at SBH also includes a focused review of habitual enoxaparin refusals and evaluation of the venous thromboembolism risk assessment protocol.

Keywords:

[no keywords provided]

Mentor(s): Monica Miller (Pharmacy)

Other Acknowledgement(s): Ellen M Schellhase (Pharmacy)

Presentation Time: Session 3: 1:30-2:30pm

iDiF Undergraduate Summer Research Program: Drone Under-Canopy Forest Survey

STEM

Authors(s):

Christina Zhang† (Science|JMHC)

Abstract:

The purpose of this project is to analyze a drone under-canopy footage uploaded by the user and provide tree visualizations, information for each tree, and an annotated video that visually highlights each detected tree along the drone's flight path while displaying the assigned ID and the estimated DBH (Diameter at Breast Height) for each detected tree. This project utilizes Typescript and React for the frontend of the website, which consists of a tab for email recording and file uploading. The frontend requires a pair of MP4 and SRT files to be uploaded and sends a request to the backend to begin the processing. The backend is mostly written in Python and uses algorithms developed by the team to process the uploaded files. Once processing completes, the results are ready to be viewed — the frontend displays the annotated video and uses the JSON file from the backend to create an interactive tree visualization that shows the ID, estimated DBH, and position of each tree when hovered over. The user can switch between different views, including UTM and Latitude/Longitude. The tree information is saved in a CSV file and can be downloaded along with the annotated video from the website. Farmers could use this tool to estimate the value of their trees by simply using a drone without needing a LiDAR. By improving the accuracy of the DBH estimations, this tool could obviate the need to manually measure each tree.

Keywords:

[no keywords provided]

Mentor(s):

Yingjie Chen (Polytechnic); Songlin Fei (Agriculture)

Other Acknowledgement(s):

Jui-Cheng Chiu (Polytechnic); Nabin Khanal (Polytechnic); Yawen Lu (Polytechnic); Su Sun (Polytechnic)

Presentation Time: Session 3: 1:30-2:30pm

Exploring Political and Socio-economic Dimensions of Public Perception on Electrified Transportation Technology in Greater Lafayette, Indiana

STEM

Authors(s):
Ava J Watson†

Abstract:

Electric Vehicles (EVs) are alternative transportation methods to assist in reducing greenhouse gas emissions. However, there is limited research on public perception of resulting infrastructure, such as Dynamic Wireless Power Transfer (DWPT), particularly when considering political party affiliation and household income as influencing factors. This study considers the role of political and socio-economic variables in shaping public perception toward EVs and DWPT in Indiana. The study took advantage of a Public Perceptions of Electrified Transportation Survey fielded in Greater Lafayette in 2024, with 275 responses analyzed. The survey asked participants a series of questions on possible positive or negative impacts of EVs and DWPT. This study builds on previous survey analyses conducted at Purdue, which revealed that participants generally viewed EVs and DWPT positively for their environmental and safety benefits, while concerns remained about infrastructure adequacy, costs, and potential community impacts. Preliminary findings suggest that from a political perspective, a higher percentage of people identified as Democrat at 42% (on a scale of slightly to extremely), 26% as Republican, 22% as moderates, and 9% preferred not to say. In terms of income, 62% reported household income above \$100,000, 31% between \$50,000 and \$100,000, and 7% below \$50,000. While analysis is ongoing, this study aims to uncover correlations that can inform future policy and infrastructure decisions. Understanding these dynamics is key to increase public support for emerging transportation technologies in communities such as Greater Lafayette.

Keywords:

Household Income; Political Party Affiliation; Dynamic Wireless Power Transfer (DWPT); Electric Vehicles (EVs)

Mentor(s):

Chiara Cervini (Engineering); Brandon Chase Myke Allen (Engineering)

Presentation Time: GRIS 103 at 9:00-9:20

Machine Learning and Quantum Simulation of Critical Behavior and Defects in Frustrated Lattice Models STEM

Authors(s):

Aritro Chatterjee† (Science)

Abstract:

Frustrated quantum systems—where competing spin interactions prevent all constraints from being satisfied—exhibit complex critical behavior that is difficult to classify using standard tools. Understanding phase transitions in such systems is crucial for condensed matter physics and quantum technologies, especially as materials like SrCu2(BO3)2 realize frustrated lattice models such as the Shastry-Sutherland lattice in the lab. This project explores whether supervised machine learning can classify quantum phases and universality classes from simulation data, even in the presence of disorder. We combine Density Matrix Renormalization Group (DMRG), a numerical method for finding ground states of quantum systems, with quantum annealing using D-Wave's hybrid solvers to study the Shastry-Sutherland and Triangular lattices. We extract correlation functions and magnetization profiles including one-third magnetization plateaus in the Shastry Sutherland lattice—and use these to train machine learning models. Our simulations currently use Julia-based DMRG and simulated annealing; we expect to soon incorporate data from physical quantum annealers and begin fullscale ML training. By integrating machine learning with quantum simulation, this project aims to create scalable, automated tools to detect criticality and phase structure in frustrated systems, including the effects of defects. Such tools could accelerate experimental mapping of phase diagrams and inform the design of new quantum materials.

Keywords:

[no keywords provided]

Mentor(s):

Bishnu Prasad Belbase (Science); Arnab Banerjee (Science)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: GRIS 103 at 9:20-9:40

In situ conversion of carboxylic acids, alcohols, and amines to aldehydes for DNA-encoded library construction STEM

Authors(s): Jocelyn Yang† (Science)

Abstract:

DNA-encoded libraries (DELs) are a new technology used for drug discovery. Contrary to traditional methods which synthesize and test each molecule separately, the encoding aspect of DELs enables both pooled chemical reactions for simultaneous synthesis and screening of a drug candidate library. This approach greatly improves the efficiency of the drug discovery process. In DEL preparation, each molecule is attached to a unique DNA tag. However, DEL-compatible reactions are often limited due to DNA damage. Reductive alkylation of amines on DNA is one of the most robust and non-damaging reactions; however, the required aldehyde building blocks have limited commercial availability due to degradation upon storage. To address this, a series of functional group conversion reactions for aldehyde synthesis were investigated for their potential usage in DEL reactions. Carboxylic acids, alcohols, and amines were first converted to aldehydes in an off-DNA reaction, then reacted with DNA by reductive amination directly from the crude reaction. The DNA reaction yields were quantified with liquid chromatography-mass spectrometry (LC-MS). The integration of a peak on the LC-MS with a mass of the desired product showed that an aldehyde made by oxidation of an alcohol with 2-iodoxybenzoic acid (IBX) had the ability to react onto DNA. After testing various conditions, the highest yield (>70%) was obtained using 500 mM MES buffer. Combining this reaction with existing ones increases the molecular diversity, raising the probability of finding a drug candidate. Future applications include constructing DELs with these reactions to test their efficacy and diversity in DEL synthesis.

Keywords:

Biochemistry; Chemistry; Drug Discovery; DNA-Encoded Libraries; Combinatorial Chemistry

Mentor(s):

Lei Wang (Pharmacy); Casey J Krusemark (Pharmacy)

Presentation Time: GRIS 103 at 9:40-10:00

Don't Bother the Driver: Sensor-Scheduling for Cognitive State Estimation During Automated Driving STEM

Authors(s): Emanuele Bossi†

Abstract:

Estimating human cognitive states is vital for safe and efficient humanautonomy interaction, especially in safety-critical contexts like automated driving. Cognitive states—such as trust, workload, and perceived risk affect driver behavior but are not directly observable. They must be inferred from behavioral, physiological, and self-report data. Prior work often relies on static, categorical models with uni-modal inputs, lacking real-time updates, uncertainty quantification, or adaptive querying of user input. We propose a novel modeling framework that treats cognitive states as continuous, time-varying latent variables and automation reliance as a discrete, observable output. Our hybrid dynamical system combines self-reports and psychophysiological signals for real-time state estimation. Critically, the framework quantifies predictive uncertainty, allowing for adaptive self-report scheduling to improve sample efficiency while minimizing participant burden. We address the question: How can online learning and dynamical systems theory be integrated to enable real-time, participant-specific estimation of cognitive states and prediction of automation reliance? Latent states are predicted using an affine dynamical model and mapped to reliance via a tree-based classifier. When self-reports are unavailable but uncertainty is high, a particle filter fuses selected physiological and gaze features using an auxiliary ensemble model to refine estimates. Experimental results demonstrate improved accuracy over static or purely data-driven baselines, highlighting the benefit of integrating dynamical models with machine learning in an online setting. This enables individualized, continuous cognitive state estimation and prediction of reliance on automation, supporting future integration into closed-loop systems for managing driver engagement in dynamic environments.

Keywords:

Dynamic Modeling; State Estimation; Machine Learning; Human-Autonomy Interaction; Sensor Scheduling

Mentor(s):

Neera Jain (Engineering); Sibibalan Jeevanandam (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Parth Uday Kelkar (Engineering)

Presentation Time: GRIS 134 at 9:00-9:20

Classification of Electrochemical Impedance Spectroscopy Components in Ultramicroelectrode Arrays

STEM

Authors(s):

Aidan Hirsch† (Engineering)

Abstract:

There are currently 5.6 million people diagnosed with some form of limb paralysis in the world. Invasive brain machine interfaces (BMI) can provide these patients with solutions such as basic typing capabilities through decoding neural signals, however a medical procedure capable of restoring functionality is not realized yet. Previous BMI efforts could not achieve a substantial restoration of limb function due to foreign body response (FBR) effects, which degrade the signal quality by decreasing the signal to noise ratio (SNR). Literature suggests shrinking the dimensions of an electrode results in a lesser FBR from the brain. Ultramicroelectrode arrays (UMEAs), a class of extremely small BMIs, trigger the brain's FBR to a point where invasive implantations can be left in for six months to a year before degradation. The UMEAs utilized in this study are coated with a sputtered iridium oxide film (SIROF) to ensure high stimulation and recording performance. However, the FBR still causes degradation of this coating, resulting in the UMEA gradually becoming ineffective for long-term stimulation purposes. Our third generation (G3) UMEAs were implanted in Sprague-Dawley rats for a period of sixteen weeks and the degradation of the SIROF coating was measured using electrochemical impedance spectroscopy (EIS). By modeling the physical characteristics of the UMEA from the EIS data, we can predict the amount of degradation of the SIROF coating at a specific timeframe. Being able to quantitatively model the amount of degradation on the UMEA allows us to understand the failure modes and improve longevity in vivo.

Keywords:

Ultramicroelectrode Arrays; Electrochemical Impedance Spectroscopy; SIROF coating; Neural Interfaces; Neuroprostheses

Mentor(s):

Qiwei Dong (Engineering); Kevin John Otto (Engineering)

Other Acknowledgement(s):

Pranshul Sardana (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 134 at 9:20-9:40

Structural and Functional Characterization of Highly Potent and Selective G Protein-Coupled Receptor Kinase 5/6 Druglike Inhibitors

STEM

Authors(s):

Phoebe G Smock† (Agriculture|Engineering)

Abstract:

Chronic heart failure and cancer remain among the foremost causes of death worldwide. G protein-coupled receptor kinases 5 and 6 (GRK5 and GRK6) have emerged as critical regulators in the pathophysiology of these diseases, making them promising targets for therapeutic intervention. This study focuses on the discovery and characterization of selective and potent small-molecule inhibitors against GRK5 and GRK6. intending to advance therapeutic strategies for heart failure and multiple myeloma. A series of highly potent and selective inhibitors was synthesized based on Sunitinib, an FDA-approved inhibitor against receptor tyrosine kinases (RTKs), and aminoquinazoline scaffolds. Their kinase activity was quantitatively assessed using radiometric kinase inhibition assays. Moreover, X-ray crystallography was employed to determine the co-crystal structures of GRK5 bound to those drug-like inhibitors, enabling detailed analysis of the binding mode and key molecular interactions within the GRK5 active site. Structural insights into the active site architecture of GRK5 provide a framework for rational optimization of inhibitor selectivity and potency. These findings lay the groundwork for the development of targeted pharmacological agents against GRK5 and GRK6 for the treatment of cardiovascular and cancerrelated diseases.

Keywords:

GRK5 Inhibitors; GRK6 Inhibitors; Sunitinib; Aminoquinazoline; Kinase Inhibition Assays

Mentor(s):

John Tesmer (Science); Sandali Lakmini Piladuwa Gamage (Science)

Other Acknowledgement(s):

Ioanna Katsamba (Engineering)

Presentation Time: GRIS 134 at 9:40-10:00

Investigating Combustion Instability Mechanisms in Turbulent Jet Ignition and Evaluating Mitigation Strategies Using High-Speed Optical Diagnostics

STEM

Authors(s):
Mo Chen† (Engineering|DSB)

Abstract:

Turbulent Jet Ignition (TJI) is a promising technology for improving internal combustion (IC) engine efficiency and emissions. Prior studies demonstrated a 13–15% improvement in fuel efficiency in production engines through prechamber and nozzle optimization, but also highlighted significantly increased cycle-to-cycle variation, particularly under low-load and cold-start conditions. This study investigates the root causes of combustion instability in a modified 2018 Ford Focus 1.0L engine outfitted with a custom TJI system. The engine operates at 1200 RPM while in-cylinder flame development is captured via high-speed endoscopic imaging at 2400 fps with an 800 × 600 resolution. Combustion pressure, emissions, and other key signals are acquired using an NI cRIO system and LabVIEW interface. By integrating optical and pressure diagnostics, this research examines how ignition delay, oxygen concentration, and prechamber preheating influence flame propagation and combustion variability. Each parameter set is evaluated for its effectiveness in reducing instability and improving combustion completeness. The study aims to build a detailed understanding of instability mechanisms and to inform strategies that enable robust, lowemission operation of TJI-equipped engines.

Keywords:

Turbulent Jet Ignition; Internal Combustion Engines; Sustainability; Combustion Stability

Mentor(s):

Afaque Alam (Engineering); Li Qiao (Engineering)

Other Acknowledgement(s): Parth Uday Kelkar (Engineering)

Presentation Time: GRIS 133 at 9:00-9:20

Optimization of Nb4C3Tx MXene Synthesis for Improved Yield and Flake Quality

STEM

Authors(s):

Pratyush Chettri† (Engineering|Science|JMHC); Aditi Akella* (Engineering)

Abstract:

MXenes are a promising family of two-dimensional transition metal carbides and nitrides with high electrical conductivity and compositiondependent properties, making them applicable in energy storage, catalysis, and electromagnetic shielding. They are typically produced by selectively etching aluminum from MAX phases using acidic solutions. The resulting layered MXene structure is intercalated with guest molecules to expand the interlayer spacing and promote delamination of layers into a colloidal solution of single-to-few layer MXene flakes. Though great progress has been made in MXene synthesis since their discovery in 2011, thicker-layered MXenes such as M4C3Tx remain relatively underexplored due to greater structural rigidity which poses challenges for etching and delamination. Our study focuses on the synthesis of Nb4C3Tx MXene from Nb4AlC3 MAX precursor and aims to optimize the process for yield and quality of resulting delaminated flakes. We systematically varied parameters for each step of the synthesis process and measured relevant outcomes. We first varied the HCl concentration and duration for MAX phase pre-treatment and identified conditions that fully removed any impurities present. We then explored etching conditions - reaction time, temperature, and HF-HCI concentration – and determined combinations that resulted in complete conversion of MAX to layered MXene by measuring interlayer spacing changes and Al removal. Finally, we tested multiple intercalation and delamination methods using various bases and salts. The resulting MXene flakes were characterized to assess quality and synthesis yield. Through this process we identified an optimized synthesis path for higher flake quality and yield of Nb4C3Tx MXene.

Keywords:

Optimization; MXene; New

Mentor(s):

Krutarth Kiran Kamath (Engineering); Brian Cecil Wyatt (Engineering);

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment



Presentation Time: GRIS 133 at 9:20-9:40

Tuning Matrix Degradability using Hydrogel Composites to Modulate Angiogenesis

STEM

Authors(s):

Twisha Tirumani Shivashankar†

Abstract:

Functional vasculature is essential for tissue survival, making angiogenesis, the formation of new blood vessels from existing ones, a key aspect of tissue engineering. To support this process, biomaterials must replicate features of the native extracellular matrix to promote cell growth and organization. Among these, matrix degradability plays a major role by regulating vascular sprouting and 3D cell migration.

Norbornene-modified hyaluronic acid (NorHA) hydrogels are widely used for their biocompatibility and tunable crosslinking. However, conventional NorHA is non-degradable, limiting cell spreading and vessel formation. While enzymatically cleavable crosslinkers allow cell-mediated degradation, they offer limited external control over matrix remodeling.

To address this, our lab developed degradable NorHA hydrogels by chemically modifying hyaluronic acid through oxidation with sodium periodate and esterification with carbic anhydride. This produced two variants: NorHA-20%Ox and NorHACA-20%Ox, which degrade over 14 and 2 days, respectively, in microgel studies. However, they lack mechanical strength, and their angiogenic potential in bulk systems remains unexplored.

This project develops composite hydrogels by blending degradable and non-degradable NorHA in ratios from 95:5 to 50:50. Compression testing showed Young's moduli ranging from 16.23 to 20.66 kPa in NorHA—NorHACA 20%Ox composites. Bulk degradation was also evaluated over time. Cell—matrix interactions were studied by encapsulating GFP-tagged NIH3T3 fibroblasts, while HUVEC-MSC spheroids were embedded to assess angiogenic sprouting. Fibroblasts appeared larger and showed minute extensions in composites with higher degradable content.

This project aims to optimize the balance between mechanical integrity and angiogenic potential for vascularized tissue engineering.

Keywords:

Angiogenesis; Matrix Degradability; NorHA; Composite Hydrogels; Vascularized Tissue Engineering

Mentor(s):

Taimoor Hasan Qazi (Engineering)

Other Acknowledgement(s):

Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: GRIS 133 at 9:40-10:00

3D Pancreatic Morphometry in Patients with Intraductal Papillary Mucinous Neoplasms and Association with Malignancy Risk

STEM

Authors(s):
Maksymilian Mroczkowski†

Abstract:

Intraductal Papillary Mucinous Neoplasm (IPMN) is a cystic precursor lesion of pancreatic ductal adenocarcinoma characterized by mucin-producing papillary formations within pancreatic ducts. IPMNs are classified as main-duct, branch-duct, or mixed-type with varying malignant potential, progressing from low-grade dysplasia to invasive carcinoma. IPMN can lead to morphological changes in the pancreas, including main duct dilation, distal atrophy, multiple cystic lesions, and contour irregularities. We hypothesize that three-dimensional morphometric differences in the pancreas are predictive of malignancy risk in IPMNs.

This retrospective study includes 180 patients with IPMN who underwent surgical resection at IU Health, along with 40 healthy individuals from the publicly available CHAOS dataset to provide normative baselines. The pancreas region of interest (ROI) was segmented, and local and global morphological features were extracted. These included volume-based metrics such as total volume, surface area, convexity, compactness, and sphericity. Additional features were derived from curvature analysis, fractal dimension, 3D moments, and spatial distribution within the ROI. Following feature extraction, univariate and multivariate analyses were performed to identify morphological biomarkers differentiating healthy tissue, low-grade IPMN, and high-grade IPMN. Quantitative features from the pancreatic ROI may show significant associations with malignancy risk in IPMN. Specific morphological parameters may serve as independent predictors of high-risk versus low-risk IPMN classification following multivariate analysis. This study establishes a quantitative relationship between pancreatic morphology and malignant transformation risk in patients with IPMN. By identifying morphological features that independently predict high-risk lesions, our findings may support non-invasive risk stratification and inform clinical decisionmaking in IPMN management.

Keywords:

IPMN; Morphometric Analysis; Pancreas; Intraductal Papillary Mucinous Neoplasm; Malignancy Risk

Mentor(s):

Fiona Kolbinger (Engineering); Muhammad ibtsaam Qadir (Engineering)

Presentation Time: GRIS 126 at 9:00-9:20

Hybrid Parallelization Framework with Dynamic Resource Management for Large-Scale EM-Multiphysics Simulations

Authors(s):

Hsin-Yu Tsern† (Engineering)

Abstract:

Many EM-multiphysics simulation algorithms are parallel-friendly, and traditional parallel solvers utilize CPU-based MPI and OpenMP to accelerate simulations through distributed memory and multithreading. However, algorithms that rely on static resource partitioning or exhibit poor resource coordination often suffer from communication bottlenecks and suboptimal CPU or memory utilization. In addition, many parallelization approaches require substantial code modifications, making them difficult to integrate with existing solvers. Moreover, while GPU acceleration has become increasingly important, many existing parallel frameworks do not take advantage of heterogeneous computing resources. In this project, a general hybrid parallelization framework combining MPI, OpenMP, and GPU acceleration—is proposed and designed to dynamically manage computational resources and optimize memory usage. The framework successfully minimizes idle resources and overlaps communication with computation, significantly improving overall efficiency. Designed with flexibility in mind, the framework abstracts parallelization strategies from solver implementation, requiring only minimal code changes to integrate with existing solvers and can be applied to a wide range of problems. It also seamlessly incorporates heterogeneous accelerators—such as GPUs—further enhancing performance across diverse platforms. Preliminary benchmarks demonstrate strong scalability, accuracy comparable to the sequential algorithm, and reduced runtime on cluster environments by several orders of magnitude. Future extensions will integrate Al-driven algorithms with other emerging methods, enabling efficient solutions for increasingly complex real-world EM-multiphysics challenges.

Keywords:

Hybrid Parallelization; Em-Multiphysics Simulation; Dynamic Resource Management; Heterogeneous Computing; GPU

Mentor(s):

Dan Jiao (Engineering); Hongyang Liu (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 126 at 9:20-9:40

Expanding Twistronics to Wafer Scale 2D films STEM

Authors(s):

Sagarika Menon†; Priya Mishra‡ (Science); Manaswini Singh‡ (Science)

Abstract:

First proposed in theory and then launched as an exciting new field with the experimental discovery of gate-tunable correlated insulator and superconductivity in "Magic Angle" Twisted Bilayer Graphene (MATBG), twistronics examines the impact of a twist angle between the lattice interfaces of stacked 2D materials on the electronic properties of the resulting structure. However, most twistronics samples so far have been created using scotch-tape exfoliated 2D materials, yielding samples limited to only a few tens of micrometers in size. Meanwhile, Molecular Beam Epitaxy (MBE) can produce high-quality thin films at the wafer scale, offering a promising route to advance both fundamental studies and practical applications for twistronics in a scalable fashion. With MBE, however, it is challenging to manipulate and stack those thin films since they are firmly attached to the substrate on which they were grown. Therefore, we need a method to reproducibly separate MBE films from the substrate without introducing tears or other imperfections, to use them for twistronics. We endeavor to build upon a recently demonstrated manual procedure that can peel wafer-scale MBE films, creating a motorized machine that performs this process in a more consistent and reproducible manner. With this approach, we will be able to integrate MBE-grown materials into twistronics research and study the electronic properties of these structures at the wafer scale, compare these results with twistronics samples produced with scotch-tape-exfoliated flakes. and bridge the gap between discoveries in fundamental science and scalable device applications.

Keywords:

2D Materials; Wafer Scale Synthesis; Twistronics

Mentor(s):

Tiancong Zhu (Science)

Other Acknowledgement(s): Kyung Jun Lee (Engineering)

Presentation Time: GRIS 103 at 10:00-10:20

Ensuring Trusted Builds Through Transparent Origins: A Tool for Visualizing Provenance and Causal Relationships in OSS Software Supply Chains

STEM

Authors(s):

Damian Munoz†; William David Boulton‡ (Science)

Abstract:

Software supply chains are processes that involve multiple parties to build software artifacts and distribute them to computers. By virtue of their complexity, software supply chains have become inscrutable. This inscrutabilty allows hackers to maliciously tamper with software before it is delivered to consumers, which can cause devastating damage (e.g., SOLARBURST [1]). Inscrutability surfaces because the systems that manage these supply chains often lack comprehensive, consistent records of provenance — making it difficult to assess the integrity of a given build. Builds with questionable integrity may become irreproducible, untraceable, or drift over time, making it difficult to assess vulnerabilities. Prior efforts like in-toto provide cryptographic guarantees for metadata tracking, ensuring a tamper-evident record of how software is built. This work presents a visual implementation of a framework that captures how software is assembled by modeling the causal relationships between four core elements: Artifacts, Steps, Resources, and Principals — a structure that was formalized as the AStRA model by Eman Abu Ishgair et al. We use the AStRA model to catalogue and visualize metadata from real-world software supply chains, enabling efficient forensic analysis and trust assessment. To support this, we developed a normalization pipeline that maps heterogeneous metadata into the data structure defined by the AStRA model. The resulting data structure is then rendered as an interactive 3D visualization — a "causal constellation" — that shows how software artifacts were created, by whom, using which tools, and in what order. This visualization module serves as a cog in the larger SBOMCtl system.

Keywords:

Cybersecurity; Supply-Chains; Provenance; Metadata; Tamper-Evident Systems

Mentor(s):

Santiago Torres Arias (Engineering); Eman Abdul-Muhd Abu Ishgair (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 103 at 10:20-10:40

Topology-Hiding Computation Tolerating Fail-Stop Adversaries

STEM

Authors(s):

Kovid Tandon† (Science)

Abstract:

Topology-Hiding Computation (THC) aims to develop secure multi party computation (MPC) protocols for incomplete communication networks, while hiding the underlying network topology. THC protocols have various applications, including anonymous networks and sensor placement. This work considers THC under a fail-stop adversary, in which the adversary can crash any party at any point of time. In prior works, proposed protocols for THC under fail-stop adversaries only guarantee security with abort, which gives an adversary the ability to control which nodes receive their output, while also leaking information about the network's topology. Furthermore, proposed protocols fail to extend to the asynchronous setting, since they crucially rely on detecting crashes. This research aims to further understand protocols for THC tolerating fail-stop corruptions in both the synchronous and asynchronous setting with minimal leakage. In the synchronous setting, we provide a protocol that tolerates fail-stop adversaries with Guaranteed Output Delivery (GOD) for all graphs. In the asynchronous setting with polynomial median delays, we provide a protocol that tolerates up to t fail-stop corruptions with no leakage for t+1 connected graphs. We also provide a novel protocol in the asynchronous setting for a wider range of graph classes and delay distributions based on proxy broadcasters. Our protocols are based on a combination of novel cryptographic primitives such as secure hardware & threshold encryption.

This is a joint work with Aniket Kate, Chen-Da Liu-Zhang, and Satvinder Singh,.

Keywords:

Applied Cryptography; Security & Privacy; Anonymity

Mentor(s):

Aniket Pundlik Kate (Science)

Other Acknowledgement(s): Satvinder Singh (Science); Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: GRIS 103 at 10:40-11:00

A Physiologically-Based Pharmacokinetic Model of Inhaled Rifampin for Treatment of Tuberculosis

STEM

Authors(s):

Noah Strawhacker† (Engineering|JMHC)

Abstract:

Current treatment of Mycobacterium tuberculosis (TB) relies on an intensive four-drug oral

regimen consisting of rifampin, isoniazid, pyrazinamide, and ethambutol. Though often

effective, this approach can lead to suboptimal outcomes, including the emergence of drug

resistance from underexposure in the lungs and significant toxicity from overexposure in the

liver and kidneys. Preliminary rodent studies support inhaled delivery of anti-TB drugs as a safer and more effective alternative to the traditional oral dose, leading to increased antibiotic concentration in the lungs, where infection lesions primarily occur. However, the impact of these inhaled antibiotics in humans remains unclear. To address this gap, a whole-body population-level pharmacokinetic model was developed to simulate time-dependent concentrations of an oral versus inhaled dose of rifampin in critical organ systems. Using this model, clinically relevant metrics - including area under the curve (AUC) and peak concentration (Cmax) - were calculated for key organ systems in a simulated patient cohort. Using target values for these metrics from the literature, the cumulative fraction of response (CFR) of TB for each dosing method was then obtained. Model predictions indicate that inhaled rifampin improves CFR in the lungs and plasma while reducing liver exposure, suggesting both greater efficacy and decreased side effects compared to the standard oral approach. These findings support the potential of inhaled rifampin as a safer and more effective therapy for TB. Future work may include the model's adaptation to a large-scale screening of TB drug delivery methods and extending its application to the treatment of other pulmonary infections.

Keywords:

Tuberculosis; Rifampin; Pharmacokinetics; Pharmacodynamics; Computational Modeling

Mentor(s):

Kali Nicole Konstantinopoulos (Engineering); Trevor Jaan Shoaf (Engineering); Elsje Pienaar (Engineering)

Presentation Time: GRIS 134 at 10:00-10:20

Investigating the Role of Lightning in Remanent Magnetization on the Surface of Mars

STEM

Authors(s):

Brianna Petruccelli† (Science|JMHC)

Abstract:

Unlike Earth, Mars does not have a global magnetic field, but instead exhibits localized crustal magnetic anomalies. The strongest of these anomalies are concentrated in a broad band in the southern hemisphere, corresponding to Noachian terrain that has remained largely unaltered since the earliest ~400 Myr of the planet's geologic history. These anomalies arise from remanent magnetization (a form of residual magnetism) with possible origins including early dynamo activity, but definitive mechanisms are still debated. We investigate if ancient lightning strikes could have been a dominant contributor through a process called lightning-induced remanent magnetization, which would have been feasibly facilitated by the warm, wet conditions of the Noachian period. To address this, we simulated the magnetic field strength produced by a flash of lightning by applying the Biot-Savart law to characterize its behavior. The computed field was then assimilated into a surface-wide probability distribution of lightning strikes, derived from a parameterized model of lightning frequency. Successive simulations were conducted to determine spatial convergence. The results showed that intensity is strongest in the southern hemisphere and near the planet's poles, but detectable surface signatures today are about 1,000,000× weaker and limited to the remaining exposed Noachian terrain. The next steps involve constructing a new surfacewide probability distribution of lightning strikes, derived from precipitation rates inferred from groundwater data. This distribution will then be subjected to the simulation and analysis process used previously, enabling a direct comparison to determine whether lightning-induced remanent magnetization is a plausible explanation for the observed magnetic anomalies.

Keywords:

Paleomagnetism; Planetary Science; Planetary Crust; Early Mars

Mentor(s):

Caue Sciascia Borlina (Science)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Ioanna Katsamba (Engineering)

Presentation Time: GRIS 134 at 10:20-10:40

Airborne Launch and Recovery System: Vision-Based Hook Localization for Autonomous Aerial Recovery of an Underwater Vehicle

STEM

Authors(s): Lorenzo Demaria†

Abstract:

Recovering underwater vehicles such as the Submersible Autonomous Module (SAM) typically requires manual piloting of drones to position a hook for retrieval, especially in unpredictable ocean environments. This project supports a broader effort to automate that process entirely from detecting the buoy to guiding the hook — using onboard vision and control systems. A convolutional neural network (CNN) has already been developed to recognize the buoy attached to SAM. However, autonomous capture also requires precise knowledge of the hook's position beneath the drone. This research addresses the challenge of estimating the 3D position of the swinging hook using either a monocular camera or a stereo camera setup, comparing the performance of both configurations alongside inertial measurements.. A Unity-based simulation replicates a drone equipped with a winch system, allowing dynamic rope control and realistic hook motion. Within this environment, a Robot Operating System 2 (ROS2) perception pipeline detects the hook in simulated images, reconstructs its 3D position using projective geometry, and fuses this data with inertial measurements through an Extended Kalman Filter (EKF). Our results show reliable hook tracking under slow flight conditions, with the EKF increasing robustness against visual dropouts. At higher speeds, performance is limited by camera frame rate and resolution. Future improvements include upgrading imaging hardware and optimizing detection for fast dynamics. This hook localization system is a critical step toward fully autonomous aerial recovery operations. If successful, it could reduce the need for manual piloting during Unmanned Underwater Vehicles (UUV) retrievals, increasing safety and efficiency in maritime missions.

Keywords:

Autonomous Aerial Recovery; Visual-Based Estimation; Dynamic Payload; Unity-Based Simulation; Extended Kalman Filter

Mentor(s):

Li-Fan Wu (Engineering); Nina Mahmoudian (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: GRIS 134 at 10:40-11:00

EXHALE (Exudate and Hydration Analysis for Lesion Evolution)

STEM

Authors(s):

Neha Saleha† (Engineering|Liberal Arts)

Abstract:

Chronic wounds, including diabetic ulcers and pressure injuries, affect over 6.5 million individuals in the United States, leading to morbidity, infection risk, and substantial healthcare costs. Current wound assessment relies on subjective visual inspections and intermittent sampling, often delaying critical complication detection. Wound exudate contains invaluable biochemical information that, if monitored continuously and spatially, could provide early, objective indicators of wound status and guide timely interventions.

This project introduces EXHALE (Exudate and Hydration Analysis for Lesion Evolution), a conformable intelligent wound dressing designed for real-time, spatially resolved monitoring of wound exudate. Our innovation integrates multimodal sensors within a biocompatible hydrogel platform to assess both the diffusion dynamics and critical biochemical composition, including pH, protein concentration, and electrolytes. This continuous, objective data stream promises unprecedented insight into wound microenvironments. We will evaluate EXHALE's performance and its ability to capture dynamic fluid profiles using advanced wound phantom models, validating the platform's responsiveness and accuracy. Sensor data will feed sophisticated machine learning algorithms, allowing wound status classification and early prediction of complications like infection or stagnation.

Our methodology involves developing artificial wound exudates by controlling pH, glucose, viscosity and temperature. Initial sensor testing on these mimics is expected to show transudates with physiological pH (~7.3-7.5) and normal glucose (~8.3 mmol/L). Chronic/infected exudates will exhibit distinctly alkaline pH (~7.8-8.9) and significantly lower glucose (<0.5 mmol/L),.

EXHALE represents a shift in wound management. Its successful development will yield a non-invasive, intelligent tool capable of delivering actionable insights directly to clinicians at a low cost.

Keywords:

Chronic Wounds; Wound Exudate; Multimodal Sensing; Real-Time Monitoring; Machine Learning

Mentor(s):

Dhiya eddine Belkadi (Engineering); Muhammad Mustafa Hussain (Engineering)

Presentation Time: GRIS 133 at 10:00-10:20

Non-Linear Spring Modeling of Anchorages in Concrete STEM

Authors(s): Priyanka Ghadiyaram†

Abstract:

Anchorages in concrete are critical systems used to secure structural elements, such as steel beams, to concrete foundations. They ensure safe load transfer, maintaining the stability and integrity of structures like buildings, bridges, and tunnels. A typical anchorage comprises a steel base plate that distributes loads through a group of heavy-duty mechanical fasteners known as anchors, which then transfer these forces into the surrounding concrete. These anchor groups are typically designed following EN1992-4 in Europe or ACI 318-19 in the US. However, these design codes often assume rigid base plates and limit anchor configurations to rectangular groups. In practice, base plates experience bending depending on anchor spacing, plate thickness, and stiffness. This bending leads to redistribution of forces within the anchor group which is not captured by conventional code-based methods, which can lead to unconservative designs. This study presents a non-linear spring model where anchors are modeled as non-linear tension-only springs, the base plate is modeled using eight-node hexahedral elements, and compression-only springs are attached below the plate to simulate the concrete support. The tensile behavior of concrete, particularly for concrete cone failure of anchors, is incorporated in the anchor spring characteristics. The developed model is validated against experimental results and is shown to effectively capture base plate bending, non-linear behavior, and redistribution of anchor forces within the group.

Keywords:

Anchors; Base Plate; Concrete; Bending; Tension-Only

Mentor(s):

Dheeraj Govindrao Waghmare (Engineering); Akanshu Sharma (Engineering)

Other Acknowledgement(s):
Radhika Arvind Bhopatkar (Engineering)

Presentation Time: GRIS 133 at 10:20-10:40

Optimizing ARU Deployment: Effects of Sampling Intensity and Spatial Arrangement on Wild Bird Biodiversity Detection Around Poultry Facilities

STEM

Authors(s):

Ana Maria De La Torre Sanchez†

Abstract:

Highly Pathogenic Avian Influenza (HPAI) poses a significant threat to commercial poultry operations; wild birds act as potential viral vectors, necessitating the identification of bird species richness near poultry facilities for developing effective biosecurity protocols. Autonomous Recording Units (ARUs) are increasingly used for avian monitoring, but there is limited guidance for their efficient deployment for biodiversity detection. This project aims to inform researchers about the optimal ARU deployment strategy to maximize wild bird species detection.

The study uses a full factorial design combining three spatial arrangements (grid-based, random, and targeted ecological sites) and four levels of sampling intensity (4, 9, 16, and 25 ARUs), resulting in 12 treatment combinations. Recordings are collected over seven consecutive days, for four hours daily (from one hour before dawn through three hours after), and analyzed using the BirdNET-Analyzer to identify species presence. The analysis focuses on total species richness, species accumulation and rarefaction curves, and detection rates relative to the number of ARUs.

It is hypothesized that deploying ARUs with medium-low intensity in ecologically relevant locations offers the best trade-off between sampling effort and detection efficiency. This study will compare the effectiveness of different combinations and provide practical recommendations for future ARU-based monitoring. By offering a clearer understanding of ARU sampling strategies, this research supports better-informed wildlife surveillance near poultry operations and contributes to HPAI risk management.

Keywords:

ARU; Richness; Wildlife; Sampling; Birds

Mentor(s):

Patrick A Zollner (Agriculture)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
Parth Uday Kelkar (Engineering); Griffin Broviak (Agriculture); Jared Franklin Trask (Agriculture); Mate Farkas (Agriculture)

Presentation Time: GRIS 133 at 10:40-11:00

Automated Monitoring and Prediction of Saginaw Bay Shoreline Response using Satellite Imagery STEM

Authors(s):

Maggie McLeod† (Engineering|JMHC)

Abstract:

Between 2013 and 2020, Great Lakes shorelines experienced considerable change from a record-setting water level increase. Previous work quantifies shoreline changes and environmental conditions during this period using multispectral satellite imagery combined with water gauge data, topography, and other sources. This study harnesses satellite imagery with machine learning modeling to identify where shoreline has recovered since the 2013-2020 changes and quantify the extent of shoreline rebuilding. Shoreline recovery locations are mapped in Saginaw Bay, Lake Huron, using 3-meter resolution, daily satellite imagery from Planet Labs. Satellite data is downloaded for 2023-2025 as input for a shoreline detection algorithm. Open-source Landsat imagery served as a testbed to ensure the algorithm's compatibility with publicly available data before applying the algorithm to modeling efforts. Horizontal shoreline positions are delineated with this pre-existing algorithm based on a Direct Difference Water Index (DDWI). Next, geoprocessing tools find rates of shoreline change across Saginaw Bay, and use these rates to classify locations as eroding, rebuilding, or stable. This information serves as a basis for a machine learning model that predicts future shoreline response. Predicted shorelines are tested on dates that have already passed and then validated with the forecasted time's actual imagery. The relationship between shoreline response and environmental factors allows for a robust analysis of Saginaw Bay's dynamic change from extreme water level fluctuations. This study provides results on the effectiveness of this model, and guidance on an algorithm that can be harnessed for finer temporal scale analysis, to inform coastal communities of beach response.

Keywords:

[no keywords provided]

Mentor(s):

Kendahl R Hejl (Engineering); Cary D Troy (Engineering)

Other Acknowledgement(s): Emily R Jakob (HHS)

Presentation Time: GRIS 126 at 10:00-10:20

The Effect of Cloud Condensation Nuclei in Stratocumulus Clouds along Southern Coastal Peru

STEM

Authors(s):

Jasmine Alayna Luckett† (Science)

Abstract:

The effect of Southeastern Pacific marine stratocumulus clouds globally impacts incoming solar radiation and helps cool the planet. They also provide water to local costal ecosystems and communities, who use fog for irrigation. These clouds are seasonal along the costal range from Peru to southern Chile. The fog and their dissolved nutrients settle into the dirt and deposit into the ecosystem. These clouds require humidity and an aerosol, or cloud condensation nuclei (CCN), to form. CCNs also affect cloud properties depending on which particle the cloud is formed on. The research question here is what the chemical makeup and source of the CCN is. Three hypotheses were proposed; there are multiple sources of CCN, cloud properties affect chemical concentrations, and CCN chemical composition differs as a function of altitude.

To test this, we partnered with National University of San Agustin of Arequipa (UNSA), a local university in Arequipa, Peru, by designing and building four low-cost fog nets and installing them along the coastal range of the Pampas de La Joya desert region, increasing in altitude from 400-800 meters. We collected the water from the nets and analyzed ions using ion chromatography. The resulting data showed high concentrations of ions when cloud density was lower and vice versa. Natural sea salt was a major component of CCN, although the largest sea salt concentrations were found at middle altitudes, and not altitudes closer to the ocean.

Keywords:

Salts; Peru; Clouds; Fog Nets; Seawater

Mentor(s):

Greg M Michalski (Science)

Presentation Time: GRIS 126 at 10:20-10:40

Impact of Disruption in Semiconductor Supply Chain with a Focus on Electric Vehicles in the U.S.

Business Case Study

Authors(s):

Eduard Alexis Ruiz Raba†

Abstract:

The global shift toward electric vehicles (EVs) has significantly increased the automotive industry's reliance on semiconductors, exposing production systems to disruptions in the chip supply chain. This study investigates how semiconductor market volatility influences EV production in the United States by applying a Vector Autoregression (VAR) model. Using monthly data from January 2017 to August 2024, we examine the relationship between the Dow Jones U.S. Semiconductor Index (DJUSSC) and automotive production data for five EV models: Tesla Model 3, Model S, Model X, Nissan Leaf, and Chevrolet Bolt.

Impulse Response Functions (IRFs) reveal heterogeneous effects: while the Tesla Model S shows minimal response, models like the Chevrolet Bolt and Tesla Model X exhibit production shocks exceeding 6% of their monthly averages. These results indicate that vehicle-specific factors such as design complexity and supply chain configuration affect vulnerability of upstream semiconductor fluctuations and the exponential increase in usage of semiconductor chips in EVs further amplify their exposure, reinforcing the need to understand this link.

To contextualize these dynamics, the study maps the semiconductor supply chain from quartz extraction to chip packaging and export to USA. This globally distributed and tiered system proved highly sensitive to exogenous disruptions, including trade tensions and the COVID-19 pandemic, which collectively triggered the 2020–2022 semiconductor shortage.

By integrating supply chain analysis with time series modeling, this research highlights semiconductors as systemic enablers in the EV ecosystem and emphasizes the strategic need of safeguarding chip supply to ensure stable production and future mobility goals.

Keywords:

Semiconductors; Electric Vehicles; Supply Chain; Production; VAR

Mentor(s): Steven R Dunlop (DSB); Dutt Jagdish Thakkar (DSB)

Presentation Time: GRIS 126 at 10:40-11:00

Forecasting U.S. Electricity Demand Using Supervised Machine Learning: A Multivariable Approach with Emphasis on Environmental Drivers and Electric Vehicles STEM

Authors(s):

Daniela Katherin Soriano Hernandez†

Abstract:

This research aims to understand the effects of different variables on electricity demand in the United States based on historical data, prioritizing an environmental context and the influence of electric vehicles (EVs). The study analyzes 13 variables, including energy source generation, electricity consumption, temperature, electric vehicles and economic indicators; each with monthly observations spanning across the last 14 years.?Machine learning supervised iterations, specifically, ridge regression models, are applied to the data. The best model identifies the strongest variables which include summer season, cooling degree days and residential electricity; all of which are coherently related to each other, and also reflected in the peaks of electricity demand.?

The study confirms that the EV fleet has a relatively smaller impact on electricity consumption, although it remains a potentially influential market. The study also identifies a clear predominance and reliance for generation of electricity on fossil fuels, especially natural gas, highlighting?the gaps in terms of renewable and mixed energies generation.? Climate change impacts, especially connected to extreme heat, underscore the importance of reducing this dependence on fossil fuels.

Even though increased renewable energy generation or a sudden rise in electric vehicle adoption seem like non-conservative scenarios, the existing infrastructure may be insufficient to support these changes. Thereby it is important to consider these scenarios and prepare for them as they could be imminent. Future approaches could include analysis using different machine learning models based on a state or regional level, and the application of autoregressive models for time series forecasting.

Keywords:

Electricity Demand; Machine Learning; Energy Mix; Electric Vehicles

Mentor(s): Steven R Dunlop (DSB); Dutt Jagdish Thakkar (DSB)

Presentation Time: GRIS 118 at 10:00-10:20

Identifying Doxorubicin-Induced Cardiotoxicity Using 4D Echocardiography

STEM

Authors(s):

Bea Olivia Cabot† (Science); Anna Julie Astrid Webb‡ (Science); Wilhelm S Smith‡; Aasish Chowdary Karuturi‡ (Science|JMHC)

Abstract:

Doxorubicin is an effective, commonly used chemotherapeutic drug. However, this drug is accompanied with disadvantages, Specifically, doxorubicin is associated with cardiotoxicity, characterized by left ventricle dysfunction. We hypothesize that 4D ultrasound imaging can reveal cardiac changes associated with doxorubicin-induced cardiotoxicity earlier in disease progression than 2D ultrasound imaging. To test this hypothesis, C57BL/6J mice were separated into treatment or control groups. Intraperitoneal injections were administered weekly for 4 weeks, each dosage equivalent to 4 mg/kg of either doxorubicin (treated) or saline (control). A Vevo3100 high frequency ultrasound system (FUJIFILM VisualSonics) was used to collect 2D and 4D ultrasound images of cardiac structures. Weekly imaging was carried out for 8 weeks following baseline imaging. 2D images were analyzed using Vevo Lab (VisualSonics) software. Parameters reflecting diastolic and systolic function including ejection fraction were collected, as well as left ventricle dimensions. Ejection fraction, or the percent of blood volume expelled from the left ventricle, is a commonly-used marker of cardiotoxicity. The 4D ultrasound images, analyzed using a custom-built MATLAB Graphical User Interface, uniquely quantified cardiac strain using the full volume of the heart. Cardiac strain is a measure of cardiac wall displacement. In mice treated with doxorubicin, decreases in both ejection fraction and strain are anticipated. Ongoing image analysis will quantify any changes in cardiac strain that may occur prior to changes in the metrics found using 2D analysis. The ability to identify dysfunction using cardiac strain before traditional analysis has potential to improve early diagnosis and treatment of cardiotoxicity.

Keywords:

Doxorubicin; Cardiotoxicity; 4D Ultrasound

Mentor(s):

Cortland Hannah Johns (Engineering); Benjamin Zeidler (Engineering); Craig Goergen (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 118 at 10:20-10:40

VECMA-3SV: Virtual Environment on-device Complexity Management Algorithm through Stochastic Single Shot Visibility

STEM

Authors(s):
Mridu Prashanth† (Science)

Abstract:

VR headsets simulate real world scenarios that are immersive, interactive, and imaginative. They are used as a training tool in a variety of fields from construction to medicine to education. Effective real-time computation is challenged by VR's limited rendering power. We describe a novel stochastic visibility algorithm for accurately and speedily displaying complex Virtual Environments (VEs) on demand during navigation by pre-computing an aggressive visible set with chosen granularity of scene components (triangles, meshes) for various scenes. Given a 3D region (view cube or view square), the algorithm finds a fraction of the original set of scene components required to render the scene from within the view region - preserving far away, out of view and currently occluded but later visible components. This offers about a 40% reduction in the visible set of triangles, speeding up on-demand rendering. VECMA-3SV is single shot with raytracing performed only once per unit of the view region, making it less expensive than state of the art methods that ray trace continuously multiple times along a view region segment. Since our view region for raytracing allows a larger field of view, our scenes average errors within 0.05% compared against ground truth and are virtually indistinguishable from it. Accordingly, the peak signal to noise ratio averages 35 dB (considered good), with the structural similarity index being very close to 1 along the full walk around the perimeter of the view region, which is at the very edge so has the least visibility in the view region. This showcases the model's potential for use in real-time applications.

Keywords:

Complex Virtual Environments; Raytracing; Single-Shot Visibility; Aggressive Visibility; Computer Graphics

Mentor(s):

Voicu S Popescu (Science)

Presentation Time: GRIS 118 at 10:40-11:00

CrayonClassifier: Detecting Emotional Cues in Children's Art with Classical Machine Learning Models

STEM

Authors(s):

Lamiya Sajidbhai Laxmidhar† (Science)

Abstract:

This project investigates the feasibility of emotion recognition in children's artwork using classical machine learning methods and hand-crafted features. Children's drawings are a widely studied medium of emotional expression in developmental psychology, yet they remain underexplored in computational emotion classification research. This project introduces CrayonClassifier, an end-to-end image classification pipeline designed to identify five core emotional categories—happiness, sadness, calmness, fear, and anger—from crayon-style children's drawings.

The dataset was curated through targeted web search and organized into labeled emotional categories. To ensure robustness and class balance, data augmentation techniques such as geometric transformations were applied. Preprocessing was performed using OpenCV, with facial or visual region-of-interest (ROI) detection where applicable. Wavelet transforms were employed for feature extraction to capture both texture and spatial frequency information.

Three classical machine learning models—Support Vector Machines (SVM), Logistic Regression, and Random Forest—were trained and evaluated. Hyperparameter tuning was conducted using GridSearchCV, and model performance was assessed via accuracy, precision, recall, and confusion matrix analysis. The finalized model was deployed through a Flask server and integrated with a web-based user interface developed using HTML, CSS, and JavaScript.

CrayonClassifier demonstrates that with appropriate feature engineering and traditional ML models, it is possible to extract and classify affective signals from children's visual expression. The work has implications for interdisciplinary applications across child development research, emotional diagnostics, and human-centered Al.

Keywords:

Emotion Recognition; Image Classification; Children; Machine Learning; Feature Engineering

Mentor(s):

Mukhamad Suhermanto (Engineering)

Presentation Time: GRIS 103 at 11:00-11:20

Changes in the Gut Microbial Community of Mice After Long-Term Antibiotic Treatment: Effects of Sex, Treatment, and Treatment Duration

STEM

Authors(s): Anna M Kiley†

Abstract:

The gut microbiome affects skeletal health by influencing immune signaling, nutrient absorption, and inflammation in bone remodeling. While sex-based differences are known in both gut microbiota and bone biology, it remains unknown whether the gut-bone axis itself is also sexdependent. Understanding how microbial composition varies with antibiotic treatment, duration, and sex may reveal sex-specific strategies to treat musculoskeletal conditions. To study this, we used a mouse gut microbiome model. Under institutional approval, mice received either no treatment or antibiotics in water (1g/L ampicillin + 0.5g/L neomycin) starting at 5 weeks of age. At euthanasia after 3, 11, and 19 weeks, we collected cecum contents, serum, and hindlimbs. 16S rRNA sequencing enabled phylum-level relative abundance analysis of the gut microbiome. Using two-way ANOVA (RStudio), we assessed sex and treatment effects at each time point. After 3 weeks, antibiotics affected Actinobacteria (p = 0.005) and Bacteroidetes (p = 0.001); Bacteroidetes also showed a sex effect (p = 0.03). At 11 weeks, Bacteroidetes was influenced by sex (p = 0.01) and treatment (p = 0.003); Firmicutes differed by sex (p < 0.001). Tenericutes showed sex, treatment, and interaction effects (p = 0.01, 0.002, < 0.001). Verrucomicrobia had a treatment effect (p < 0.001). By 19 weeks, treatment effects became dominant: Actinobacteria, Bacteroidetes, Firmicutes, Proteobacteria, and Verrucomicrobia all showed treatment effects. These results suggest sex shapes early microbiome changes, while prolonged antibiotics drive sustained shifts. This may help guide future research leveraging the gutbone axis to prevent or treat musculoskeletal disease.

Keywords:

Gut Microbiome; Gut-Bone Axis; Sex-Based Differences; Antibiotic Treatment

Mentor(s):

Deva Chan (Engineering); Cameron Xavier Villarreal (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Pranshul Sardana (Engineering)

Presentation Time: GRIS 103 at 11:20-11:40

Ultrasound-based assessment of murine cardiac remodeling in chronic hypertension during pregnancy

STEM

Authors(s):

Sarah Elizabeth Grev† (Engineering)

Abstract:

Chronic hypertension occurs in about 2% of pregnancies and can lead to fatal complications for mother and child [1]. Interestingly, research suggests that the heart may be able to effectively adapt to maintain function during hypertensive pregnancy [1]. However, little is known regarding this cardiac remodeling process. Therefore, our objective was to quantify the cardiac adaptations that occur in hypertensive pregnancies. We assessed cardiac remodeling in mouse models of hypertensive pregnancy group (HT+PREG, n=5), chronic hypertension (HT, n=7), and normotensive pregnancy (PREG, n=4). We collected long axis ECG-kilohertz visualization images and anatomical M-mode and short axis 4D images of the left ventricle via ultrasound. Wall thickness, diameter, stroke volume (SV), ejection fraction (EF), and cardiac output (CO) were measured using VevoLab (VisualSonics Inc.). EF decreased in HT animals across the experimental timeline. Wall thickness significantly increased from mid-pregnancy (gestational (e) day 12.5) to postpartum day 1 in the HT+PREG group (p<0.05). Conversely, CO and SV significantly increased compared to baseline at eday12.5 and pday1. respectively, in the HT+PREG group. These results suggest that cardiac function can be maintained during chronic hypertensive pregnancy. Future work involves completing 4D strain and histological analysis of cardiac tissue samples. Overall, this study provides insights into cardiac function and geometric remodeling occurring during hypertensive pregnancies. A potential broader outcome is a better understanding of clinical management of hypertensive pregnancies.

[1] A. N. Battarbee, et al., AJOG, 2020.

Keywords:

Hypertension; Pregnancy; Cardiac Remodeling; Ultrasound

Mentor(s):

Elnaz Ghajar-Rahimi (Engineering); Craig Goergen (Engineering)

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: GRIS 103 at 11:40-12:00

Health Persona: An Al-Powered Multimodal Health Platform for Real-Time Symptom Analysis and Personalized Insights on hEDS

STEM

Authors(s):
Mansi Abhijit Dhamne†

Abstract:

Hypermobile Ehlers-Danlos Syndrome (hEDS) is a heritable connective tissue disorder characterized by joint hypermobility, pain, fatigue, and variable dysautonomia. Its rarity and variable symptom profile make diagnosis an arduous journey, further complicated by the absence of known genetic markers. Even post-diagnosis, traditional episodic care models often fail to capture the subjective and fluctuating nature of hEDS symptoms, leading to fragmented clinical insight and suboptimal treatment. To aid diagnosis and to facilitate a personalized treatment plan, we present Health Persona, an Al-powered mobile health system for continuous, patient-centric monitoring of autonomic physiology, symptoms, and contextual information (e.g., environment, time of day, activity). The system features a privacy-preserving architecture that captures and annotates multimodal data, including speech, text, and physiological signals from wearable devices and in-app interactions. A conversational AI interface supports patient engagement through symptom journaling and check-ins. Data are analysed using adaptive methods to identify patterns across symptoms, physiology, and context, enabling actionable insights such as flare predictors, symptom clusters, and consultation summaries. Initial development focuses on usability, flexible symptom entry, and chatbot accuracy based on user feedback. To assess the reliability of the speech-to-text component used in patientclinician summaries, we compared ASR outputs to manually transcribed consultations (N=10). The system achieved an average Word Error Rate (WER) of 8.96%, indicating high transcription fidelity for downstream tasks. Health Persona offers a promising path toward earlier diagnosis and individualized, data-driven care for the holistic treatment of hEDS patients. Future work will evaluate its clinical relevance and impact on patient outcomes.

Keywords:

Machine Learning in Healthcare; Digital Health; Hypermobile Ehlers Danlos Syndrome; Conversational AI; Wearable Devices

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Mentor(s): Matthew Peter Ward (Engineering)

Other Acknowledgement(s): Emily R Jakob (HHS)

Presentation Time: GRIS 134 at 11:00-11:20

Injectable granular hydrogels for potential cardiac tissue repair applications

STEM

Authors(s): Mihika Desai† (Engineering)

Abstract:

Myocardial infarction (MI) is one of the leading causes of death globally, characterized by myocardial tissue necrosis and fibrotic scarring. Postinfarction remodeling and wall thinning often lead to heart failure. Minimally invasive biomaterial therapeutics offer promise for tissue repair by mechanically reinforcing the myocardium. Acellular hydrogels are ideally suited for this purpose but often have limited porosity and injectability. This study explores an injectable and microporous granular hydrogel system assembled using hyaluronic acid microparticles. Microgels were fabricated using norbornene-functionalized hyaluronic acid (NorHA) with a flow-focusing microfluidic device and crosslinking using 20 mW/cm² UV light. Microgels were imaged via light and fluorescence microscopy after washing with phosphate-buffered saline. Granular hydrogels were assembled at low and high packing densities using centrifugation (12,000 RCF) and vacuum filtration, respectively. Granular hydrogels were characterized using oscillatory shear rheology, including strain sweeps (0.5 - 500%), recovery tests, and rotational viscosity measurements to evaluate mechanical behavior, injectability, and recovery after yielding. Covalently crosslinked microgels were successfully fabricated with a mean diameter of 91 +/- 9 µm. Jamming of these particles produced granular hydrogels. Ongoing experiments aim to evaluate how packing density influences rheological behavior and injectability, and to assess in vivo tissue responses in a mouse model. We hypothesize that increased packing will modulate shear-thinning and self-healing properties, as well as alter storage modulus and yield strain. Overall, this project explores the potential of injectable and microporous granular hydrogels as a biomaterial therapeutic for potential applications in MI treatment.

Keywords:

[no keywords provided]

Mentor(s):

Taimoor Hasan Qazi (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Emily R Jakob (HHS)

Presentation Time: GRIS 134 at 11:20-11:40

Advanced Radiomics for Early Detection of Bone Fragility in Women Undergoing Bariatric Surgery and GLP-1 Receptor Agonist Treatment for Rapid Weight Loss

STEM

Authors(s):

Aarya Gajendra Sontakke† (Science)

Abstract:

Rising obesity among women has led to bariatric surgery and glucagonlike peptide-1 receptor agonist (GLP-1 RA) therapy. These treatments induce weight loss and improve metabolic health but may weaken bone structure and raise fracture risk. Early detection of bone fragility is vital. Standard dual-energy X-ray absorptiometry (DXA) scans cannot capture local structural bone changes after treatment, delaying identification of patients at risk for treatment-induced fragility until fractures occur. Novel imaging biomarkers are required for timely monitoring and early intervention to prevent complications. For a preliminary analysis, we collected high-resolution peripheral quantitative computed tomography (HR-pQCT) scans of the distal tibia from eight participants, six women and two men, receiving GLP-1 RA therapy and 61 age- and sex-matched controls. We cropped images to remove background, segmented five anatomical regions (soft tissue and bones) using a previously developed deep learning model, and post-processed to correct anomalies. Furthermore, we subdivided each soft tissue region into muscle, fat, and skin compartments and extracted comprehensive radiomic features, including first-order statistics, second-order texture metrics, threedimensional shape descriptors, and wavelet and Fourier transform coefficients. Using these features, we aim to extract clinically relevant structural patterns that differentiate the GLP-1 group from controls. Finally, we are developing a convolutional neural network to integrate whole-volume image information with radiomics outputs, laying the groundwork for an automated, personalized framework to detect early treatment-related bone fragility. Our imaging framework will enable noninvasive detection of early bone weakening after rapid weight loss in women with obesity, allowing personalized monitoring to reduce fracture risk.

Keywords:

[no keywords provided]

Mentor(s): Mohseu Rashid Subah (Engineering); Pranshul Sardana (Engineering); Rachel Kathleen Surowiec (Engineering)

Presentation Time: GRIS 134 at 11:40-12:00

Imaging and characterization of shock-induced aerobreakup in aqueous-IPA droplets

STEM

Authors(s):

Matthew S Leight† (Engineering|JMHC); Soham Pawaskar‡ (Engineering|Liberal Arts); Eleanor Captola Hostetler* (Engineering)

Abstract:

One complex threat faced by hypersonic vehicle designers is found in microscopic-sized ice and liquid particles that make up clouds in the upper atmosphere. These particles can fragment across shock waves emanating from hypersonic vehicles and cause damage by impacting and cratering the vehicle surface; yet, literature contains few experimental observations of their breakup phenomena. This study uses Purdue's 3-Inch Shock Tube to classify the breakup modes of such particles across shock waves from Mach 1 to 3, predict the size and shape of child particles, and propose physical models for breakup. The initial phase of the project examines the effect of droplet surface tension and viscosity on breakup regime by varying droplet chemistry. Aqueous solutions of isopropyl alcohol are created, dispensed into the shock tube, and hit with a shock. The breakup is captured with a high-speed camera using a Schlieren optical system, while pressure traces are recorded by pressure transducers within the tube. High-speed video shows the development of vibrational, bag, bag-and-stamen, and stripping type breakup, along with various transitional breakup modes. Analysis of droplet and shock properties reveals breakup regimes distinguished through Weber and Reynolds numbers. Timing delays of the electrical burst system are collected for use of particle-shock synchronization later in the study. Results show Weber and Reynolds numbers can be used as predictive tools for modelling particle breakup in supersonic flight regimes. However, overlap in breakup regimes and the existence of transitional modes may necessitate use of probabilistic models for particle size in damage assessment.

Keywords:

Shock Tube; Droplet Breakup; Schlieren Videography; Atmospheric Particles

Mentor(s):

Joseph S Jewell (Engineering); Siddharth Bhatnagar (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
Radhika Arvind Bhopatkar (Engineering)

Presentation Time: GRIS 133 at 11:00-11:20

Automation Methods for Gamma Ray Spectroscopy and Data Analysis

STEM

Authors(s):

Myron Milad Tadros† (Engineering); Mason Patrick Julius Levere† (Science); Siddhant Jain†; James Thomas Pittard* (Science); Sydney Metz* (Science|JMHC)

Abstract:

Gamma-ray spectroscopy is used by nuclear physicists to better understand the structure of the nucleus in excited states. By observing the decays from an excited nucleus, we can create level-schemes that map its allowed energy states and transitions. With this knowledge, we can identify specific energy states that are useful in application to batteries known as isomers. Isomers are states with a long half-life. allowing for the storage of energy with little decay at a smaller size than their chemical counterparts. However, few convenient isomer states are currently known, and more level-schemes are required to identify more isomer states. The current method to create level-schemes demands months of expert labor, making isomer identification slow and hard to reproduce. We recast the task as an image-to-graph translation problem and propose a machine-learning pipeline that turns an entire coincidence matrix directly into a level-scheme. We explore a solution for this problem by using convolutional neural networks as well as conditioning an autoregressive graph generator on the synthetic gamma-gamma matrix input. To build intuition before tackling sparse experimental data (<1% signal), we train and validate on Monte-Carlo-derived gammagamma matrices and level-schemes, progressively increasing spectral complexity to mimic realistic noise. Utilizing the machine learning models mentioned, the level-schemes generated will serve as a benchmark for the accuracy of the model when used on real gamma-gamma data. By staging development in these synthetic environments, we aim to deliver a framework capable of real-time, reproducible spectroscopy once migrated to experimental data.

Keywords:

Gamma Ray Spectroscopy; Machine Learning; Nuclear Physics; Monte Carlo; Level Scheme

Mentor(s):

Andreas Jung (Science); Mark Ward (Science); Ace Rounds (Science)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 133 at 11:20-11:40

Scalable and Uncertainty-Aware Operator Learning via Quantum Deep Ensembles

STEM

Authors(s):

Purav Matlia† (Science)

Abstract:

In many scientific and engineering domains, operators—mappings between infinite-dimensional function spaces—are used to model functional relationships, including those arising in the solution of partial differential equations (PDEs). Deep Operator Networks (DeepONets) offer a data-driven framework for learning such operators, but classical DeepONets face challenges related to computational scalability and reliable uncertainty quantification, particularly during rare but critical events. To address these issues, we build on recent advances in quantum machine learning by extending the quantum DeepONet framework, which reduces forward-pass complexity from quadratic to linear. We incorporate the Superposed Parameterized Quantum Circuit (SPQC) architecture to represent an ensemble of quantum DeepONets within a single parameterized quantum circuit. The ensemble is constructed using random initialization and bootstrap aggregation (bagging), and the SPQC enables the simultaneous evaluation of all ensemble members in one quantum inference pass. To support reliable uncertainty estimates, we use a conformal prediction framework that generates prediction intervals with guaranteed accuracy. We evaluate our approach using the antiderivative operator and analyze the impact of quantum measurement noise on predictive reliability. Our results demonstrate that this method enables scalable operator learning on fault-tolerant future hardware while supporting rigorous uncertainty estimation, making it a promising approach for real-time, high-stakes applications such as power system monitoring.

Keywords:

Quantum Machine Learning; Operator Learning; Uncertainty Quantification; Conformal Prediction; Deep Operator Network (DeepONet)

Mentor(s):

Guang Lin (Science); Christian Bolivar Moya Calderon (Science)

Other Acknowledgement(s):
Andres Catalino Castillo Jimenez (Engineering)

Presentation Time: GRIS 133 at 11:40-12:00

Influence of zeolite framework and diffusional constraints on carbon selectivity during methane dehydroaromatization STEM

Authors(s):

Maxwell K Bartlett+; David W Ball*

Abstract:

Abundant natural gas (~90% methane) found in isolated shale gas reservoirs is often flared due to high transportation costs and lack of technologies to transform methane into useful products, emitting ~500 million tons of CO2 per year, exacerbating detrimental greenhouse gas effects. Methane dehydroaromatization (DHA) is an oxygen-free reaction that produce benzene and H2, catalyzed by molybdenum active sites supported onto zeolites. Zeolites are aluminosilicate crystalline materials that influence rates, selectivities and stability for methane DHA. Specifically, the chabazite (CHA) framework is promising for methane DHA due to its improved long-term stability during reaction-regeneration cycles. However, chabazite's small pore openings (?4 Å) impose diffusion limitations and its large internal cavities (?8 Å) promote carbon (i.e., coke) deposition, decreasing benzene selectivity. We seek to alleviate diffusional constraints by synthesizing CHA materials containing mesoporous voids, allowing for higher benzene selectivity and reduced coking. Al-substituted CHA was synthesized according to literature references and treated in air at 300, 400, and 450? (1 h). Then, CHA zeolites were exposed to alkaline treatment with 0.4 M NaOH (ag.) at varying contact times (30, 60 minutes). Treated samples were characterized using powder X-ray diffraction (XRD), Ar adsorption isotherms (87 K), and elemental analysis (ICP). XRD peaks evidence that CHA crystallinity does not change significantly after the alkaline treatment. Moreover, Ar isotherms evidence increasing air-treatment temperature and alkaline-treatment time leads to higher density of mesopores. These post-synthetic protocols provide a method to systematically investigate the effect of morphological changes on diffusivity and benzene selectivity for methane DHA.

Keywords:

[no keywords provided]

Mentor(s):

Angel Noel Santiago Colon (Engineering); Rajamani P Gounder (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
Jorge Enrique Neira Garcia (Polytechnic)

Presentation Time: GRIS 126 at 11:00-11:20

Formation of silicate spherules in impact produced vapor plumes

STEM

Authors(s): Gregorio Lince†

Abstract:

Collisions among planetesimals are a likely source of the atomic and molecular gases detected in many relatively young debris disks. The fraction of silicate vapor that re-condenses, as well as resulting spherule size, are not well known for sub-kilometer impactors. We extend the one-dimensional Lagrangian hydrocode developed by Johnson and Melosh, where silica ANEOS and homogeneous nucleation theory are coupled to simulate projectiles from 10 km down to 1 mm at 16-50 km/s. After verifying the benchmark ~250 um spherules formed at a 10 km, 21 km/s collisions, we find that spherule size is smaller in the outer layers of the plume, and a linear dependence on impactor size is observed, as well as a complex one on impactor velocity. Size-velocity and condensed-mass-velocity provide quantitative evidence of whether collisional vapor can account for the amount of gas present in debris disks.

Keywords:

Spherule; Impact Processes; Cratering; Earth; Nucleation

Mentor(s):

Brandon Charles Johnson (Science); Shigeru Wakita (Science)

Presentation Time: GRIS 126 at 11:20-11:40

Ultra-Low-Frequency dynamic light scattering spectroscopy with a Fresnel biprism common-path digital holography system

STEM

Authors(s):
Agustin Lopez Zapata†

Abstract:

Fluctuation spectroscopy of dynamic speckle measures intracellular transport by detecting Doppler frequency shifts produced by a broad range of cellular motions related to different mechanisms and functions that maintain cellular healthiness. The scale in which these speeds occur require a stable enough system capable of resolving subtle frequency offsets. This work utilizes a common-path interferometric system with a low-coherence NIR source, based on a Fresnel biprism geometry, which enhances stability by ensuring the signal and reference traverse the same optical path. Mechanical disturbances influence is therefore minimized, allowing to measure ultra-low frequency shifts. This technique yields image-domain autocorrelations that reveal dynamic speckle fluctuations by performing the Fourier reconstruction of the selfreferencing speckle fields. The sensitivity extension to frequencies below 1 mHz grants this approach to unfold a new window into slow biological processes, such as cytokinesis and cell crawling. These advancements lay the groundwork for future applications in live tissue studies and drug response monitoring, though such applications remain under active investigation.

Keywords:

Biodynamic Imaging; Digital Holography; Dynamic Light Scattering; Common-Path Interferometry

Mentor(s):

David D Nolte (Science)

Other Acknowledgement(s):

Dawith Lim (Science); Shivani Mahajan (Agriculture); Gabriel Goodwin (Science)

Presentation Time: GRIS 126 at 11:40-12:00

Using 4D Ultrasound to Predict Heart Tissue Scarring After a Heart Attack

STEM

Authors(s):

Laura Fernanda Martinez Galindo†

Abstract:

Background: Each year, over seven million people experience a heart attack. Some hearts recover, but many develop stiff scar tissue that limits pumping and leads to heart failure. We cannot yet predict which hearts will follow this path, losing the chance for timely personalized treatment before it is too late.

Objective: Determine whether early in vivo 4D strain measurements can predict ex vivo fibrotic remodeling after myocardial infarction (MI).

Methods: MI was induced in 20-week-old female C57BL/6Jvr mice (n=3) by permanent left coronary artery ligation. 4D ultrasound was performed at baseline, 4 hours, 5 days, and 30 days post-MI. We measured regional circumferential (Ecc), longitudinal (Ell), radial (Err), and surface area (Ea) strain using a custom MATLAB toolbox. At 30 days post-MI, tissue was stained with Alcian Blue and quantified for fibrosis using ImageJ. Strain and fibrosis data were mapped to the AHA 17-segment model, excluding basal segments.

Results: Global strain analysis showed that lower early strain values correlated with higher fibrosis at day 30. The strongest negative correlation was observed for Ea at 4 hours post-MI (p=0.00013, R²=0.38), followed by Ecc (p=0.00081, R²=0.31), and EII (p=0.0496, R²=0.12). This pattern was most evident in the apical lateral and posterior segments, where lower strain aligned with increased fibrosis.

Discussion & Conclusion: Early strain reductions were heterogeneous but large in apical lateral and posterior segments, which showed the most fibrosis 30 days after infarction. These results support the use of 4D ultrasound-derived strain as a potential non-invasive predictor of fibrotic remodeling post-MI.

Keywords:

Heart Attack; Cardiac Remodeling; 4D Ultrasound; Fibrosis; Strain

Mentor(s): Craig Goergen (Engineering); Elnaz Ghajar-Rahimi (Engineering)

Other Acknowledgement(s):
Jake Anthony Castro (Engineering)

Presentation Time: GRIS 118 at 11:00-11:20

Dobutamine Stress Testing in 4D Strain Detection of Early Cardiotoxicity in a DOX-Treated Mouse Model STEM

Authors(s):

Aasish Chowdary Karuturi† (Science|JMHC); Wilhelm S Smith‡; Bea Olivia Cabot‡ (Science); Anna Julie Astrid Webb‡ (Science)

Abstract:

Doxorubicin (DOX) is a widely used chemotherapy drug, but its clinical use is limited by cardiotoxic effects that can lead to heart failure. Approximately 6% of patients develop clinical heart failure, and up to 18% experience subclinical dysfunction. This project tracks cardiac function and strain over time after DOX treatment in male C57BL/6J mice, focusing on dobutamine stress test as a way to detect latent cardiac damage that conventional echocardiography fails to characterize. Animals were administered 4 doses of 4 mg/kg body weight DOX weekly for X weeks; control animals were administered an equivalent volume of 0.9% saline.2D and 4D echocardiographic images were collected at baseline and 8 weekly time points afterwards using a Vevo 3100 ultrasound system from FUJIFILM Visualsonics. Metrics like ejection fraction, cardiac output, and chamber dimensions were measured using VevoLAB software. A custom MATLAB-based GUI developed in the Cardiovascular Imaging Research Laboratory was used to extract global and regional cardiac strain values from the 4D datasets. We performed dobutamine stress testing to evaluate whether strain changes become more pronounced under increased cardiac workload, expecting that changes in regional strain after dobutamine injection will reveal cardiac dysfunction before any non-dobutamine metrics. If confirmed, this would suggest that 4D strain imaging combined with stress testing is a more sensitive method for identifying cardiac dysfunction due to DOX. This could improve preclinical screening for cardiotoxicity in drug development studies as well as have potential clinical diagnostic applications.

Keywords:

Doxorubicin; Cardiotoxicity; 4D Strain Imaging; Dobutamine Stress Test; Echocardiography

Mentor(s):

Benjamin Zeidler (Engineering); Cortland Hannah Johns (Engineering); Craig Goergen (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 118 at 11:20-11:40

Multi-Omics Profiling Reveals Host Drivers of C. difficile Severity

STEM

Authors(s):

Aryaman Dewan† (Science)

Abstract:

Clostridioides difficile infection (CDI) is a leading cause of antibioticassociated diarrhea and colitis, with over 220,000 cases annually in the United States, While symptomatic CDI can lead to severe complications or death, a significant number of individuals remain asymptomatic carriers, suggesting that host-specific factors influence disease outcomes. This study aims to elucidate the proteomic and lipidomic differences between symptomatic and asymptomatic murine models of CDI to uncover endogenous protective mechanisms and identify potential therapeutic targets. Using mass spectrometry-based analyses, we profiled fecal and intestinal samples to characterize differences in host protein expression and lipid composition and their correlation with disease severity. Our preliminary findings indicate that symptomatic mice exhibit disruptions in lipid metabolism, including depletion of antiinflammatory lipid species and altered bile acid profiles. In contrast, asymptomatic mice maintain lipid signatures associated with mucosal protection and immune modulation. Proteomic analysis further identified distinct patterns of immune and barrier-regulatory protein expression that may contribute to resistance against symptomatic disease. By integrating these datasets, we propose a set of candidate lipids and proteins that may serve as biomarkers of resilience or therapeutic targets. These findings provide new insight into host-pathogen dynamics and offer promising avenues for the development of interventions aimed at reducing CDI severity and recurrence.

Keywords:

Clostridioides Difficile Infection; Mass Spectrometry; Proteomic; Lipidomic; Host-Pathogen Dynamics

Mentor(s):

Ahmed Abdelkhale Hassan (Vet Med); Punyatoya Panda (Vet Med)

Presentation Time: GRIS 118 at 11:40-12:00

Differentiating Types of Microbial Movement as Agnostic Biosignatures

STEM

Authors(s):

Gretchen K Minich† (Science|JMHC)

Abstract:

The search for life beyond Earth requires knowledge of robust biosignatures. With such a diversity of potentially inhabited planetary environments in the Solar System, e.g., subsurface oceans on the Moons of Jupiter, it is prudent to develop strategies to detect life that are independent of chemical composition. Movement has been previously suggested to be a biosignature (Glaser, 1996; Nadeau, 2016; Nadeau, 2017). However, it is not yet understood whether living movement and non-living movement can be distinguished with accuracy. The purpose of this study is to investigate microscopic movement of life that may be definitively distinguished from various forms of abiotic movement. This study involves recording videos on a microscopic level of random abiotic movement that could be detected on planets beyond Earth such as evaporation, melting, and vibration. In addition, videos depicting distinct movements of microbial life such as mitosis, flagellar motility, and swarming will be taken and compared to the distinct abiotic motion. In collaboration with Johns Hopkins Applied Physics Laboratory, a computer program will be developed using velocity vectors of the motions to train the program to characterize motions as abiotic or biotic. The program will be tested for false positives and negatives across a diverse array of videos taken in our lab and our collaborators' lab at Niagara University. The development and training of a program such as this using the described videos could be utilized to analyze recorded data from a probe on a different planet to passively search for life.

Keywords:

Microbiology; Movement; Astrobiology; Biosignature; Abiotic

Mentor(s):

Ben K D Pearce (Science)

Presentation Time: GRIS 103 at 12:00-12:20

Detection of Extracted Actinides from Water Based Solutions Using Tensioned Metastable Fluid Detector Sensor Technology

STEM

Authors(s):

Pranav Mahesh Kuruba† (Science); Everett John Nally* (Engineering)

Abstract:

Due to the significant health and safety impact of water-borne radionuclides, the United States Environmental Protection Agency (USEPA) regulations require nationwide monitoring to ensure that radioactivity levels are at/below safe levels; this is especially the case for alpha radiation-emitting actinide atoms such as uranium, radium, radon, etc. Monitoring for ultra-trace (pCi/L) levels of such radionuclides in water supplies is known to be a challenging task. Conventional techniques require days to weeks of laboratory examinations with specialized separations and spectroscopic instruments. This SURF project aims to utilize Purdue's novel tensioned metastable fluid detector (TMFD) sensor technology along with a specially developed protocol for rapidly concentrating actinides via uptake in an inexpensive extractant, Bis(2ethylhexyl) Phosphate (HDEHP). Once the HDEHP extracts the actinides, it is mixed with a carrier (methanol) to dissolve in the TMFD sensing fluid for rapid evaluation (within hours) of ultra-trace concentrations of uranium isotopes. Previous work has demonstrated that actinide extraction and detection is possible using ~2 v/o HDEHP; the current work has shown that it appears feasible to detect concentrations in the pCi/L range using TMFD technology, alongside using 10 v/o HEDP (for enhanced actinide extraction). If successful, the resulting apparatus and associated protocol are expected to result in a leap forward technique, possibly for use in over 50,000 nationwide municipalities, which annually must obtain such evidence and report to homeowners and federal-state regulatory bodies.

Keywords:

Tensioned Metastable Fluid Detector (TMFD); Waterborne Radionuclides; Actinide Extraction; Radiation Detection Technology; Ultra-Trace Radionuclide Detection

Mentor(s):

Rusi P Taleyarkhan (Engineering); Stepan Ozerov (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Jonathan Paul Koziarz (Engineering); Parth Uday Kelkar (Engineering)

Presentation Time: GRIS 103 at 12:20-12:40

How three indicators of depression influence young people Social Science

Authors(s):
Aahan Bajpai† (Science)

Abstract:

Depression is one of the most common psychiatric disorders and has significant impact on adolescents' lives. Using data from the National Longitudinal Study of Adolescent to Adult Health (Add Health), this study investigates the relationship between depression and negative future thinking. Add Health is a nationally representative cohort of individuals born between 1976-1982, interviewed across five waves. This study uses data from waves 1 (N = 20,745, aged 12-18) and 4 (N = 15,701, aged 24-32), which includes retroactive depression diagnoses reported in wave 4, depressive symptoms in waves 1 and 4, and polygenic scores for depression created from genetic data collected in wave 4. We also use prediction questions to test the hypothesis that depressed adolescents have more negative future-thinking compared to nondepressed adolescents. First, we will code three indicators of depression for each participant: self-reported medical diagnosis of Major Depressive Disorder (MDD), reporting symptoms of MDD in adolescence, and a polygenic score that indicates genetic likelihood of MDD. We will use correlation and linear regression analyses to assess the link between adolescent indicators of depression and future-thinking on mortality, love, and illness. And test them against actual life outcomes, using more statistical models, which will be compared for accuracy of selfpredictions. Medical practitioners could tailor their approach by identifying at-risk youth to prevent negative life outcomes. Future work on this project will involve mediation analyses to test if a young person's perception of their life outcomes can mediate the association between depression indicators and prospective life outcomes.

Keywords:

Depression; Linear Regression; Future Thinking; Polygenic Scores; Life Outcomes

Mentor(s):

robbee Wedow (Liberal Arts); Katherine Nina Thompson (Liberal Arts)

Other Acknowledgement(s):

Lipi Roy (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 103 at 12:40-1:00

Embedding Schur Product into Prime-Field Multiplication STEM

Authors(s):
Mukul Agarwal† (Science)

Abstract:

Embedding elementwise operations on vectors over small fields into arithmetic over large prime fields is a central problem in cryptographic protocol design. A key example is the Schur product, or componentwise multiplication. Efficient embeddings allow multiple such operations to be executed using a single field multiplication.

This work focuses on the case where the Schur product is over bits, corresponding to elementwise logical AND, and asks: How densely can this function be embedded into a single prime-field multiplication?

Prior approaches, such as those based on the Chinese Remainder Theorem, achieve a packing rate of only log(p)/log log(p) bits into a field of size p, far below the theoretical maximum. We introduce an embedding technique which takes the discrete logarithm in the multiplicative group of the prime field.

This construction achieves an asymptotic improvement, packing up to log(p)/log(3) bits per field multiplication—about 63% of the optimal packing rate of log(p)/log(2). An exhaustive search shows no strictly better embedding exists for up to four input bits. While this method is inefficient in practice due to the computational hardness of discrete logarithms, these results demonstrate a significant improvement over existing embeddings.

Future work will aim to develop embeddings which maintain computational efficiency by avoiding discrete-logarithm computations and embeddings which do not leak any information beyond the result of the Schur product itself.

Keywords:

Cryptography; Multi-Party Computation; Reverse Multiplication Embeddings

Mentor(s):

Hemanta K Maji (Science)

Other Acknowledgement(s): Ioanna Katsamba (Engineering)

Presentation Time: GRIS 134 at 12:00-12:20

A Successive-Approximation Analog-to-Digital Converter for Data Acquisition in a System-on-Chip

STEM

Authors(s):

Stanley Tzarkwai So† (Engineering)

Abstract:

[Abstract Redacted]

Keywords:

[no keywords provided]

Mentor(s):

Seyedehmarzieh Rouhani (Engineering); Mark Johnson (Engineering)

Other Acknowledgement(s):

David Matthew Czerwonky (Engineering)

Presentation Time: GRIS 134 at 12:20-12:40

Engineering Nonlinear Optical Activation Functions for High Speed, Low-Power Light-Based Neural Networks

Authors(s):

Ruben Canora Alvarez† (Engineering); Atish Bhungalia*

Abstract:

The intrinsic wave properties of light provide a powerful mechanism for achieving unparalleled data transmission rates at minimal energy cost. Consequently, in recent years the idea of developing All-Optical Neural Networks (AONNs) has raised as the solution to the computational limitations of the current Neural Network architectures. Despite their potential, the development of deep AONNs is limited by the high optical power demands of conventional nonlinear optical processes, which limits scalability. In our work, we experimentally tested our novel nonlinear optical activation function scheme based on quantum interference, consisting of an atomic ensemble driven by two laser fields. In addition, the nonlinear responses we achieved are formally equivalent to the two fundamental activation functions in digital neural networks: Rectified Linear Unit (ReLU) and Sigmoid functions. Not only we proved our fully tunable multi-input, multi-output network scheme, but also demonstrated the feasibility of constructing large-scale, deep AONNs with millions of neurons powered by less than 100W of optical power and at ultra-fast speeds. Furthermore, with the aid of Spatial Light Modulators (SLMs), we performed all the linear computations at the speed of light, and combined with the nonlinearity, we brought into reality a fully functional one-layer AONN with a high level of accuracy for image classification. By demonstrating minimal propagation losses and high scalability, our results inaugurate a new era toward high-speed, scalable and energyefficient optical neural networks for next-generation Al hardware.

Keywords:

Neural Networks; Optics; Ultra-Fast Computations; Innovation; Al

Mentor(s):

Shengwang Du (Engineering); Hadiseh Alaeian (Engineering)

Other Acknowledgement(s):

Ziqi Niu (Engineering); Xinzhe Xu (Engineering); Radhika Arvind Bhopatkar (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 134 at 12:40-1:00

Temporal variations in sublimation and their relation with ridge formation in Martian mid-latitude ice scarps STEM

Authors(s): Laura Sofia Perez†

Abstract:

Ice scarps have been found in Martian mid-latitudes, but their origin remains uncertain and the mechanisms driving their evolution are still unknown. These icv scarps often contain multiple ridges, which may result from variations in sublimation rates of exposed ice, possibly influenced by changes in obliquity, leading to the accumulation of lag in the scarp's pit. We aim to relate the timing of sublimation changes with the amount and separation of ridges in a representative scarp (named South 1) in the southern hemisphere, and compare ridge properties (i.e., quantity and spacing) at scarp sites across different latitudes and hemispheres. We base our project on a compiled list of documented scarps on Mars, with a detailed focus on South 1 for sublimation rate analysis. We perform topographical analysis using the GIS software JMARS and high-resolution HiRISE images to identify scarps and map their main ridges. A 1-D thermal model is used to simulate Martian surface conditions over the past 20 million years, using obliquity variations to generate yearly surface temperatures and sublimation rates, starting with present-day parameters. We also use the model to test sublimation sensitivity to changes in elevation, slope, and scarp orientation. We compare topographic ridge data to identify key differences between ridges in the southern and northern hemispheres and detect regional patterns in morphology. We will assess whether obliquity-driven sublimation cycles can be linked to ridge formation and whether these features preserve a record of past Martian climate. Preliminary results show alternating sublimation rates at South 1 that may correspond to observed ridges.

Keywords:

Mars; Ice Scarps; Sublimation; Ridges; Obliquity Cycles

Mentor(s):

Ali Bramson (Science); Kris Laferriere (Science)

Other Acknowledgement(s):

Pranshul Sardana (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 133 at 12:00-12:20

Evaluating Active Site Properties Governing the Hydrothermal Stability of Phosphorus Modified MFI Zeolites

Authors(s):

David W Ball+; Aakash Sanjay* (Engineering)

Abstract:

Zeolites are catalysts widely used in industrial chemical processes for upgrading raw feedstocks into value-added products. These catalysts contain active (H+) sites, confined within molecular-sized voids (<2 nm), that shape-selectively stabilize desired reactive intermediates. Their structure comprises a porous framework of interconnected silicon oxide (Si4+) tetrahedra occasionally substituted by aluminum (Al4+) that generate net-negative charges, which are charge-compensated by active Brønsted (H+) sites. When operating as industrial catalysts, zeolites are routinely exposed to steam at high temperatures (>700 K), leading to loss of H+ sites via hydrolysis of framework aluminum. To mitigate H+ site loss, commercially available MFI (framework type) zeolites are commonly treated with phosphorus species, which results in higher H+ site retention upon exposure to steam at high temperature (hydrothermal treatments). However, the amount of phosphorus required to retain the maximum number of H+ sites varies with active site content and precursor identity, requiring empirical models for catalyst design. Herein, we elucidate molecular interactions between phosphorus and H+ sites that govern hydrothermal stability by studying model MFI zeolites impregnated with gradually increasing phosphorus content. H+ site counts before and after hydrothermal treatments will be used as a proxy to quantify hydrothermal stability, and will be complemented by kinetic studies of H+ site-catalyzed probe reactions to evaluate reactivity of pristine and steam-aged phosphorus-MFI samples. Together, these data elucidate the interactions between phosphorus species and H+ sites in MFI zeolites that govern their hydrothermal stability and reactivity, allowing the design of phosphorus-stabilized zeolites that account for these site-specific interactions.

Keywords:

Hydrocarbon Upgrading; Zeolites; Acid Catalysis; Hydrothermal Stability; Phosphorus Modification

Mentor(s):

Bereket Tassew Bekele (Engineering); Rajamani P Gounder (Engineering)

Other Acknowledgement(s):

Sarah Margaret Gustafson (Engineering); Jorge Enrique Neira Garcia (Polytechnic)

Presentation Time: GRIS 133 at 12:20-12:40

Electrocatalyst development for decarbonized solid oxide electrochemical ethane dehydrogenation

STEM

Authors(s):

Ally Guo†; Charity E Smith‡

Abstract:

Ethylene is a key chemical used to manufacture plastics and many other materials. Demand for such materials is projected to grow, however ethylene is produced through ethane dehydrogenation (EDH) at high temperatures, one of the most energy and carbon intensive processes in the chemical industry. This project aims to develop a protonic ceramic electrochemical reactor for EDH with heterogenous metal catalysts dispersed in a porous anode. Using an electrochemical reactor instead of a thermal reactor reduces energy costs and CO2 emissions associated with EDH because the reaction is driven by renewable electricity instead of heat from burning fossil fuels. Unlike thermal reactors, the physical design of the electrochemical reactor also allows for the ethylene to be intrinsically separated from other species, further reducing energy costs for ethylene production. Electrochemical cells loaded with different metal catalysts were characterized using XRD and SEM to evaluate the cell and catalyst structure. SEM revealed that catalysts loaded via solution infiltration allowed the catalyst to be dispersed evenly throughout the pores of the anode, resulting in high catalyst surface area and loading. Because of the higher surface area and loading, cells with catalyst exhibited higher activity compared to reference cells. The properties of the catalyst itself resulted in higher selectivity for ethylene during EDH, and improved stability due to decreased catalyst deactivation due to coking. Further work is needed to optimize cell fabrication and reactor conditions, but this work demonstrates a promising electrochemical reactor design with high selectivity, activity, and stability for decarbonizing ethylene production.

Keywords:

[no keywords provided]

Mentor(s):

Brian Michael Tackett (Engineering); Po-Chun Huang (Engineering)

Other Acknowledgement(s):

Jorge Enrique Neira Garcia (Polytechnic)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 133 at 12:40-1:00

Engineering 2D Materials for Controlled Quantum Defects and Beyond

STEM

Authors(s):

Manaswini Singh† (Science); Sagarika Menon‡; Priya Mishra‡ (Science)

Abstract:

Atomic-scale quantum defects in solid-state platforms hold immense promise for the next generation technologies in quantum sensing, communication, and computation. Exploring their full potential demands exceptional control over defect creation, placement, and coherent behavior of individual defects. Two dimensional materials, especially hexagonal boron nitride(hBN), provide a compelling platform for quantum defects due to their atomically smooth surface, wide bandgap, and tunable heterointerfaces. We plan to utilize Scanning Tunneling Microscopy (STM) to probe engineered quantum defects in hBN with atomic precision, and this presentation will focus on implementing the technique to fabricate hBN/graphite heterostructures compatible with STM measurements. We acquire isolated few-layer graphene and hBN through scotch-tape exfoliation and assemble them into heterostructures using a Polypropylene Carbonate (PPC) stamp. We employ PPC films on a cushion-like PDMS to pick up and assemble layers of thin hBN and graphite over a thick sample of hBN over a silicon wafer, achieving flat and atomically clean interfaces essential for STM measurement. Notably, the number of hBN layers determines its dielectric and electronic landscape, which can directly impact our STM measurement. To accelerate and standardize the process of picking optimal hBN samples. I am developing a machine learning model that predicts the number of hBN layers from optical images and AFM data. By integrating all aspects of our experimental journey, our work will establish a pathway for exploring engineered quantum defects in 2D systems with atomic precision, ultimately enabling quantum sensing applications.

Keywords:

Quantum Sensing; 2D Materials; Machine Learning; Scanning Tunneling Microscopy (STM); Quantum Defects

Mentor(s):

Tiancong Zhu (Science)

Other Acknowledgement(s): Kyung Jun Lee (Engineering)

Presentation Time: GRIS 126 at 12:00-12:20

Deep Learning-Based Prediction of CO? Migration in Geological Storage Formations: Insights of Sleipner Project

Authors(s):

Santiago Felipe Tique Sarmiento†

Abstract:

This research proposes a novel forward-predictive framework for modeling CO? plume migration in geological storage formations, demonstrated at the Sleipner site in the Utsira Formation. By training a 3D U-Net on a 2001 CO? distribution label as a forward reference, this work moves beyond traditional reconstruction approaches, introducing a predictive capability essential for proactive subsurface monitoring.

The model, trained using amplitude-matched and interpolated seismic cubes, achieved high predictive accuracy in upper and middle layers (L9 and L5), with Dice scores above 0.97 and IoU up to 0.96 in early years. These results align with high-permeability pathways identified through detailed permeability analyses, confirming the geological controls on CO? migration. In deeper layers (L1), the network showed limitations due to slower plume progression and lower data quality, highlighting the need to integrate formation heterogeneity.

Controlled experiments revealed the model's sensitivity to amplitude variations, leading to artifacts or false-positive CO? predictions in areas affected by surface-related multiples. This underscores the importance of carefully selecting baseline and time-lapse datasets and training the network to handle amplitude mismatches to ensure reliable predictions.

Integration of the Sleipner Benchmark 2019 permeability model provided critical geological context, supporting the inclusion of petrophysical constraints in future models. Additionally, while 2D sparse labeling offered fast implementation, it introduced artifacts, whereas sparsely trained 3D networks maintained better spatial continuity.

Overall, combining geological heterogeneity, physical constraints, and volumetric seismic data into deep learning frameworks offers a promising path for robust, future-oriented CO? plume prediction, enabling better risk assessment, early leakage detection, and informed CCS management.

Keywords:

Neural Networks; Deep Learning; Carbon Capture and Storage; Sleipner Project; 4D Seismic Surveys

Mentor(s):

Yunyue Li (Science)

Presentation Time: GRIS 126 at 12:20-12:40

Scaling up of the synthesis of zeolite catalysts to obtain desired bulk and atomic-scale properties

STEM

Authors(s):
Juan Pablo Chitiva Arteaga†

Abstract:

Light alkene oligomerization is a promising pathway to synthesize higher molecular weight hydrocarbons useful as transportation fuels. Brønsted acidic zeolites (particularly MFI-type) have been used in commercial alkene oligomerization processes. Research on scaling up economical MFI zeolite synthesis from lab-scale to commercial scale-up target is important for developing a continuous process for producing a liquid product from light hydrocarbon gas feeds using an olefin oligomerization process. Here, we study the synthesis of MFI zeolites in different scales to observe the effect of the scale-up in their atomic and bulk properties. The synthesis of MFI zeolites with scale-up alters their physicochemical properties based on two different gel compositions containing an organic structure-directing agent (SDA) with/without inorganic cation. Some zeolites also showed the XRD patterns of the fully crystallized MFI structure or amorphous phase as being modified by the molar ratio of the structure directing agent (SDA) and crystallization time. These findings suggest that to maintain certain desired properties of the zeolite it is necessary to modify the recipe of the synthesis according to the scale to adjust the outcome of the synthesis, which consolidates a great first approximation to the industrial manufacturing of zeolite catalysts with tailored properties at commercial scales.

Keywords:

Zeolite Synthesis; Catalysis; Zeolite Catalyst; Scale-Up

Mentor(s):

Sanghyun Ahn (Engineering); Rajamani P Gounder (Engineering)

Presentation Time: GRIS 126 at 12:40-1:00

Data-Free Backdoor Injection Attacks on Vision Transformers STEM

Authors(s):

Valeria Nicole Espinoza Tarazona†

Abstract:

Recent advances have demonstrated the vulnerability of vision transformers (ViTs) to backdoor attacks, even in scenarios where access to the original training data is not available. In this project, we build upon the Data-Free Backdoor Injection Attack (DBIA) framework to investigate the feasibility of embedding backdoors into pre-trained transformerbased models without using any task-related data. Our work adapts the DBIA method to a new dataset, distinct from CIFAR-10, and evaluates its applicability in alternative real-world visual tasks. By generating universal attention-maximizing triggers and fine-tuning a small subset of neurons via Projected Gradient Descent, we are able to effectively inject backdoors while preserving the model's performance on clean inputs. We present empirical results demonstrating the high attack success rate and low degradation in accuracy across different transformer architectures. This research highlights the generalizability of data-free backdoor attacks and emphasizes the urgent need for robust defenses tailored to transformer models in computer vision.

Keywords:

Backdoor Attack; Vision Transformers; Data-Free Learning; Adversarial Machine Learning; Model Security

Mentor(s):

Jin Kocsis (Polytechnic)

Presentation Time: GRIS 118 at 12:00-12:20

Hand in Hand: Kinetics of Chiral Cluster Formation in Serine Octamers

STEM

Authors(s):

Alana Kathryn El Thomas† (Liberal Arts|Science)

Abstract:

Homochirality, the fact that life uses only one mirror image form of most molecules, is a fundamental aspect of biology. Despite significant developments in origins of life research, why D-sugars and L-amino acids were selected from mostly racemic (50:50 D:L) molecules remains unclear. Our research aims to understand this by analyzing serine octamer clusters through mass spectrometry. These clusters are composed of molecules in close contact with one another, which makes the clusters sensitive to the chirality of each molecule. Using the initial rate method adapted to a linear ion trap mass spectrometer, clusters of serine and other amino acids were examined. Our results show that the octamer—clusters of eight serine monomers—more quickly substitutes serine for amino acids of its same chirality, forming chiroselective clusters of, for example, 6 L-Ser + 2 L-Pro. These experiments enable the specific study of attractive interactions between chiral molecules, work that has not been systematically explored and that may help explain the chemistry that led to life.

Keywords:

Chemistry; Mass Spectrometry; Chirality

Mentor(s):

Brison Avery Shira (Science); Robert Graham Cooks (Science)

Presentation Time: GRIS 118 at 12:20-12:40

O-Vacancy Perspective to Explain Imprint in Metal-HZO-Metal Capacitors via In-Situ Photoluminescence

STEM

Authors(s):

Rana Yuvraj† (Science); Bach Son Nguyen‡ (Engineering)

Abstract:

Hafnia-based ferroelectrics offer great promise for emerging memories but are impeded by imprint that presents a consistent hurdle for read-out reliability: however, the origin of this phenomenon remains unclear. This study investigates the imprint in Hf(Zr)O2 (HZO) Metal-Ferroelectric-Metal (MFM) capacitor stacks and proposes a mechanism considering charged O-vacancies as a primary factor affecting imprint. Capacitor stacks—50 nm of W at the bottom electrode, 10 nm HZO ferroelectric layer, 5 nm of W and 5 nm of Pt to create semi-transparent top contact—are placed under a spectroscopy system while contacted to a Radiant Ferroelectric Tester. The capacitors are initially poled to either have their polarization pointing down (i.e. towards bottom electrode) or up. The measurements include an initial PL scan, a polarization hysteresis loop (PE-Loop), a so-called "wake up process" to ensure consistent ferroelectric response followed by a final polarizing pulse to ensure uniform poling of a film in a certain direction. After poling, PL measurements were taken continually during a 3-hour period during which the device was not electrically disturbed from the final polarizing pulse. After the 3-hour period, a final PE-loop was acquired to assess changes in the HZO with time. Variations in PL-intensity and the PEloop with time were then compared. For films held in an upward polarization, an increase in coercive field with time (i.e., the amount of imprint) correlated to a larger variation in PL-intensity over the first hour. In preceding work, changes in PL were indicative of changes in the number and charge-states of O-vacancies in HZO. Here, using this knowledge, the correlation suggests that O-vacancies are an underlying cause of imprint. Specificially, we speculate that the increase in PL intensity observed after poling upward suggests that as more domains switch and guide electrons to the top interface, O-vacancies gain charge that generates an electric field, leading to an increased voltage requirement for switching. Findings of this mechanism can help mitigate imprint and improve reliability of Hafnia-based ferroelectrics.

Keywords:

Hafnia-Based Ferroelectrics; Imprint; O-Vacancies; Hf(Zr)O2 (HZO); Metal-Ferroelectric-Metal Capacitor

Mentor(s):

Thomas Edwin Beechem (Engineering); Fernando Josue Vega (Engineering)

Presentation Time: GRIS 118 at 12:40-1:00

Mechanisms of Speech Perception: Cross-Linguistic Vowel Discrimination and Kinesthetic Learning Technology

Creative

Authors(s):

Aastha Rasesh Patel† (Engineering)

Abstract:

Speech perception is influenced by the physics of sound waves, specifically how the human auditory system processes frequency components and resonance patterns. This study examines how native speakers of the world's ten most spoken languages (Hindi, Urdu, English, French, Bengali, Portuguese, Arabic, Mandarin Chinese, Spanish, and Russian) differ in their ability to detect differences in vowel sounds. Through an online hearing test, participants identify whether pairs of synthesized vowels with slight frequency shifts sound the same or different. Building upon this foundation, this study now extends to examine different English dialects to further enhance understanding of how dialectal variations affect language perception. Just Noticeable Differences (JNDs) in formant perception are analyzed to determine whether speakers of languages and dialects with larger vowel inventories exhibit more refined discrimination abilities than those with fewer vowels. Concurrent with this research, a kinesthetic language learning application is being developed utilizing live video feeds to provide learners with audio descriptions and interpretations of their surroundings in their target language, with optional captions. The audio frequency is initially set for easy perception based on their language history and gradually adjusts toward colloquial limits as users accumulate practice hours, creating an adaptive learning environment. This research provides insights into how native languages affect auditory perception, speech processing, and second language learning.

Keywords:

[no keywords provided]

Mentor(s):

Linda E Haynes (Liberal Arts)

Presentation Time: GRIS 103 at 1:00-1:20

Improving small molecule drug oral dissolution kinetics via drug-polymer salts

STEM

Authors(s):

Luke DeLion† (Agriculture|Engineering)

Abstract:

Vodobatinib (VBN) is a very weakly basic, anticancer treatment with low oral bioavailability and poor enteric solubility. Polymeric amorphization techniques offer viable approaches to improving such biopharmaceutical properties. In this work, we demonstrate that an emerging salt synthesis method called slurry conversion can successfully produce multiple amorphous drug-polymer salts with enhanced dissolution rates. Two acidic polymers, polystyrene sulfonic acid (PSSA) and polyacrylic acid (PAA), were individually evaluated for salt formation with VBN. Each formulation involved mixing the drug and polymer in a 1:2 (v/v) ratio of protic liquid to solvent and a 1:9 (w/w) solid to solvent ratio. The mixtures were stirred at elevated temperatures, then dried with vacuum heating to yield amorphous salts. Tetrahydrofuran and acetonitrile served as solvents, while ultra-pure water and ethanol were used as protic liquids to facilitate acid-base interactions. Drug loadings at 10%, 20%, and 40% were tested, with most slurries exhibiting complete dissolution and amorphization during mixing. In biorelevant fluid, in vitro testing revealed significantly faster dissolution rates compared to crystalline VBN and a hot-melt extrude formulation. 1H NMR spectroscopy indicated residual solvent remained after drying, highlighting areas for improvement. For effective salt formation, protonation of the quinoline nitrogen atoms on VBN is expected to occur, which can be confirmed by X-ray photoelectron spectroscopy. Additionally, the amorphous characteristic of each salt will be analyzed using X-ray powdered diffraction. Overall, slurry conversion is a potential alternative for very weakly basic drugs that provides excellent dissolution profiles.

Keywords:

Amorphous Drug–Polymer Salt; Vodobatinib; Polyelectrolytes; Dissolution; Bioavailability

Mentor(s):

Mojhdeh Baghbanbashi (Engineering); Sophia R Dasaro (Agriculture); Kurt Ristroph (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 103 at 1:20-1:40

Imaging and Machine Learning of Defects in Semiconductors STEM

Authors(s): Hamdan Ashfaq†

Abstract:

Sn-58Bi solder alloys are critical components in electronic packaging applications. Microstructural patterns directly influence mechanical properties and joint reliability. Manual analysis of these microstructures is subjective and time-intensive. The different types of patterns that form under varying thermal conditions affect material behavior. Accurate classification is essential for optimizing processing parameters. This research develops a machine learning framework to automatically categorize microstructural patterns in Sn-58Bi solder based on scanning electron microscopy images. Sn-58Bi samples were processed under four distinct cooling conditions: water quenching, air cooling at 34°C/min, controlled cooling at 6°C/min, and slow cooling at 1°C/min. SEM images were acquired and cropped to create a training dataset. Each image patch was manually labeled according to dominant pattern type: fishbone, lamellar, fine, or coarse structures. A ResNet-50 convolutional neural network architecture was implemented with transfer learning to classify these patterns. Data preprocessing included image augmentation to enhance model robustness. Preliminary results with 310 training images demonstrate 82% validation accuracy in distinguishing between the four microstructure classes. This demonstrates competitive performance using 75% fewer training images than comparable studies. Analysis confirms that faster cooling rates produce finer, more irregular structures, while slower cooling promotes larger, organized patterns. The automated classification system identifies subtle differences that correlate with cooling history. This approach provides an objective, quantitative tool for microstructure analysis in electronic packaging applications. Future work will expand to multiple datasets of over 1000 images while aiming for higher accuracy and integrating mechanical property predictions, enabling potential manufacturing applications.

Keywords:

Deep Learning; Microstructure Classification; Solder Alloys; Image Processing; Materials Characterization

Mentor(s):

Nikhilesh Chawla (Engineering); John Aaron Wu (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s): Pranshul Sardana (Engineering)

Presentation Time: GRIS 103 at 1:40-2:00

Peridynamics Thin Film Peeling STEM

Authors(s):

Mike Xiao† (Engineering); Ben N Aaron‡

Abstract:

The peeling of thin films is a crucial process in various applications ranging from engineering to biomedical systems, such as the design of highly resistant structures and drug delivery patches. However, there is currently a limited understanding of uncontrolled fracture during peeling despite its widespread use, leading to material waste and inefficiencies. We aim to investigate parameters in which a thin film attached to a rigid substrate can be cleanly peeled off without leaving any residue. In contrast, outside of this regime the peeling process results in fracture of the film. An open-source MATLAB code named PDMATLAB2D(PD) is used to model peeling under various critical conditions like film thickness. material property, and fracture energy. The PD simulations generate stress-strain data, crack propagation patterns, and energy dissipation metrics, which are analyzed to identify fracture thresholds. Our simulations reveal that there is a specific range of conditions where residual-free peeling occurs. The findings will provide guidelines for optimizing peeling processes to enhance manufacturing reliability and material performance. Further studies can be achieved by examining fracture modes of different materials.

Keywords:

Peridynamics; Fracture Mechanics; PDMATLAB2D; Thin-Film Peeling; Clean Peeling

Mentor(s):

Ivan C Christov (Engineering); Ziyu Wang (Engineering)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: GRIS 134 at 1:00-1:20

Structure-Based Drug Development for Autoinflammatory Immune Dysregulation and Ibrutinib-Resistant Leukemia STEM

Authors(s):

Andrew M Strawhacker† (Engineering|JMHC)

Abstract:

A hyperactive variant of protein phospholipase C gamma 2 (PLCG2), known as S707Y, has been genetically linked to autoinflammatory immune dysregulation (APLAID), characterized by severe tissue lesioning and immunodeficiency, as well as to resistance to the leading leukemia treatment ibrutinib. Currently, there are no PLCG2-targeted therapies for these conditions. This project aims to address this gap by identifying and optimizing inhibitors of PLCG2 S707Y through an integrated approach of kinetic characterization, structural analysis, and computational modeling. Using a fluorescent substrate analog, the S707Y variant was confirmed to exhibit approximately 7-fold higher catalytic activity compared to the wild-type enzyme, consistent with its proposed pathogenic role. To search for inhibitors, high-throughput screening by affinity selection mass spectrometry (ASMS) identified several PLCG2-specific binding compounds, which were subsequently evaluated using the fluorescence platform. One of these compounds inhibited PLCG2 S707Y in vitro, with its IC50 and maximum inhibition determined at a 5nM enzyme concentration. Derivative molecules were then explored for chemical moieties that increase inhibitor potency. To guide inhibitor optimization, the crystal structures of PLCG2 S707Y with and without the initial lead compound were determined by X-ray diffraction at Argonne National Laboratory's Advanced Photon Source. These structures were analyzed alongside binding predictions generated by MIT's novel Boltz-2 machine learning platform, providing an integrated foundation for structure-based inhibitor refinement. These findings provide the first structural characterization of PLCG2 S707Y and identify an early-stage inhibitor, representing a first step in PLCG2-targeted therapies for APLAID and ibrutinib-resistant leukemia.

Keywords:

PLCG2; APLAID; Ibrutinib Resistance; X-Ray Crystallography; Drug Design

Mentor(s): Andrew D Mesecar (Centers & Institutes); Bridget Louise Kaiser (Agriculture)

Presentation Time: GRIS 134 at 1:20-1:40

Accurate Georeferencing of UAV Synthetic Aperture Radar Images Using Digital Elevation Models

STEM

Authors(s):

Emiko A Sano†; Grace Guan Man Meyer* (Hillsdale College)

Abstract:

Unmanned Aerial Vehicles (UAVs) equipped with Synthetic Aperture Radar (SAR) offer a cost-effective and efficient platform for highresolution remote sensing at microwave frequency. Producing accurately geocoded SAR imagery over complex terrain without distortion, however, is a challenge due to the radar's side-looking observation geometry, which can cause layover, foreshortening, and shadowing. While georeferencing methods currently exist for satellite-based SAR, very few have been adapted for UAV platforms. This research seeks to adapt georeferencing algorithms that integrate a digital elevation model (DEM) from a national database and LiDAR measurements. The algorithm that is developed will provide an accurately georeferenced SAR image through geometric corrections. The proposed method aims to create a computationally efficient and more accurate georeferencing algorithm by using the location information recorded by the onboard high accuracy GNSS/INS system that provides the local incidence angle, eliminating the need for ground control points and interpolation. The geolocation output of the proposed method will be evaluated to assess alignment by comparing the geolocated corner reflector positions to their known coordinates and to high resolution LiDAR-derived DEMS over an agriculture testbed at the Purdue Agronomy Center for Research and Education (ACRE) and the Martell Forest. The results from this study should ultimately help implement corrections for complex terrain. A further step for this work would be to continue to use this algorithm to correct for radiometric errors.

Keywords:

Synthetic Aperture Radar (SAR); Unmanned Aerial Vehicles (UAVs); Georeferencing; Digital Elevation Model (DEM); Geometric Correction

Mentor(s):

Melba M Crawford (Engineering); Weihang Li (Engineering); Fatemeh Azimi (Engineering)

Other Acknowledgement(s): Varun Aggarwal (Engineering)

Presentation Time: GRIS 134 at 1:40-2:00

Developing a Transparent Microfluidic Platform for Loop Mediated Isothermal Amplification

STEM

Authors(s): Grace O Jost

Abstract:

As one of the Nucleic Acid Amplification Technologies (NAATs), loopmediated isothermal amplification (LAMP) is an increasingly used assay for early diagnosis of viruses. LAMP allows for faster analysis of genetic material than traditional polymerase chain reaction (PCR) testing and has been successfully used in the detection of pathogenic diseases, such as SARS-CoV-2 (COVID-19). LAMP operates at a constant temperature, significantly reducing both cost and time to result, while PCR requires expensive thermocycling equipment and longer processing times due to the thermal cycling required for denaturing DNA in each cycle. However, as a key performance index, the sensitivity and the reaction rate should be improved to become a gold standard for disease diagnostics. In this project, we designed and developed a microfluidic platform optimized for LAMP reactions, aiming to enhance the sensitivity of LAMP. Our microfluidic integrates a resistive microheater, fabricated on an ITO-covered glass and powered via low-voltage DC input, to maintain a stable isothermal temperature of 65°C, which is required for the LAMP reaction. A 3D-printed chamber mitigates evaporation while a Polydimethylsiloxane (PDMS) substrate fixes the reaction droplet, enabling on-chip amplification and potential real-time detection. Compared to standard benchtop LAMP or PCR systems, our device reduces reagent consumption, accelerates reaction time, and enhances portability for point-of-care (POC) use. Preliminary tests demonstrate reproducible amplification with reduced volume. Integration with optical detection methods is in progress to enable real-time monitoring and enhanced signal clarity. This work demonstrates a promising step toward scalable, low-cost diagnostics, especially in resource-limited settings, with future integration potential for colorimetric or fluorescence-based readout systems.

Keywords:

SARS-CoV-2; COVID-19; LAMP; NAATs; Microfluidics

Mentor(s):

Taehong Kim (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 133 at 1:00-1:20

Nondestructive Multimodal Classification of Counterfeit Integrated Circuits using Spectral and Profilometry Measurements

STEM

Authors(s):

Kevin Yu† (Engineering); Wei Lun Chang† (Engineering); Sean Ross Klein† (Engineering); Justin E Bullock†

Abstract:

Counterfeit Integrated Circuits are repackaged, remarked, or cloned versions of current chips. They often do not meet the specifications of authentic chips, and using them in place of genuine parts puts systems at risk of malfunction, damage, and malware/spyware.

In recent years, counterfeiters have improved their processes to evade existing forms of counterfeit detection. A procedure to quantify the efficacy of novel nondestructive screening methods, as well as combine their results into a multimodal classification model, remains desired. Our group explores several nondestructive analyses for verifying device authenticity using Spectrophotometry, X-Ray Spectroscopy, and Profilometry measurements.

Using 1 authentic and 4 potential counterfeit sources of Raspberry Pi chips, we collected spectral, elemental, or photographic data from an Analytical Balance, X-ray Fluorescence (XRF), X-ray Photoelectron Spectroscopy (XPS), UV-Vis-NearIR Spectroscopy, Laser Induced Beam Spectroscopy (LIBS), Gas Chromatography (GC), Optical Microscopy, UV Fluorescence Microscopy (UVF), Contact Profilometry, and Laser Profilometry. We employ statistical analysis and machine learning (ML) to distinguish features of the counterfeit groups.

For each of the 10 methods, we estimate the cost and time of measurement, cost and time of training data collection, cost and time of ML training, and confidence in distinguishing counterfeits. We recommend the top three methods based on our decision matrix, and note that anyone can change the weights to create a priority list to align with their constraints and values. We demonstrate that the results of multi-modal measurements can be combined to greatly increase the confidence in device authenticity.

Keywords:

Nondestructive; Counterfeit; Spectroscopy; Profilometry; Multimodal

Mentor(s):

Sheng-wen Huang (Engineering); Peter Bermel (Engineering)

Presentation Time: GRIS 133 at 1:20-1:40

Assessing Lead Levels in Human Bone with Portable XRF and Benchtop XRF Technology to Explore Links to Cognitive Function

STEM

Authors(s):
Grace Ann Kowis† (HHS)

Abstract:

This study investigates the role of cumulative metal exposure specifically lead (Pb)—in relation to neurodegeneration in an elderly population, with a focus on Alzheimer's disease (AD). Lead is a wellestablished neurotoxin associated with various adverse health effects. including cognitive decline. While animal studies have demonstrated promising associations between heavy metal exposure and the development of AD- or Parkinsons disease (PD)-associated neuropathology, they cannot confirm the presence of these neurodegenerative disorders. Human-based research remains limited and often inconclusive. To address this gap, we utilized both a portable X-ray fluorescence (pXRF) device and a benchtop XRF system to noninvasively measure lead concentrations in skull bones from 191 elderly human donors, including individuals diagnosed with AD. Bones were scanned for 12 minutes using the pXRF and for 7 minutes using the benchtop XRF. Data were processed and analyzed using MATLAB to quantify Pb concentrations, while statistical analysis was conducted in R using parametric and non-parametric tests such as ANOVA, Kruskal-Wallis, Wilcoxon rank-sum, and Spearman correlation. The averaged Pb concentrations were compared across biological sex and APOE genotype. Associations between bone Pb levels and cognitive diagnosis, as well as neuropathological markers, were also examined. Preliminary results show that males had higher average bone Pb levels than females (pXRF p-value = 0.00162, benchtop p-value 0.00205). This can be attributed to higher rates of bone resorption during female menopause, which can release Pb from bone into the bloodstream. Additionally, while a trend was observed between elevated bone Pb levels and certain cognitive and neuropathological markers, the association with APOE genotype was weaker than expected (ANOVA p-value = 0.851). This provides limited support for the hypothesis that APOE genotype influences Pb accumulation. However, as this study only examined one genetic factor and one environmental exposure, further research is needed before broader conclusions about gene-environment

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

interactions in AD can be made. These findings are still under analysis, and continued statistical investigation is necessary to draw definitive conclusions.

Keywords:

Lead (Pb); Alzheimer's Disease (AD); X-Ray Fluorescence (XRF); Apoe Genotype; Neurodegeneration

Mentor(s):

Linda Nie (HHS); Majid Khorsandi (HHS)

Other Acknowledgement(s):

David Matthew Czerwonky (Engineering)

Presentation Time: GRIS 133 at 1:40-2:00

Room Temperature Aging Effects on Microstructural Solidification Behavior of Sn-Bi Low-Temperature and Sn-Ag-Cu High-Temperature Solder Alloys

STEM

Authors(s):

Diego Jimenez Rivera†

Abstract:

In modern microelectronics, most interconnections for devices are fabricated using high melting point Tin-Silver-Copper (SAC) or low melting temperature Tin-Bismuth (SnBi) solder alloys. These play an important role in the operation of microelectronic devices from cell phones and household appliances to satellites and rockets, where if one single connection is damaged, performance is reduced significantly. even causing failure. Solder alloys must therefore be as reliable as possible. However, a big challenge faced is thermal reliability, which contributes to microelectronic device failure when semiconductors heat up and cool down, and in harsh use environments. It is well known that aging of solder joints can lead to changes in their performance; however, there is insufficient data on why and how aging behavior occurs to improve the reliability of the solder alloys. By studying how solidification affects microstructure changes after soldering and aging, a thorough guide can be made for improving alloy selection. Test samples consist of Sn-Bi and SAC solder balls applied on printed circuit boards with OSP and ENIG surface finishes using different reflow profiles, then aged at room temperature from 0 to 7 days. Polishing is carried out to expose the microstructures of solder joints at the cross-sectional area. Optical microscope and SEM images are taken to carry out microstructure evaluation. By comparing the microstructures between different compositions, substrates, and aging conditions, identifying solidification effects on microstructure with room temperature aging can provide a better baseline for future mechanical and electrical testing in alloy composition selection based on application conditions.

Keywords:

Lead-Free Solder; Solidification; Thermal Reliability; Room Temperature Aging; Microstructure Development

Mentor(s):

Lijia Xie (Engineering); Carol A Handwerker (Engineering); John E Blendell (Engineering)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
David Matthew Czerwonky (Engineering)

Presentation Time: GRIS 126 at 1:00-1:20

NuFold RNA Database: Creating a Deep Learning Tertiary Structure Prediction Library with Secondary Structure Confidence

STEM

Authors(s): David Platt†

Abstract:

The three-dimensional structure of non-coding RNA is vital in understanding its biological function. Due to the difficult nature of solving structures experimentally, prediction via deep learning offers an effective alternative. Expanding upon Kihara Lab's prediction software, NuFold, the NuFold Database was created with the goal of making RNA tertiary structure predictions as accessible as those for proteins. To create a library of prediction models that accurately depict structural confidence. we implemented methods for evaluating the preservation of secondary structure within the final tertiary model. We quantify this by calculating an F1 score that compares high-confidence secondary structures from prediction methods (IPKnot, an RNA secondary structure prediction method used to run NuFold, and RNACentral's R2DT, a prediction method based on a large library of known RNA structures) to the identified secondary structures in the tertiary model. A high F1 score indicates the fold is successfully maintained in 3D, serving as a metric complementary to local scores like the predicted local distance difference test (pLDDT). We further validate this F1 score by correlating it with metrics relevant to NuFold, primarily multiple sequence alignment depth. to identify statistical relevance. We use these results to provide users with a predicted structure model that both validates its per-nucleotide accuracy, and preservation of secondary structure. Currently the database contains 13,837 individual predicted RNA sequences from the human genome. We plan to extend the data to both model organism and global health noncoding transcriptomes.

Keywords:

Deep Learning; RNA; Structure Prediction; Tertiary/3D Structure; Database

Mentor(s):

Daisuke Kihara (Science); Yuki Kagaya (Science)

Presentation Time: GRIS 126 at 1:20-1:40

Actin Remodeling in Threshold Setting for T cell Degranulation

STEM

Authors(s):
Quinte Robinson†

Abstract:

Cell-based immunotherapies, especially Chimeric Antigen Receptor (CAR) T cells, are promising cancer treatments that redirect T cell cytotoxicity to eliminate tumors via secretion of lytic molecules such as perforins and granzymes (degranulation). While highly effective against blood cancers, their success in solid tumors is limited, partly due to ontarget, off-tumor toxicity when CAR T cells attack healthy cells with low levels of the same antigens. We have shown CAR T cells can be triggered by single-molecule events, suggesting a mechanism for aberrant activation. However, the precise determinants of when, where, and how much degranulation occurs remain unclear. We hypothesize that cellular machinery regulating degranulation also sets activation thresholds. Actin remodeling integrates upstream signaling required for T cell activation, with local actin clearance necessary for effective degranulation. By systematically varying tumor antigen density, we will investigate how signaling strength drives actin remodeling and lytic granule mobilization. T cells will interact with model surfaces presenting defined antigen densities, and membrane-proximal events will be visualized using total internal reflection fluorescence (TIRF) microscopy. Actin and lytic granules will be fluorescently labeled with FastAct and LysoTracker, respectively, to simultaneously monitor remodeling and granule dynamics. We aim to define where the membrane is licensed for degranulation and what governs granule fusion, informing refinements to CAR T cell therapies that improve tumor killing while reducing healthy tissue damage.

Keywords:

Cancer; Biophysics; Immunology

Mentor(s):

Kevin Lynn Scrudders (Science); Shalini T Low-Nam (Science)

Presentation Time: GRIS 126 at 1:40-2:00

Automated, High-Throughput Cryo-EM and CLEM Workflows for Population-Level Liposome Characterization STEM

Authors(s): Lucia Zhang†

Abstract:

Cryo-electron microscopy (cryo-EM) is widely used to characterize biological molecules, ranging from proteins to drug delivery vehicles. However, analysis of these particles remains predominantly manual, creating costly bottlenecks and limiting scalability. Furthermore, while correlative light and electron microscopy (CLEM) provides subcellular localization information by combining fluorescence and electron signals, existing workflows for image correlation are similarly labor-intensive.

In this project, we aimed to build a modular workflow to address these challenges. The first component is an automated, high-throughput pipeline for the detection and characterization of liposomes, which serve as a model system for drug delivery mechanisms. I trained a U-Net convolutional neural network to segment liposomes from electron micrographs. I then developed MATLAB and Python scripts to extract quantitative morphological features, such as size and circularity, from the segmented liposomes. The second component of the workflow improves the speed and precision of CLEM image registration. I implemented a novel two-step correlation strategy by first aligning large-scale structural features (such as cryo-grid hole patterns) and then refining the alignment using smaller fluorescent fiducials. The liposome characterization pipeline rapidly recognizes particles and extracts accurate, populationlevel statistics. Maximizing the number of features used for CLEM alignment additionally enables more robust correlations while increasing efficiency.

Together, these tools offer enhanced resolution in CLEM imaging workflows, along with high-throughput, spatially contextualized analysis of liposome populations. This framework provides a foundation for applying CLEM to therapeutic delivery mechanisms for preclinical development.

Keywords:

Cryo-EM; Machine Learning

Mentor(s): Samuel Hartzler (Science); Lauren Ann Metskas (Science); Hongjia Li (Engineering)

Presentation Time: GRIS 118 at 1:00-1:20

Lunar Water Acquisition via In Situ -Resource Utilization STEM

Authors(s):

Isaac Parks† (Engineering); Clark Lay* (Engineering|JMHC)

Abstract:

Space travel offers both the advent of vast scientific advancement and discovery, and the potential for substantial economic development. However, space travel is extremely expensive, due to the energy needs required to break Earth's gravitational field. One factor that could reduce costs and advance space travel is In Situ-Resource utilization (ISRU). ISRU is the process of utilizing existing materials on extraterrestrial bodies as opposed to bringing the required resources from Earth. This research specializes in procuring water for human spaceflight operations or agricultural projects on the lunar surface. As such, this paper looks to develop a system with which Lunar regolith may be processed to generate useable water. Previous data on Lunar water supplies was collected to determine the chemical composition and properties. From this, an experimental setup for procuring water was developed. Namely, this included heating the regolith to its desorption temperature using energy provided from concentrated solar power. Water is then separated from other gaseous contaminants using a membrane system before recondensing the water for use. In lieu of lunar experimentation, a model was developed to capture the critical elements. This model will assist in determining the viability of Lunar regolith for the ISRU production of water.

Keywords:

ISRU; Water; Space; Moon

Mentor(s):

Xavier I Morgan-Lange (Engineering); David Warsinger (Engineering)

Presentation Time: GRIS 118 at 1:40-2:00

Impacts of artificial light at night on growth and stress responses in American toads

STEM

Authors(s):

Stiwar Albeiro Catano Cardeno†; Jabez Soongeui Shin‡ (Science)

Abstract:

With ongoing urban expansion, wildlife habitats become more fragments and exposed to novel sensory pollutants, such as artificial light at night (ALAN). Although previous research has increasingly explored how ALAN influences adult amphibians' morphology and physiology, its developmental impacts on tadpoles are less understood. This study investigates how ALAN alters tadpole growth, metamorphosis, and survival in American toads (Anaxyrus americanus). We evaluated responses to two prevalent urban light spectra; broad-spectrum white LED light and narrow-spectrum yellow incandescent light, simulating common types of streetlights in urban nighttime illumination. The lights were set at 15 lux, following the specifications for standard street and pedestrian lighting used in Indiana. These levels were validated through field measurements at multiple roadway sites in West Lafayette, IN. We raised tadpoles under three lighting conditions: control (natural environmental light), white LED light and yellow incandescent light. We then assessed the effects of each treatment on tadpole morphology and physiology, including indicators of stress, by the end of development. We hypothesized that exposure to artificial light at night during development would alter tadpole physiology and morphology, potentially increasing stress levels—as indicated by elevated corticosterone release—delaying metamorphosis, and reducing limb and body length. As size at metamorphosis is a key predictor of adult fitness, understanding these effects is essential for assessing long-term population impacts. These changes could impair survival to adulthood and lower recruitment, with implications for long-term population persistence. Continuing global declines in amphibian populations, continued research on the effects of urban lighting on amphibian development and fitness is essential.

Keywords:

Artificial Light At Night; American Toad; Morphology; Physiology; Urbanization

Mentor(s):

Ana Maria Ospina Larrea (Science); Ximena Bernal (Science); Jonathan Lopez (Science); Caitlin Gabor (Texas State University)

Presentation Time: GRIS 103 at 2:00-2:20

Comparative neurotoxicity of PFAS chemicals STEM

Authors(s): Serena Yu† (HHS)

Abstract:

Per- and polyfluoroalkyl substances (PFAS) are a group of synthetic chemicals found in many common products, such as food packaging, textiles, and cosmetics. They are widely used in manufacturing because of their water- and oil-resistant properties. However, PFAS are extremely persistent and have become widespread environmental contaminants. Legacy PFASs, including perfluorooctanoic acid (PFOA), were voluntarily phased out due to health concerns, but they remain in the environment and living organisms. Growing research shows that PFAS can cross the blood-brain barrier and can contribute to neurotoxicity. Of increasing concern is their potential role in neurodegenerative diseases, including Alzheimer's disease and related dementia (ADRD). Despite this, the neurotoxic mechanism of developmental PFOA exposure remains poorly understood. This research uses a human induced pluripotent stem cell (hiPSC) model to examine how PFOA exposure affects neurons and potentially contributes to an ADRD-like phenotype. After developmentalstage PFOA treatment, we observed persistent changes in neuronal activity, synaptic density, and levels of phosphorylated tau in neurites, based on a range of biochemical assays. These findings suggest impairments in key neuronal characteristics and accumulation of ADRDrelated biomarkers. In addition, we detected reduced oxygen consumption using the Seahorse Mitostress test and decreased mitochondrial membrane potential using tetramethylrhodamine methyl ester (TMRM) dye, indicating disrupted mitochondrial function. Overall, the results suggest that developmental PFOA exposure impairs neuronal properties and mitochondrial activity in hiPSC-derived neurons, which may contribute to ADRD-like phenotypes. Future directions include exploring whether mitochondrial function can be restored in PFOAexposed neurons by supplying them with healthy supporting cells, such as astrocytes.

Keywords:

Neurodegenerative Diseases; Alzheimer's Disease and Related Dementia (ADRD); Per- and Polyfluoroalkyl Substances (PFAS); Neurotoxicity

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Mentor(s): chongli Yuan (Engineering); Shichen Wu (Engineering)

Other Acknowledgement(s): Parth Uday Kelkar (Engineering)

Presentation Time: GRIS 103 at 2:20-2:40

Optimized Components with Multi-Materials Solutions STEM

Authors(s):
Allison C Renshawt

Abstract:

Functionally graded materials (FGM) that spatially vary in composition and microstructure can offer improved mechanical performance for aerospace applications at a lower cost. Using additive manufacturing (AM) processes, these materials can be created with gradients in structural and thermal properties, enabling design interplay between structural requirements and cost. Specifically, AM processes like directed energy deposition allow for the simultaneous deposition of multiple powder compositions at adjustable rates. To create the most stable gradients in composition for the creation of FGM's, the transition path between two or more unique alloy compositions can be identified by analyzing thermodynamic property data. For this project, Thermo-Calc was used to predict thermophysical properties and phase equilibria for high temperature alloys as a function of composition and temperature. A weighted-sum model was used to identify optimal compositional pathways by minimizing differences in thermal expansivity, density, and thermal conductivity between subsequent layers, avoiding deleterious secondary phases, and accounting for the printability of each compositional step via Scheil solidification and crack susceptibility modeling. Optimal pathways between pure niobium and Ti64(Ti-6Al-4V) are shown as a proof-of-concept for utilizing thermophysical data to create stable composition gradients and demonstrate a generalizable framework that can be applied to additional alloy systems.

Keywords:

Functionally Graded Materials; Thermo-Calc

Mentor(s):

Michael D Sangid (Engineering); Lucas Darby Robinson (Engineering)

Other Acknowledgement(s):

Parth Uday Kelkar (Engineering)

Presentation Time: GRIS 103 at 2:40-3:00

MorphoFoot: Shape-Adaptive Pneumatic Foot Boosts Multi-Terrain Locomotion in Legged Robots

STEM

Authors(s):

Zihan O Zeng† (Engineering)

Abstract:

Legged robots often struggle to move effectively across varied and unpredictable terrains, such as mud, sand, and steep slopes. To address this, we have developed a novel robotic foot that uses pneumaticallyactuated astructures to adapt its shape dynamically. By adjusting its shape, the foot can modulate contact forces to control how it interacts with different surfaces, enhancing stability, efficiency, and maneuverability. Our tests show that this innovative design significantly improves locomotion by reducing the robot's sinking into sand, minimizing resistance in sticky mud, and allowing it to maintain balance on steep inclines. Compared with a geometrically matched rigid foot, the adaptive design eliminates measurable sinkage under a 10 N load by inflating to 8 cm in diameter, reduces suction forces by 84% in highwater mud and 98% in medium-water mud through shape modulation. Long-term durability testing revealed an 18% increase in relaxed balloon diameter after 100 cycles of inflation to 80%, yet the maximum loadbearing capacity remained unaffected, confirming robust and repeatable performance. Additionally, the adaptive foot enables the robot to perform unique actions such as walking on water and even executing skipping motions. Beyond just movement, this adaptive design opens new possibilities for robots to grasp and manipulate objects, broadening their potential applications in real-world environments.

Keywords:

Robotics; Locomotion; Terrain Interaction; Contact Force Manipulation

Mentor(s):

Upinder Kaur (Engineering)

Presentation Time: GRIS 134 at 2:00-2:20

Altering a Biobased Epoxy via Fillers to Improve Adhesion to Wood

STEM

Authors(s):

Chantelle April Miller† (Engineering|JMHC)

Abstract:

Biobased adhesives are a relatively new development that have the potential to replace conventional petroleum-based adhesives, reducing the use of fossil fuels. However, biobased glues have vet to be comparable with petroleum adhesives across the board in cost, strength, and industrial scaling, limiting their marketability. Inspired by the chemistry that mussels use to adhere to rocks, a biobased epoxy created in the Wilker lab shows promise as a scalable, 100% biobased adhesive. This research intends to discover what kinds of additive fillers can improve this biobased epoxy adhesive's strength and cost. In particular, trends in material type, particle size, and filler amount will be analyzed. Various fillers are added to the biobased adhesive for each combination of filler and particle size. The modified adhesives are then applied to wood substrates, cured, and tested for lap-shear strength. Preliminary results show that most filler additions greatly increase the strength of the adhesive, with smaller particle sizes being more effective at increasing adhesion strength. The findings from this research will help inspire stronger, more effective biobased adhesives, giving them a better edge in the adhesives market.

Keywords:

[no keywords provided]

Mentor(s):

Isabelle Kathryn Schaekel (Science); Jonathan J Wilker (Science)

Other Acknowledgement(s):

Ioanna Katsamba (Engineering)

Presentation Time: GRIS 134 at 2:20-2:40

Surface Tension Study of Fluorine-free Firefighting Foam based on the Mixture of Hydrocarbon and Silicone Surfactants

STEM

Authors(s): Pham Thanh Ngan Dinh†

Abstract:

Fluorocarbon surfactants are key components in aqueous film-forming foams (AFFFs), a common Class B fire-fighting foam, owing to their superior surface-active properties compared to hydrocarbon surfactants. The unique surface activities of fluorine-based AFFFs suppress flammable liquid fires by forming a foam layer and aqueous film on the burning fuel surface, effectively separating the fuel from oxygen in air. Nonetheless, fluorosurfactants in AFFFs belong to the poly-fluoroalkyl substances (PFAS) chemical family, characterizing them as highly persistent environmental and health hazards. To address these concerns, efforts to develop fluorine-free foam alternatives (F3) have emerged. Some F3 studies have explored synergistic fire-fighting effects in aqueous mixtures of hydrocarbon and silicone surfactants, with the overarching goal of formulating foams with equal performance as their fluorine-based counterparts. This research studies surface tension – an important surface property of AFFFs - in aqueous solutions of two silanes with commercial hydrocarbon surfactants. Mixtures of varying silane-hydrocarbon ratios are shaken vigorously and their foam stabilities are qualitatively assessed by visual observation of foam heights over monitored time intervals. Selected mixtures with high foam stabilities are then characterized for surface tension using Kruss Drop Shape Analyzer and comparatively discussed with established literature. Experimental results show that combinations of the two silanes synthesized in our laboratory - 3-aminopropylTris(trimethylsiloxy)silane (QAT) and 3aminopropylmethylBis(trimethylsiloxy)silane (QAB) - with the silicone surfactant Silsurf A008 produce solutions with high foam stabilities. Combinations of QAT and QAB with additional commercial surfactants are to be explored for potential synergism, with promising combinations to be further investigated for fire-fighting capabilities and toxicology profiles.

Keywords:

Aqueous Film-Forming Foam; Fluorine-Free Foam; Silicone Surfactant; Surface Tension; Foam Stability

Mentor(s):

Carlos J Martinez (Engineering); Nicole Lin Franklin (Engineering); Elizabeth Cecilia Malek (Engineering)

Other Acknowledgement(s): loanna Katsamba (Engineering)

Presentation Time: GRIS 134 at 2:40-3:00

Implementation and Evaluation of Large Language Model-Based Intelligent Tutoring Systems in Biological Engineering Curricula

STEM

Authors(s):

Ha Nguyen†; Shreyans Jain‡; Ekagrah Kumar‡ (Agriculture|Engineering); Nihar Dharmesh Shah*

Abstract:

Modern educational systems struggle to offer personalized, inquirybased learning that develops critical thinking. Traditional teaching often falls short in engaging students through guided questioning, limiting their ability to understand concepts independently. Socratic AI tutors combine the proven pedagogical effectiveness of Socratic questioning with the scalability of artificial intelligence, delivering structured, question-driven support instead of direct answers. However, in specialized fields like Biological Engineering, existing tutors lack in-depth domain expertise and depend on costly, closed-source models. To address this gap, an open-source Gemma-7B language model was fine-tuned and integrated with a retrieval-augmented generation (RAG) pipeline and Socratic dialogue style, creating a custom Biological Engineering Al Tutor. A hybrid synthetic dataset of Socratic teaching dialogues was used for finetuning, and a knowledge base curated from over 15 textbooks, peerreviewed articles, and course materials powered the retrieval component. Performance evaluation, measured by accuracy, relevance, coherence, and inference latency, demonstrated that the custom tutor matches commercial LLMs in accuracy and content relevance, maintains interactive-speed responses, and operates at a fraction of the cost. User feedback indicated strong student engagement, with learners affirming that Socratic questioning promotes active learning. This research established a scalable, cost-effective framework for specialized engineering education. Future steps include structured evaluation of student outcomes, direct comparisons to commercial models, integration into classroom settings, iterative refinements to validate learning gains, and adaptation for other disciplines.

Keywords:

LLMs; Socratic Teaching; Biological Engineering; Synthetic Data Generation; Retrieval-Augmented Generation

Mentor(s):

Dharmendra Saraswat (Engineering); Martin R Okos (Engineering); Varun Aggarwal (Engineering); Daniel N Hauersperger (Agriculture); Adeayo Daniel Adewumi (Agriculture)

Other Acknowledgement(s):
David Matthew Czerwonky (Engineering)

Presentation Time: GRIS 133 at 2:00-2:20

Using ABAQUS to Simulate Nanoindentation on Bismuth-Modified SAC305 Solder Alloys

STEM

Authors(s): lan Strachan† (Engineering)

Abstract:

Solder materials such as SAC305 are commonly used in electronics, and understanding their mechanical properties is critical for making sure these electronics are reliable. Previous experiments have shown that adding Bismuth (Bi) to SAC305 increases the hardness, while increasing strain-softening behavior. Researchers were able to see this effect using two different types of nanoindenters: Berkovich and Cube-corner, which have different tip angles and result in different plastic strain, 8% and 22% respectively. To explore this behavior further, finite element analysis (FEA) is being used to model how SAC305 and SAC305 with 1-3% Bi behave when indented. With 2D axisymmetric models of the indenters that create different angles and apply material properties based on experimental data. Simulations such as these are valuable because they provide detailed insight into subsurface stress and strain distributions, which are often difficult or even impossible to capture accurately through traditional experimental techniques. The results are expected to show that sharper indenters, like the Cube-corner, cause more concentrated plastic deformation than the Berkovich tip. Similar to the experimental observations, it is predicted that the Bi-added allows will respond with higher overall flow stress. These simulations will provide an explanation as to why the materials behave the way they do and support future work on designing better solder materials for high-temperature electronics.

Keywords:

Nanoindentation; SAC305; Strain-Softening; Abaqus; Simulation

Mentor(s):

Jia-Huei Tien (Engineering); David Bahr (Engineering)

Other Acknowledgement(s):

David Matthew Czerwonky (Engineering)

Presentation Time: GRIS 133 at 2:20-2:40

Assessment of Thermal and Radiation Effects of MOSFETs using Early-Stage Remote Instrumentation

STEM

Authors(s): Ayah Rahman†

Abstract:

Metal-oxide semiconductor field effect transistors (MOSFETs) are critical components within power circuits found in systems exposed to nuclear and gamma radiation environments. These components must survive elevated radiation and thermal conditions to ensure system integrity. Previous literature exploring MOSFET failure has highlighted the need for a live-monitoring system to measure the output voltages and drain-source resistance of a MOSFET per unit dose. Due to its commercial availability, the BSS1119N MOSFET contained within a boost converter circuit is evaluated. This paper seeks to explore methods for assessing thermal and nuclear effects under elevated heat and radiation conditions. Additionally, methods to remotely conduct resistance measurements and challenges are discussed.

To analyze the MOSFET's response to raised temperatures, a 10k ohm PTC thermistor was incorporated within the circuit to allow for negative feedback with respect to temperature. The results of the thermal experiment show that within our range of interest, 24° to 80° C, the system output voltage decreases from 34.5 V at room temperature to 29 V as temperature increases before steadily returning to its nominal value at room temperature. Evidence shows that PTC experiments conducted within the radiation environment of Purdue Reactor Number One (PUR-1) have negated known boost converter voltage increases due to temperature dependence. As a result, any increase in output voltage can be reasonably assumed to be from radiation-induced damage as opposed to induced temperature changes. While ongoing efforts are being made to refine live monitoring, these findings will improve the overall diagnostic capabilities of power conversion circuits.

Keywords:

Nuclear Radiation; MOSFET; Temperature; Live-Monitoring

Mentor(s):

Matthew M Niichel (Engineering); Peter Bermel (Engineering); Stylianos Chatzidakis (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
David Matthew Czerwonky (Engineering)

Presentation Time: GRIS 133 at 2:40-3:00

Design of a single-ended CMOS inverter ring oscillator DCO with 16-stage switched capacitor coarse tuning and 6-bit C-2C ladder fine tuning for a RISC-V system-on-chip application STEM

Authors(s):
Dylan Swanson†

Abstract:

[Abstract Redacted]

Keywords:

Analog / Mixed-Signal Integrated Circuit Design; Digitally Controlled Oscillator; Single Ended Ring Oscillator; Switched Capacitor Tuning; C-2C Ladder

Mentor(s):

Seyedehmarzieh Rouhani (Engineering); Mark Johnson (Engineering)

Other Acknowledgement(s):

David Matthew Czerwonky (Engineering)

Presentation Time: GRIS 126 at 2:00-2:20

Autonomous Quadcopter Battery Swapping for Extended UAV Endurance

STEM

Authors(s):

Jamie Chanadol Henson† (Engineering); Adina Ioana Margineantu‡ (Science); Clifford Walter Gamble* (Engineering)

Abstract:

This research project explores a method for autonomously extending the endurance of small UAVs through midair battery swapping. Thus. enabling a quadrotor drone ("receiver") to rendezvous with a second drone ("supplier") and exchange its depleted battery mid-flight, eliminating the need to land for recharging and allowing increased endurance anywhere. This capability could dramatically improve the persistence of UAV operations in fields such as search and rescue. monitoring, and logistics. The methods involved designing a dual-drone system where the receiver uses onboard sensors and guidance logic to dock with the supplier. The team developed the autonomy software in Python and integrated it with a Pixhawk flight controller, focusing on guidance, navigation, and control (GNC) for reliable docking. A third, smaller backup battery ensures the receiver remains powered during the battery exchange. The team implemented a custom-made copper-bladed plug prototype that enables convenient battery swapping while maintaining high current flow and providing electrical contact. The results demonstrate that autonomous midair docking and power continuity through a battery swap are feasible at lab scale. Early flight tests show stable hovering and guidance with onboard power maintained are needed during swap transitions. In conclusion, a new direction for longendurance drone missions has emerged, enabling continuous operations through in-air energy replenishment. Future work includes improving docking precision, mechanical reliability, and scaling to more complex mission profiles.

Keywords:

Unmanned Aerial Vehicle; Autonomy; Control; Aerospace Engineering; Electrical Engineering

Mentor(s):

Ran Dai (Engineering)

Other Acknowledgement(s): Yooseung Choi (Engineering); Anamano Editi Ikoh (Engineering)

Presentation Time: GRIS 126 at 2:20-2:40

Utilizing Wearable Technology to Improve POTS Diagnostic Testing

STEM

Authors(s):

Monique Watson† (Engineering)

Abstract:

Postural orthostatic tachycardia syndrome (POTS) is a form of dysautonomia characterized by a heart rate (HR) increase ?30 beats/minute (bpm) within 10 minutes of standing from a supine position, without a significant blood pressure drop. POTS can diminish quality of life with symptoms including tachycardia, headaches, and fatigue. Despite established diagnostic criteria, POTS is often underrecognized or misdiagnosed due to its episodic nature. Symptoms may not consistently be present during diagnostic testing, leading to false negatives during in-office testing. Wearables offer a promising solution through continuous physiological monitoring. Individuals with hypermobile Ehler-Danlos Syndrome (hEDS), a population in which POTS is prevalent, wore a Corsano CardioWatch 2B for 30 days. The wearable continuously measured physiological metrics, and utilizing movement data, the time when individuals stood from bed was identified. Assuming standing from bed involves transitioning from supine to standing, it can mimic the orthostatic change during in-office assessments. Thus far, eight healthy controls and seven individuals with hEDS were analyzed. Initial findings show considerable variability in individuals' mean HR increases, ranging from 6.60 to 27.02 bpm in healthy controls and 8.15 to 27.71 bpm in individuals with hEDS. However, there was a notable difference in step count, averaging 27 steps in individuals with hEDS and 64 steps in healthy controls. suggesting activity may contribute to HR increases in controls. Future work of incorporating activity during the period of interest may stratify hemodynamic changes and better identify group differences. These findings support the potential of wearables in advancing POTS diagnostic testing.

Keywords:

Wearable Heath Monitors; Diagnostic Testing; Postural Orthostatic Tachycardia Syndrome; Hypermobile-Type Ehlers-Danlos Syndrome; Heart Rate Dynamics



Presentation Time: GRIS 126 at 2:40-3:00

Sex-dependent differences in cardiac function and strain in doxorubicin-induced cardiomyopathy

STEM

Authors(s):

Anna Julie Astrid Webb† (Science); Bea Olivia Cabot‡ (Science); Aasish Chowdary Karuturi‡ (Science|JMHC); Wilhelm S Smith‡

Abstract:

Doxorubicin is a chemotherapeutic agent used to treat many types of cancer. While effective, doxorubicin can cause cardiomyopathy, a disease affecting the heart muscle. Although the effects of doxorubicin on the heart are well studied, the mechanisms leading to cardiomyopathy are not well understood. Previous studies have used murine models to study the cardiotoxicity of doxorubicin. These reports showed that cardiac dysfunction is more pronounced in male compared to female mice. The goal of this study is to further evaluate sex differences in doxorubicin induced cardiomyopathy using 4-dimensional strain mapping techniques. In this study, both female and male C57BI/6J mice received weekly imaging and injections of doxorubicin (4 mg/kg) for 4 weeks, followed by weekly imaging for 5 weeks. Two-dimensional (2D) and fourdimensional ultrasound (4DUS) images were acquired using the Vevo 3100 ultrasound system (FUJIFILM VisualSonics) allowing visualization of the heart in vivo over the course of the study. These 4DUS images were analyzed using 4D strain tracking software, providing more accurate and detailed regional measures of cardiac dysfunction than achieved from 2D images alone. The expected findings of this study are that female C57BI/6J mice will have less severe outcomes based on previous studies. Subtle changes in cardiac strain and function not seen in traditional ultrasound methods may be observed, explaining the mechanism by which doxorubicin leads to sex dependent differences in cardiomyopathy. The sex-specific findings from this study have the potential to improve patient-specific treatment for doxorubicin-induced cardiomyopathy.

Keywords:

Doxorubicin; Cardiomyopathy; Sex-Dependent; Cardiac Strain

Mentor(s):

Cortland Hannah Johns (Engineering); Benjamin Zeidler (Engineering); Craig Goergen (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 118 at 2:20-2:40

Effects of Adding Processed and Unprocessed Lean Red Meat to a U.S.-Style Healthy Vegetarian Dietary Pattern on Fasting Plasma Trimethylamine N-oxide (TMAO) in Young Adults

STEM

Authors(s):

Mara Valentina Ugaz Angeles† (HHS)

Abstract:

Trimethylamine N-oxide (TMAO) is a metabolite found in blood that is produced when certain nutrients found in animal-based foods, including red meat, are broken down by gut bacteria. Observational studies have associated higher red meat intake with higher plasma TMAO and increased risk of cardiometabolic diseases. We assessed the effects of adding unprocessed (URM) or processed (PRM) lean red meat to a lacto-ovo vegetarian (LOV) healthy dietary pattern (HDP) on plasma TMAO concentrations.

The results presented are from a secondary, retrospective objective of a cross-over randomized controlled trial. 19 participants (42% female; age 26 ± 4 years; BMI 23 ± 3 kg/m², mean \pm SD) without diagnosed disease consumed the LOV-HDP (control), URM-HDP or PRM-HDP diets during three 3-week dietary interventions, each separated by 5-week washout periods. TMAO was measured in fasting plasma samples obtained before and at the end of the second and third week of each intervention period.

The addition of unprocessed or processed lean red meats to a LOV HDP tended to influence intervention-induced changes in TMAO (Time*Diet, p=0.066). TMAO did not change over time with the LOV-HDP (?0.19 \pm 0.38 $\mu\text{M},$ p=0.621), and increased with the URM-HDP (0.75 \pm 0.38 $\mu\text{M},$ p=0.046) and PRM-HDP (0.73 \pm 0.37 $\mu\text{M},$ p=0.013). These findings suggest that adding red meat to a lacto-ovo vegetarian diet may influence short-term changes in TMAO, a potential index of cardiometabolic disease risk, among young healthy adults when they start consuming a healthy diet.

Keywords:

TMAO; Lacto-Ovo Vegetarian (LOV); Healthy Dietary Pattern (HDP); Unprocessed Lean Red Meat (URM); Processed Lean Red Meat (PRM)

Mentor(s): Wayne W Campbell (HHS)

Presentation Time: GRIS 103 at 3:00-3:20

Synthesis and Characterization of the TbCr6Ge6 Kagome Magnet

STEM

Authors(s):

Adriana Maria Velasquez Medina†

Abstract:

[Abstract Redacted]

Keywords:

Electrical Transport; Flux Growth; Kagome Lattice; PPMS; MPMS

Mentor(s):

Mohan Bikram Neupane (Science); Arnab Banerjee (Science); Luis Henrique Vilela Leao (Science)

Other Acknowledgement(s):

Arjun Unnikrishnan (Science); Bishnu Prasad Belbase (Science); Jhinkyu Choi (Science)

Presentation Time: GRIS 103 at 3:20-3:40

Fecal microbiota transplantation therapy alters resistome burden and horizontal transfer potential in a diseasedependent manner

STEM

Authors(s):

Sakesh Andhavarapu† (Science|JMHC)

Abstract:

Antimicrobial resistance (AMR) is a top global public health and ongoing threat that was associated with 4.71 million deaths in 2021, including 1.14 million deaths directly attributed to AMR. As the effectiveness of traditional antibiotics declines and new antibiotic development remains slow, patients undergoing long-term or repeated antibiotic treatments. such as those with recurrent Clostridium difficile infection (rCDI) or colonization by multidrug-resistant bacteria (MDRB), face increasingly limited treatment options. In these high-risk populations, when conventional therapies fail, microbiome-based strategies such as Fecal Microbiota Transplantation (FMT) offer an alternative by restoring microbial balance either independently or alongside antibiotics. Although research has been conducted to investigate the clinical outcomes of FMT, the extent to which it impacts genetic mechanisms of resistance, including AMR genes (ARGs) and mobile genetic elements (MGEs) patterns remains insufficiently characterized. Critically, there is a lack of comprehensive, temporally resolved network analyses that examine how FMT influences persistence, reduction, or transfer of ARGs that have innate transfer potential due to their association with MGEs over time. To investigate these patterns, 263 publicly available metagenomic samples from FMT donors and recipients (Pre-FMT and Post-FMT) that span rCDI , MDRB infections, and melanoma were analyzed. Resistome and mobilome count matrices were produced utilizing gene classification pipelines. A novel Network-based framework has been implemented to analyze and visualize the temporal modifications of ARGs and MGEs in the microbiome. In this network, nodes represent ARGs or MGE mechanisms, annotated by their source origin (donor or recipient). Edges represent temporal shifts in abundance or co-localization relationships, encompassing longitudinal dynamics and potential genomic ARG-MGE links. The most significant changes observed were the emergence of 4.359 new intragenomic colocalizations from unknown sources and the disappearance of 4,564 pre-existing ones following the FMT procedure. Additionally, our results show 130 instances of transfer from the donor to

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

the patient and the persistence of 386 colocalizations that were present in the patient before and after treatment. Only 19 colocalizations were found to persist across all three stages. By quantifying the distinct colocalization dynamics, these findings can contribute to th

Keywords:

Antimicrobial Resistance (AMR); Fecal Microbiota Transplantation (FMT); Colocalization; Temporally Network Analyses

Mentor(s):

Ilya Slizovskiy (Vet Med); Alejandro Dale Kimball (Centers & Institutes)

Presentation Time: GRIS 103 at 3:40-4:00

Foldable Underwater Acoustic Metamaterial for broadband low frequency mitigation

STEM

Authors(s):

Shaocheng Wu† (Engineering)

Abstract:

Pile-driving noise poses significant risks to marine life. However, current noise mitigation systems (NMS) typically struggle to attenuate low-frequency noise effectively, are hard to deploy on a large scale, and are expensive and hard to operate. To address the limitation in NMS, we proposed a Underwater Acoustic Metamaterial that has standout properties, including being foldable and having superior low-frequency noise reduction, and is easy to manufacture.

In this research, we developed a foldable waveguide array utilizing airentrained plates to build soft boundaries that efficiently block low-frequency sound transmission. Additionally, Air-entrained plates were manufactured with a 3D-printed flexible resin, and an array of waveguides was constructed using them as well. Furthermore, Both COMSOL simulations and underwater experiments were verified. The simulation results indicated an average of 35 dB, with a peak noise reduction of 120 dB. The experiment results showed an average insertion loss of 30 dB, with a maximum reduction of 60 dB over several octave bands. Finally, Future research will investigate scalability and adaptability to deployment in large underwater environments.

Keywords:

Acoustic Metamaterials; Noise Control; Underwater Acoustics

Mentor(s):

Yijie Zhang (Engineering)

Presentation Time: GRIS 134 at 3:00-3:20

Solder Alloy Characterization for Microelectronic Reliability Insights (SCALE HI/AP)

STEM

Authors(s):

Timothy P Malloy† (Engineering|JMHC); Son Quoc Son Phan‡ (Engineering)

Abstract:

Solder joint failure in microelectronics can appear in many ways. Electromigration and solder joint fatigue are some of the most common reliability concerns for solder alloys. Electromigration in solder alloys – the movement of metal atoms due to high density currents - causes degradation of solder. Solder joint fatigue, on the other hand, is the mechanical degradation that occurs due to repeated stress and strain from thermal cycling. Solder joint geometry and material composition are known to affect the rate at which these degradations occur. To better understand these degradations, this research aims to develop a testing platform for electromigration in solder alloys and collect data to characterize their fatigue performance. For electromigration, a custom PCB was designed using KiCad 9.0 and printed by a vendor. A copper line 30 microns in height has 3 gaps: 300 microns, 200 microns, then 100 microns. In these gaps, custom solder paste was placed (various pastes were tested, including tin-silver-copper and tin-bismuth). As highdensity current flowed through the circuit, the increases in resistance an indication of electromigration – across the joints vs time were graphed. For fatigue testing, the HiDAC lab's custom-made closed-loop precision mechanical tester applied a displacement profile to the solder joint. This machine ran fatigue tests until the load range decreased by 75%, defining the N25 fatigue life. Fatigue tests were performed over different strain ranges, covering both high-cycle and low-cycle fatigue. Our platforms enables solder characterization and provides deeper insights into solder alloy reliability in microelectronics.

Keywords:

Solder; Electromigration; Fatigue; Microelectronics; SCALE

Mentor(s):

Sean Yenyu Lai (Engineering); Ganesh Subbarayan (Engineering)

Other Acknowledgement(s):

Parth Uday Kelkar (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 134 at 3:20-3:40

Acoustic Application to Air Conditioning Filter System STEM

Authors(s): Chen Han Chan† (Engineering)

Abstract:

The increasing demand for electric energy to power air-conditioning systems during summers has contributed significantly to atmospheric pollution. Maintaining indoor air quality requires filtration systems capable of efficiently capturing sub-micron and coarse particulate aerosols (0.25-1.0 ?m). However, fine particles are challenging to remove and necessitate high-grade filters, which increase airflow resistance and, consequently, fan energy consumption. This creates a need for an energy-efficient method to filter these aerosols while minimizing energy use. This research explores the application of acoustic trapping techniques within air-conditioning systems to enhance air quality without sacrificing airflow or increasing energy costs. Through a combination of COMSOL simulations and testing of 3D-printed acoustic structure prototypes, we investigate the use of twenty 40 kHz transducers to generate a standing wave field. This field creates a pressure differential, pushing particles from pressure anti-nodes to nodes. When the acoustic force surpasses the drag force, effective particle trapping is achieved. The feasibility of integrating acoustic trapping to improve filtration in air-conditioning systems is currently under investigation, with wind tunnel experiments planned to validate the concept. Additional experiments and simulations are needed to further assess performance and support implementation in real-world airconditioning systems, aiming to provide a sustainable and energyefficient solution for indoor air quality management.

Keywords: [no keywords provided]

Mentor(s): Junfei Li (Engineering)

Presentation Time: GRIS 133 at 3:00-3:20

Discovering and Designing Novel Perovskite Photovoltaic Materials via Machine Learning

STEM

Authors(s):
Junyeong Ahn† (Engineering)

Abstract:

Perovskite semiconductors are promising materials for high-efficiency photovoltaics due to their outstanding optoelectronic properties. emerging as a sustainable energy source through solar cell applications. Perovskites with the ABX3 composition (A, B = metal or organic cations with varying oxidation states; X = chalcogen or halogen anions) have gained interest for their excellent phase stability and compositional tunability. However, combinatorial possibilities arising from the many choices of A. B. and X site species, and their respective mixing fractions. a large number of possible ABX3 perovskites remain undiscovered. In this work, we used machine learning (ML) methods to design new stable and synthesizable ABX3 compounds for photovoltaic (PV) applications. Hypothetical charge-neutral ABX? compounds were generated based on the oxidation states of the constituent ions, their associated chemical properties were used as numerical descriptors to train ML regression models for predicting stability and electronic properties. The synthesizability of the generated compounds was predicted using positive-unlabeled (PU) classification learning, referencing experimentally synthesized compounds collected from the literature using a large language model (LLM). Regression models were trained on a computational dataset of perovskite properties, namely the decomposition energy and the electronic band gap. Predictions were made for thousands of novel compositions, and screening was performed to yield many new materials with stability against decomposition to alternative phases, high probability of synthesis, and PV-suitable band gaps. To ensure the practicality of the proposed materials, future studies will involve DFT calculations of optoelectronic properties and the realization of hypothetical materials through targeted synthesis and characterization.

Keywords:

Perovskite Semiconductors; Photovoltaic Devices; Machine Learning; Computational Materials Science

Mentor(s): Arun Kumar Mannodi Kanakkithodi (Engineering); Rushik Desai (Engineering)

Presentation Time: GRIS 133 at 3:20-3:40

Improving Echocardiographic Aortic Aneurysm Assessment in Marfan Syndrome Patients

STEM

Authors(s):

Joshua Paik† (Science); Felix Dinklage‡; Ahhyun Lee‡

Abstract:

Marfan syndrome (MFS) is a genetic connective tissue disorder caused by a variant of the fibrillin-1 (FBN1) gene, leading to abnormalities in organs reliant on tissue elasticity. Proximal thoracic aortic aneurysms (TAAs) are a major clinical concern, particularly in pediatric MFS patients, due to their risk of dissection or rupture.

Diagnosis and monitoring of TAAs often depend on manual measurements of aortic root diameters from the parasternal long axis views of transthoracic echocardiograms. However, this method is prone to interobserver variability (IOV), which impacts consistency in clinical assessment.

To mitigate these limitations, we developed a graphical user interface (GUI) that incorporates a novel feature tracking algorithm for the aortic root boundaries and extracts the diameter values across time at physiologically significant locations from anatomical M-mode images, along with Green-Lagrange Circumferential Strain (GLCS) from standard echocardiographic image data.

We evaluated the GUI on a cohort of 28 children between 5 to 10 years of age (14 with MFS and 14 controls). Maximum diameters at the annulus, sinus of valsalva (SoV), sinotubular junction (STJ), and ascending aorta were compared against manual measurements made by a board-certified pediatric cardiologist, with intraclass correlation coefficient (ICC) and linear regression coefficient (R²) values of 0.721/0.5802, 0.977/0.969, 0.528/0.7399, 0.779/0.6302, respectively. As pathophysiologically expected, MFS patients generally showed lower GLCS than controls.

This tool enhances the reliability of aortic root assessment by improving precision. Future work will include clinical validation on a larger cohort and integration of deep learning for automated aortic root annotation.

Keywords:

Marfan Syndrome; Aneurysm; Echocardiography; Strain

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Mentor(s): Shubh Parag Mehta (Engineering); Craig Goergen (Engineering); Benjamin Landis (Indiana University)

Other Acknowledgement(s): Samskrithi Sivakumar (Office of the Provost)

Presentation Time: GRIS 133 at 3:40-4:00

A DNA Damage Analysis of Breast Cancer Cells Under Cyclic Mechanical Actuation

STEM

Authors(s):

Maria Macias† (Engineering); Angelica Sofia Gonzalez-Ng‡

(Engineering); Eliza Louise Thurs‡ (Engineering)

Abstract:

Metastasis is the leading cause of mortality in breast cancer, yet tumor cell behavior and their response to mechanical cues in the pre-metastatic niche remains poorly understood. This study investigates how breast cancer cells respond to strain mimicking lung tissue dynamics, with a focus on DNA damage. Using a custom-designed micro-actuating lung model, we cultured mApple at p53BP1 and H2B-GFP reporter cells on fibrillar fibronectin-coated substrates subjected to cyclic mechanical forces that simulate respiratory motion. A group of cells were treated with escalating concentrations of Niraparib (0.1-10 µM), a PARP inhibitor, as a positive control. To visualize and quantify DNA damage in real-time, we tracked the red nuclear foci upon DNA double-strand break formation through confocal microscopy. Following treatment, cells were lysed directly from the fibronectin band and collected for protein quantification of ?-H2AX. This approach allows us to analyze how mechanically primed tumor cells in a lung-like niche modulate their DNA repair capacity in response to chemotherapeutic stress. These findings contribute to understanding how mechanical environments influence therapeutic resistance and could inform strategies to target metastatic progression at early, mechanosensitive stages.

Keywords:

Pre-Metastatic Niche; Breast Cancer; DNA Damage; PARP Inhibitor

Mentor(s):

Luis Solorio (Engineering); Madison Mckensi Howard (Engineering); Juan Camilo Mesa Agudelo (Engineering)

Other Acknowledgement(s):

Presentation Time: GRIS 126 at 3:00-3:20

CLCN1 missense mutation predicted to be responsible for congenital myotonia in a domestic shorthair cat STEM

Authors(s): sarah nelson†

Abstract:

Congenital myotonia is a neuromuscular disease that causes the muscles to remain tense after a voluntary contraction for some time after the initial event. This is typically a result of dysfunction in chloride channels in the skeletal muscle membranes; these channels help maintain a stable charge across the membrane to prevent spontaneous action potentials. Variants in the CLCN1 gene (encoding a chloride channel protein) are associated with congenital myotonia in a myriad of species, including humans, dogs, and the well-known fainting goats. Recently, a domestic shorthair cat presented with clinical signs that align with congenital myotonia; the cause of this cat's disease was unknown but speculated to be genetic. Therefore, DNA from this cat was subjected to whole genome sequencing, and the data examined for causative variants private to this cat, compared to >100 other feline genomes (all assumed to be unaffected by congenital myotonia). A plausible causal variant was identified in this cat's CLCN1 gene. specifically a homozygous missense variant (ChrA2:157,195,615 c.979G>T, p.Val327Phe). In silico testing was explored to predict the effect of this amino acid change, which likely impairs the ion channel gate function of the protein. Given that this cat was found as a stray, it can only be speculated that this homozygous variant resulted from inbreeding, which is not uncommon in feral cat populations. This work adds to our knowledge of congenital myotonia in cats and across all mammals, which will allow for the continued exploration of new diagnostic and therapeutic measures in the future.

Keywords:

Neuromuscular Disease; Veterinary Genetics; Chloride Channel

Mentor(s):

Kari J Ekenstedt (Vet Med)

Other Acknowledgement(s):

Jeanna Marie Blake (Vet Med); Madeline Christina Coffey (Vet Med)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Time: GRIS 126 at 3:20-3:40

Creating a Xenografted Human Vascularized Chimeric Brain Model

STEM

Authors(s):

Oliver Thomas Johnson† (Science|JMHC)

Abstract:

Cerebral blood vessels are essential for transporting nutrients throughout the brain and regulating the entry of materials into the brain through the Blood-Brain Barrier (BBB), Dysfunction of the brain's vascular system is linked to conditions such as stroke, vascular dementia, and Alzheimer's disease. Growing evidence shows significant differences between human and mouse vascular cells. For example, human vascular cells express higher levels of Alzheimer 's-associated genes. Therefore, it is urgent to develop human vascular models to better understand how the vascular system affects brain health and disease. An in vivo vascular model, in which human blood vessels are perfused and functionally integrated into the host's brain, has not yet been developed. To create these models, we will inject human Pluripotent Stem Cell (hPSC)-derived vascular progenitor cells into mice and allow the cells to grow and differentiate within the mouse brains. We will examine human vasculature maturation in host brains by harvesting, sectioning, and immunohistochemically staining the brains at different times post-cell injection. The staining will target markers for the main cell types needed for functional blood vessels and the Blood-Brain Barrier: endothelial cells, smooth muscle cells, pericytes, and astrocytes. Developing this chimeric vascularized brain model will provide a more physiologically relevant system for studying neurovascular contributions in healthy and diseased conditions, such as Alzheimer's disease and Vascular Dementia.

Keywords:

Neuroscience; Stem Cells; Blood Vessels; Alzheimer's Disease

Mentor(s):

Ranjie Xu (Vet Med)

Other Acknowledgement(s):

Xingjian Gu (Vet Med); Dongkai Guo (Vet Med)

Presentation Available July 27 - August 1

Design and Deployment of a A Kubernetes-Based Data Warehouse for HPC analytics

STEM

Authors(s):

Randy Alejo†; Abigale Tucker‡

Abstract:

High-performance computing (HPC) clusters produce vast amounts of data, but inconsistency in accessing that data limits its utility. This poses a challenge many operators of these systems face: How does one create a centralized system that can monitor and utilize this data? A common solution posed is to adopt a Software as a Service (SaaS) solution. These solutions provide an easy way to store and process data, but can be prohibitively expensive to deploy and operate. As an alternative, we developed our own data warehousing solution, utilizing the processing power of Purdue's most powerful supercomputer; Anvil.

To emulate the data handling capabilities of SaaS systems, our warehouse implements an Extract Transform Load (ETL) pipeline using open-source services from the Apache ecosystem like Kafka and Iceberg. My primary contribution to the project was configuring software deployments in Kubernetes, the orchestration platform responsible for deploying these tools. With built-in support for load balancing, and rolling updates, Kubernetes provides a robust framework for running services at scale.

The ETL pipeline is operating on Kubernetes, running on Anvil hardware. This system streamlines data access, providing users with a centralized and user-friendly interface for querying cluster data. It also allows admins to quickly respond to ongoing issues using grafana alerting. The result of this solution is a vastly simplified data querying experience. Users no longer need to juggle a diverse set of tools and interfaces, they can instead interact with one standardized sql-based interface and web dashboard.

Keywords:

HPC; Kubernetes; Apache; Data Warehouse; SQL

Mentor(s):

Samuel A Weekly (Information Technology); Patrick T Finnegan (Information Technology)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Available July 27 - August 1

Automated Question Generation for Technical Support in High-Performance Computing

STEM

Authors(s):

David Burns†; Christina Joslin‡ (Science|JMHC|Graduate)

Abstract:

High-performance computing centers handle a large number of support tickets, many of which are repetitive, which is a hindrance on support staff who must respond to similar issues repeatedly. One solution is to automatically generate answers to frequently asked guestions (FAQs) by analyzing support tickets. The goal was to automate this process using a pipeline that integrates natural language processing tools and large language models. Although the tickets were already organized by topic, the existing categories were too broad, requiring further refinement. Tickets were first filtered by frequency and recency of the issue. A large language model was then used to summarize the ticket contents into concise, structured issue-resolution pairs. This model was fine-tuned using low rank adaptation using legacy tickets. Manual inspection of the summaries led to the choice of summarization approach, as quantitative metrics did not perform well in comparison. The tickets were then clustered using K-Means. This decision was based on several quantitative metrics, such as silhouette score. After clustering, the topranked sub-clusters were selected for FAQ generation. Two methods were tested: generating a single Q&A per cluster, and splitting the cluster content into multiple pairs. While both approaches worked, the one-step approach appeared to produce better results according to empirical testing. Initial reviews suggest that the new FAQs are more consistent and readable, helping to reduce ticket volume, improve documentation, and assist in training new staff.

Keywords:

Natural Language Processing; Large Language Models; High Performance Computing; Question Generation

Mentor(s):

Ashish Ashish (Information Technology)

Presentation Available July 27 - August 1

Transforming Technical Support with Artificial Intelligence: Structured Question Generation from Support Tickets STEM

Authors(s):

Christina Joslin† (Science|JMHC|Graduate); David Burns‡

Abstract:

The creation of forums for frequently asked questions began in the 1980s to provide users with answers to common problems without requiring direct assistance from technical support staff. However, the growing scale and complexity of user inquiries in high-performance computing environments has surpassed the capacity of traditional support methods. To address this challenge, we developed an automated solution that generates frequently asked questions from historical technical support ticket data. This multi-stage process began by summarizing raw support tickets into issue-resolution pairs using a fine-tuned large language model enhanced by Low-Rank Adaptation adapters and eight-bit quantization. The model was trained on synthetically generated examples to improve performance on domainspecific inputs. These structured summaries were then embedded and grouped using K-Means clustering, with a custom scoring mechanism based on cluster size, cohesion, and separation guiding the selection of high-quality clusters. Finally, representative examples were passed to an instruction-tuned large language model using few-shot learning techniques for frequently asked question generation. Early results indicated that this pipeline improves the relevance, clarity, and consistency of generated content. By transforming unstructured ticket logs into actionable knowledge, our approach reduces redundant inquiries, accelerates resolution, and supports scalable technical support infrastructure. This work contributes to broader efforts to modernize documentation and assistance systems using artificial intelligence in complex computing environments.

Keywords:

Frequently Asked Questions; Large Language Models; Low-Rank Adaptation; Semantic Clustering; Few-Shot Learning

Mentor(s):

Ashish Ashish (Information Technology)

Presentation Available July 27 - August 1

Empowering Research: Easy-to-Use Bioinformatics Workflow Templates

STEM

Authors(s):

Abigail Lin†; Sadra Williams‡

Abstract:

Computational methods are essential to modern biological research, yet many scientists face a steep learning curve with using the highperformance computing (HPC) required for large-scale data analysis. To bridge this gap, we have created user-friendly workflow templates that balance accessibility with scientific rigor. Our platform provides easy-touse Console User Interfaces (CUIs) for key bioinformatics applications, including genome assembly, variant calling, and RNA sequencing. This allows researchers with little to no programming experience to execute complex analyses with ease, while also producing transparent and auditable code. Furthermore, we offer a general-purpose workflow template that enables users to construct custom bioinformatics pipelines. including automated CUI generation using configuration files. To ensure accessibility and reproducibility, all templates are accompanied by clear, step-by-step documentation that guides users through customization and deployment. By pairing intuitive interfaces and comprehensive documentation, our methodology lowers the entry barrier to computational research. It not only empowers a broader scientific community to harness HPC resources but also inherently promotes best practices of reproducible, scalable, and transparent science, fostering innovation and interdisciplinary collaboration.

Keywords:

Workflow; Bioinformatics; High-Performance Computing; Reproducibility; Pipeline

Mentor(s):

Arun S Seetharam (Information Technology); Nannan Shan (Information Technology)

Presentation Available July 27 - August 1

AnvilOps: Increasing Accessibility of Kubernetes with Automated Builds and Deployments

STEM

Authors(s):

Brendan Swanson†; Emma Zheng‡ (Science)

Abstract:

Kubernetes is a robust container orchestration system that provides an abstraction for provisioning hardware resources in favor of lightweight, portable containers, making it a common choice for organizations that need to run reliable software systems. However, deploying and maintaining resources in a Kubernetes cluster is difficult for the average user due to its steep learning curve and the extensive, complex configurations required.

To make Kubernetes deployments faster and easier, we present AnvilOps, a platform-as-a-service that automates the entire Kubernetes deployment lifecycle. Users can deploy apps from Git repositories (hosted on GitHub.com or GitHub Enterprise) into their own Rancher project. AnvilOps will clone the repository, build and push a container image, create Kubernetes resources, and expose the app on a custom subdomain. Railpack, a frontend for BuildKit, eliminates the need to write Dockerfiles in many cases, simplifying cloud-native application development for developers using popular languages and frameworks. Once the app is deployed, AnvilOps provides an easy-to-use dashboard to view logs and container statuses in real time and update persistent volumes, environment variables, number of replicas, and build options.

This solution significantly lowers the barrier to entry for Kubernetes deployments, allowing users to focus more on improving their apps instead of writing verbose configurations.

Keywords:

Kubernetes; Platform as a Service; Docker; CI/CD (Continuous Integration/Continuous Delivery); DevOps Automation

Mentor(s):

LJ Lumas (Information Technology); Haniye Kashgarani (Information Technology)

Presentation Available July 27 - August 1

Building a Data Pipeline and Warehouse for Supercomputing Environments

STEM

Authors(s):

Abigale Tucker†; Randy Alejo‡

Abstract:

Analyzing data produced by supercomputers is essential for performance monitoring, anomaly detection, and ensuring the long-term usability of computational resources. This project presents a data pipeline and warehouse for collecting, transforming, storing, and guerying supercomputing data using data engineering tools. Services are configured and deployed in a persistent, container-based environment with a database on physical hardware. Initially, simulated data, such as system logs and monitoring data, is ingested and processed into structured, queryable formats. This testing validates pipeline functionality before integrating production data. The resulting data store will serve as a foundation for future analysis, visualization, and operational insights for use by data scientists, system engineers, and end users of the computing resources. This work advances the development of scalable infrastructure that support system-wide monitoring, performance optimization, and resource efficiency within Purdue University's supercomputing environment.

Keywords:

Data Engineering; ETL; HPC; Data Warehouse; Data Pipeline

Mentor(s):

Samuel A Weekly (Information Technology); Patrick T Finnegan (Information Technology)

Presentation Available July 27 - August 1

Empowering Research: Easy-to-Use Bioinformatics Workflow Templates

STEM

Authors(s):

Sadra Williams†; Abigail Lin‡

Abstract:

High Performance Computing (HPC) is a powerful tool for bioinformatics, offering scalability and speed. However, it can be challenging for researchers with limited programming experience or for non-computer scientists. To address this, we have developed user-friendly, step-bystep workflow templates for three common bioinformatics tasks: genome assembly, RNA-seq, and variant calling. These workflows utilize Python, R, and Bash scripts to execute standard bioinformatics tools. Each workflow features a custom console user interface built with the Python package Urwid. The interfaces are designed to guide researchers through the process, allowing them to easily modify options while abstracting away the complexities of the underlying code. All workflows, scripts, and documentation - detailing versioning, usage, and additional help resources – are available on a Github repository. With clear documentation, an intuitive interface, and flexible scripts, our workflows enhance scalability, reproducibility, usability, and portability, enabling users to focus on deriving insights from their data rather than learning new tools.

Keywords:

Bioinformatics; High Performance Computing (HPC); Workflow; Workflow Templates; Accessibility

Mentor(s):

Nannan Shan (Information Technology); Arun S Seetharam (Information Technology)

Presentation Available July 27 - August 1

AnvilOps: Accelerating the Kubernetes deployment cycle STEM

Authors(s):

Emma Zheng† (Science); Brendan Swanson‡

Abstract:

The container orchestration system Kubernetes enables researchers to run and manage container-based tools and applications, providing a valuable complement to traditional HPC workflows. However, deploying applications to Kubernetes requires familiarity with container image building and resource configuration, posing a significant challenge to users. To add further friction, many deployment steps must be repeated with each application update. To ease adoption of Kubernetes, we developed AnvilOps, a platform-as-a-service solution that automates the complex task of application deployment. AnvilOps is comprised of a Node.is web application and several Kubernetes components, including a Buildkit daemon that manages container image builds. The application leverages the Rancher API to provision resources inside a user's projects and maintain access control. Through the web interface, a user can deploy an application from a GitHub repository with little to no configuration needed. AnvilOps automatically builds a container image. creates the necessary Kubernetes resources, and makes the application available on a custom subdomain. In particular, AnvilOps can build applications either from user-provided Dockerfiles or by using the Railpack frontend to Buildkit to generate build plans, eliminating manual build configuration. Furthermore, AnvilOps enables continuous deployment through GitHub webhooks; when updates are pushed or triggered by workflow events, the application is automatically rebuilt and redeployed. The platform streamlines a lengthy deployment procedure into an automated loop that requires minimal user intervention. AnvilOps bridges the gap of support for users unfamiliar with Kubernetes infrastructure, augmenting the accessibility of persistent services in HPC.

Keywords:

Kubernetes; Docker; Automation; Continuous Deployment; Platform as a Service

Mentor(s):

LJ Lumas (Information Technology); Haniye Kashgarani (Information Technology)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Available July 27 - August 1

EV adoption and infrastructure under high wildfire risk in the wildland-urban interface (WUI) and during wildfire evacuation STEM

Authors(s):

Angel Antayhua-Reynoso†

Abstract:

The Wildland-Urban Interface (WUI)—areas where human development intermingles with wildland vegetation- has expanded by 46% between 1990 and 2020 in the United States. With 115 million Americans today living within these areas, research shows that the WUI is also at the highest risk for wildfires. As electric vehicle (EV) adoption increases and electrified transportation infrastructure expands, WUI communities face unique barriers shaped by dispersed infrastructure, elevated wildfire risk, and limited charging availability. Unlike more urbanized areas, many WUI zones in Utah lack the dense, redundant charging infrastructure needed to support reliable EV use during emergency scenarios. These vulnerabilities are amplified during fire seasons when utilities may cut power to prevent ignition, directly impacting the operability of home charging and limiting mobility during critical evacuation windows. This study examined the current and potential landscape of EV adoption in Utah's WUI regions, with a particular focus on the risks associated with wildfire evacuations and preemptive power shutoffs. Drawing on regional data, land use patterns, and demographic trends, we assess how these compounded risks affect EV uptake. We argue that planning for EV adoption in Utah's WUI must integrate emergency preparedness, microgrid resilience, and investment in off-grid or backup charging solutions. This study aims to inform transportation and wildfire policy in Utah by highlighting the need for a coordinated, place-based approach to ensure that the state's push toward electrification supports, rather than undermines, safety and resilience in high-risk communities.

Keywords:

Electrical Vehicle Adoption; Wildfires; Wildland-Urban Interface; Evacuation Planning

Mentor(s):

Brandon Chase Myke Allen (Engineering); Chiara Cervini (Engineering)

Presentation Available July 27 - August 1

Dynamic PCM-Based System for Passive Thermal Management in High-Powered EV Wireless Charging Stations STEM

Authors(s): Sofiia Goncharuk†

Abstract:

Electric vehicles (EV) high-powered wireless charging stations can transfer up to 1 megawatt (MW) of electrical power within 35 minutes, however, they generate significant waste heat, even at high efficiencies (95%). This results in a heat flux of approximately 25 kW/m² - presenting a major thermal management challenge for the charging pad. Passive cooling strategies are important to ensure reliable operation without relying on bulky, noisy, or energy-consuming active thermal management systems.

This study investigates a dynamic Phase Change Material (PCM)-based heat sink as a potential solution for passive thermal management in high-powered EV charging applications. A transient three-dimensional numerical simulation is implemented in ANSYS Fluent to model the phase change behavior of paraffin wax as the PCM. To validate the simulation, a corresponding experimental setup is designed and fabricated.

The temperature distribution along the height of the PCM-based heat sink is analyzed and compared between the numerical and experimental results. Special attention is given to the influence of dynamic PCM behavior on maintaining thin solid–liquid interface closer to the power electronics (e.g., the ferrite core), thereby preventing superheating of the molten region. This improves thermal efficiency and temperature control throughout the system.

Integrating a dynamic PCM system into a high-powered wireless charging station gives a passive, scalable, and energy-efficient cooling method that significantly improves thermal performance. By providing greater system reliability and minimizing temperature increase, PCM-based approach supports broader EV adoption by enabling faster, safer, cost-effective, energy-efficient, and more sustainable charging infrastructure.

Keywords:

Phase Change Materials (PCM); Passive Thermal Management; Wireless EV Charging Stations; Dynamic PCM; High Heat Flux

Mentor(s):

Brandon Chase Myke Allen (Engineering); Chiara Cervini (Engineering)

Presentation Available July 27 - August 1

Simulating Dynamic Wireless Power Transfer in Urban Environments Using CARLA

STEM

Authors(s): Aaron Paddy†

Abstract:

The continued growth of electric vehicles (EVs) has sparked interest in new charging approaches that reduce downtime and expand access beyond fixed locations. Dynamic Wireless Power Transfer (DWPT). which enables vehicles to charge while driving, offers an exciting future direction but remains largely experimental. This study focuses on the development of a flexible simulation and testing framework to explore DWPT in urban environments. Rather than optimizing for a single "best" solution, we aim to create a digital platform that helps evaluate different roadway coil designs, placement strategies, and traffic interactions under realistic city conditions. Using the CARLA simulator, we recreate sections of the Salt Lake City road network to examine how vehicles might interact with DWPT infrastructure in practice. Our approach emphasizes building a high-fidelity, adaptable simulation environment over drawing premature conclusions on specific charger configurations. By enabling systematic testing of various design and deployment scenarios, this work provides a foundation for future research and planning of in-motion charging systems tailored to specific city needs. Ultimately, the project contributes a new open-ended toolset for researchers and planners interested in integrating DWPT into urban transportation systems, supporting informed decision-making rather than prescribing a fixed solution.

Keywords:

Dynamic Wireless Power Transfer; Electric Vehicles; Wireless Charging; CARLA Simulator; Salt Lake City

Mentor(s):

Brandon Chase Myke Allen (Engineering)

Presentation Available July 27 - August 1

Machine Learning-Based Prediction of Power and Efficiency in Dynamic Wireless Power Transfer for Electric Vehicles

Authors(s): Seyedarshia Shamszadeh†

Abstract:

With the increasing demand for owning electric vehicles(EVs), predicting efficient charging solutions are crucial for long-distance travel, especially for autonomous driving. This study focused on estimating Power and Efficiency in a Dynamic Wireless Power Transfer (DWPT) system for electric vehicles using a machine learning approach. This study recognized variations in lateral offset and relative yaw angle could cause significant changes in mutual inductance, directly affecting power transfer efficiency. Thus, a series of parametric simulations were performed in ANSYS Maxwell to generate a dataset of mutual inductance based on various lateral offsets and relative yaw angles. The results were then imported in PLECS to simulate the power transfer. Then an Artificial Neural Network (ANN) model was trained to predict power and efficiency based on alignment variables. The machine learning model enables fast and accurate estimation of Power and Efficiency without the need for repeating simulations which is suitable for prediction of load profile for large scale DWPT. Finally, a real-world simulation between Salt Lake City and Logan was provided to test the accuracy of the machine learning model.

Keywords:

Load Profile Prediction; Machine Learning; Dynamic Wireless Power Transfer (DWPT); Power Transfer Efficiency; Autonomous Driving

Mentor(s):

Brandon Chase Myke Allen (Engineering); Chiara Cervini (Engineering)

Presentation Available July 27 - August 1

Crop Yield Prediction at Multiple Spatial Scales with Statistical Machine Learning

STEM

Authors(s):

Vaibhav Charan† (Science)

Abstract:

Understanding and accurately predicting crop yield is becoming increasingly important today in the face of global food security challenges, and thus, the availability of standardized data and scalable models is the need of the hour. To support this, researchers have developed CY-Bench (Crop Yield Benchmark), a comprehensive dataset that helps forecast maize and wheat yields on a global scale. This research project primarily involved working with the CY-Bench dataset aiming to improve crop yield prediction through machine learning. Initially, papers explaining the CY-Bench dataset and other papers for agriculture modeling were studied and analyzed in detail. The research then progressed to reproducing the benchmark results, showcasing the accessibility of the dataset. Building on this foundation, the research then progressed to developing new models such as regression trees and incorporating new derived features such as Leaf Area Index and Evapotranspiration in existing models. To streamline development, a subset focusing on Indiana was isolated from the broader US dataset. The results showed a significant reduction in the Indiana MAPE values compared to the US data. These initial outcomes are very promising, and there remains scope for further improvement. Including new features and experimenting with advanced models could potentially help improve the accuracy of the predictions.

Keywords:

Crop Yield Prediction; Machine Learning; Feature Engineering; CY-Bench Data

Mentor(s):

Pratishtha Poudel (Agriculture); James V Krogmeier (Engineering)

Presentation Available July 27 - August 1

Turning the Tables with Tech: Scambaiting Tools and Their Applications

STEM

Authors(s):

Doetri Ghosh† (Polytechnic)

Abstract:

Online financial scams have become increasingly complex, utilizing fake social media accounts, remote access tools, deepfake recordings, and other advanced scamming tactics. In response, a growing community of scambaiters have matched this technological sophistication, in their efforts to disrupt the scam ecosystem. Various tools are used throughout scambaiting sessions, where proper use of technology is essential for success. Limited research exists on the changing needs and tools involved in scambaiting. This study bridges this gap by conducting qualitative analyses of 250 posts from the Reddit group r/Scambait. We explore various aspects of technology use, specifically looking into recommendations and requests circulating in the scambait community.

Keywords:

Online Financial Fraud; Online Scams; Scambaiting

Mentor(s):

Tatiana Ringenberg (Polytechnic)

Presentation Available July 27 - August 1

Foraging Behavior and Social Influence in Dynamic Traffic Social Science

Authors(s):
Malhar Sushil Jadhav† (Science)

Abstract:

The task involves creating a simulation to study the dynamics of social influence within a real-time, multi-user virtual environment. Each player must forage for limited resources, such as charging stations, and utilize their limited tools, such as energy and money balance effectively in this environment. The main objective is to explore how factors such as pricing, user budgets, and competition for resources influence decision-making and social behavior. The project involves two main parts: the server and client side. The client side controls the interface and parameters for the environment, whilst the server side handles client-server communication, the game state, and recording data using MySQL and a JSON configuration file. An overview of the features and their code is provided in the progress report.

By combining real-time communication between server and clients, interactive dashboards for adjusting parameters, and persistent storage of user interactions to compete for limited resources, this project represents a fusion of behavioral science and web development.

Keywords:

[no keywords provided]

Mentor(s):

Torsten Reimer (Liberal Arts)

Other Acknowledgement(s):

Thomas Eagan Gorman (Liberal Arts); Yesid Fajardo Galvis (Liberal Arts); Juan Pablo Loaiza Ramirez (Liberal Arts); Satish V Ukkusuri (Engineering)

Presentation Available July 27 - August 1

Electronic and Thermal Properties of Cs2Ti1-XZrXl6 Vacancy-Ordered Double Perovskites

STEM

Authors(s): Samuel A Azzarello†

Abstract:

Lead-free perovskites have recently attracted significant attention due to their potential for optoelectronic applications. In this study, we investigate the structural, mechanical, thermodynamic, electronic, and optical properties of the vacancy-ordered double perovskites Cs2Ti1-XZrXI6 (X = 0, 0.25, 0.5, 0.75, 1) using first-principles calculations. Density Functional Theory (DFT) was employed with various functionals (PBE, SCAN, HSE), both with and without spin-orbit coupling (SOC). Our results indicate that all compositions are mechanically and thermodynamically stable. All Cs2Ti1-XZrXI6 compounds exhibit direct band gaps, and alloying with Zr increases the effective masses of charge carriers compared to the pure Cs2Til6 or Cs2Zrl6. Electrical and thermal transport properties were evaluated using the Boltzmann transport equation via the BoltzTraP2 code, revealing promising thermoelectric performance. Optical analysis shows strong and broad absorption in the visible range. These findings suggest that Cs2Ti1-XZrXI6 materials are promising candidates for optoelectronic and thermoelectric applications.

Keywords:

Optoelectronic; Thermoelectric; Vacancy-Ordered Double Perovskites; Lead-Free Perovskites; First-Principles Calculations

Mentor(s):

Mengen Wang (University of North Carolina at Chapel Hill)

Presentation Available July 27 - August 1

Radiation Shielding Materials for Modular Power Systems STEM

Authors(s):

Alessandra Nicole Contreras†; Trinity M Aguilar†

Abstract:

Modular power systems intended for radiation-intense environments such as geosynchronous orbit must withstand total ionizing doses (TID) up to 300 krad without mechanical or electronic failure. Traditional aluminum shielding adds mass and may generate secondary Bremsstrahlung x-rays when struck by high-energy charged particles, increasing the internal radiation dose on electronics. To protect against these effects, three low-Z polymer materials (polypropylene (PP), polyethylene (PE), and Bakelite (BK)) were identified as candidates for outer shielding layers. Preliminary tests included degradation and radiation exposure experiments in which Nexperia Gallium Nitride (GaN) field-effect transistors (FETs) were subjected to 300, 1000, and 3000 krad of gamma radiation using a Co-60 source. Post-irradiation measurements showed considerable threshold voltage shifts and moderate increases in leakage current at higher doses.

Thermogravimetric analysis (TGA) was performed at 90 °C and 150 °C under inert nitrogen flow to evaluate relative off-gassing behavior of PP, PE, and BK, with results indicating minimal mass loss in PE and PP (<0.2%) and significant mass loss in BK (>4%). Additional beta irradiation tests at 20 kGy were performed to evaluate polymer shielding durability and dose attenuation, using a linear accelerator (LINAC) as a monoenergetic 6 MeV electron source. Post-irradiation microscopy revealed dielectric breakdown in PP and discoloration in all polymers. Dosimetry measurements showed that BK was most effective per unit thickness at shielding the dosimeter from the electron stream. In conclusion, if off-gassing can be mitigated by pre-baking, Bakelite represents the most promising candidate for polymeric shielding against charged-particle radiation flux in modular power systems.

Keywords:

Radiation Hardening; Power Modular System; Thermogravimetric Analysis; Gamma Irradiation; Beta Irradiation

Mentor(s):

Patrick McCluskey (University of Maryland); Dane Miller (University of Maryland)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Other Acknowledgement(s):
Clifton Buxbaum (University of Maryland)

Presentation Available July 27 - August 1

Optimizing Packaging Techniques for GaN FET, EPC7014, in Space Environments

STEM

Authors(s): Susan Huang†

Abstract:

As wide bandgap (WBG) semiconductors, such as gallium nitride (GaN), gain more prominence in aerospace applications, the packaging needs of advanced semiconductors must evolve to meet extreme performance demands. These electronic components offer significant advantages, such as high power efficiency, thermal conductivity, and switching speeds, but their small form factor, mechanical fragility, and sensitivity to thermal and electrical stress pose major challenges for packaging and for heterogeneous integration in space environments. The EPC7014 GaN field-effect transistor (FET) is a compact, high-performance device well-suited for power conversion and control in spacecraft systems. Despite its benefits, the lack of optimized packaging solutions limits its operational lifetime. This research aims to design, prototype, and test a packaging scheme based around the GaN die's dimensions, material interfaces, and performance characteristics, in order to enhance the survivability of GaN-based electronics in orbital atmospheres. Building upon insights from power device assembly literature, a custom layout will be created and rigorously tested for structural capabilities under simulated thermal cycling, charge dissipation, and reliability conditions. Key design variables include solder material selection, heat sink interface design, and conformal coating strategies. By combining theoretical knowledge, experimental configurations, and testing, the effectiveness of the packaging is comprehensively assessed. The goal is to improve device durability by enhancing material selection and mechanical design for future miniaturized power systems and to support the broader adoption of GaN technologies in emerging space-qualified hardware. This work will support future radiation testing aimed at evaluating the practicality of the design considerations.

Keywords:

Heterogeneous Integration; Wide Bandgap Semiconductors; Power Device; GaN Packaging; HI/AP

Mentor(s):

Enxia Zhang (University of Central Florida)

† Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Available July 27 - August 1

Modeling the Impact of Terrestrial Radiation on Quantum Bits Using the G4CMP Toolkit

STEM

Authors(s): Solomon R Jackson†

Abstract:

Quantum computing has the potential to transform technology, but one of the biggest challenges it faces is the sensitivity of quantum bits, or qubits, to external interference. Radiation from the environment, like muons and neutrons, can pass through the materials that hold qubits and cause errors. These particles might not even hit the qubit directly, but they can still deposit energy that travels through the material and disrupts quantum information.

My project focuses on simulating these types of radiation events using a tool called G4CMP, which is an extension of the Geant4 physics engine. It enables me to model how particles move through cryogenic materials, such as silicon and germanium, and how they generate phonons, which are vibrations that propagate through the material and can impact nearby qubits. So far, I have set up test cases to simulate muons hitting a germanium substrate and observed how that energy spreads out from the point of impact.

Even at this early stage, the results indicate that radiation can have an effect far from its point of entry into the system, which is a significant concern for scaling up quantum devices. As the project progresses, I'll examine other types of radiation and expand the tests to various materials. The goal is to better understand how these effects occur, so that future hardware designs can be more resistant to them. This type of modeling could play a crucial role in making quantum systems more reliable.

Keywords:

Quantum Computing; Radiation Effects; G4CMP; Phonon Propagation; Qubit Decoherence

Mentor(s):

Donald Reising (University of Tennessee Chattanooga)

Presentation Available July 27 - August 1

Design and Fabrication of a Basic Printed Circuit Board (PCB) for Educational Applications

STEM

Authors(s):

Shayan Hasib Jafri† (Engineering)

Abstract:

This project focuses on design, simulation, and fabrication of a simple Printed Circuit Board (PCB) to serve as a tool for education for beginners in electronics. PCBs are a fundamental component in modern electronic devices, and understanding their design process is crucial for aspiring engineers. Using CAD software such as KiCad, we developed a schematic for a basic circuit . The design was then converted into a PCB layout, ensuring proper trace routing and component placement. A prototype is fabricated using a milling machine and chemical etching techniques, followed by soldering components onto the board. The final product is tested for functionality. This project provides a hands-on introduction to PCB manufacturing, emphasizing design considerations, material selection, and fabrication challenges. The results highlight the importance of precision in circuit design and serve as a foundation for more complex PCB projects. Future work may include integrating additional components, such as sensors or microcontrollers, to expand the board's functionality.

Keywords:

Printed Circuit Board; PCB; Circuit Design; KiCAD; Electronic Education

Mentor(s):

Mark Johnson (Engineering)

Presentation Available July 27 - August 1

DIGITALIZATION OF STARS FOR WIDESPREAD USE STEM

Authors(s):

Pierce Yungjoon Johnson† (Engineering)

Abstract:

Purdue University's Summer Training on Awareness and Readiness for Semiconductors (STARS) program is a nationally acclaimed microelectronics workforce development initiative. Over its three-year lifespan, STARS provided over 100 students - primarily rising sophomores - with an accelerated education of the chip design process by immersing them in rigorous and open-ended design projects. While the value that STARS provides to its alumni is significant, our goal for it is to reach a wider and more diverse audience of undergraduates, such as students belonging to institutions that lack Purdue's extensive resources. Our proposed solution is to digitalize STARS curriculum and content such that they can be freely shared and used by other microelectronics educators via the popular simulation repository, nanoHUB. While STARS curriculum and content is now formally hosted on nanoHUB as of this year, its adoption by other educators may still be inhibited by lack of resources. Therefore, we conducted a literature review of approximately 40 hours to identify microelectronics education programs being offered by other undergraduate institutions that are similar in scope or scale of STARS. By comparing key features of STARS and similar programs from this literature review, we will be able to make informed refinement to the digitalized content on nanoHUB to facilitate its reception. With the insights gathered, we progress our goal of enhancing both the scalability and quality of STARS to better promote educational pathways towards a career in microelectronics.

Keywords:

NanoHUB; Semiconductors; Stars; Microelectronics Education; Chip Design

Mentor(s):

Ben Arie Tanay (Engineering)

Other Acknowledgement(s):

Kerrie Douglas (Engineering); Mark Johnson (Engineering)

Presentation Available July 27 - August 1

Measuring and comparing signal feature variation under degrading Temperature versus radiation conditions

Authors(s): Colin J Keeter†

Abstract:

Radio frequency (RF) devices are frequently exposed to harsh environmental conditions, including temperature extremes and ionizing radiation. This study investigates whether signal feature variations caused by temperature changes exhibit similar patterns to those induced by radiation exposure. Specifically, we analyze how signal characteristics—such as carrier frequency offset (CFO), signal-to-noise ratio (SNR), and other relevant metrics—respond to increasing temperature and compare these trends to previously collected total ionizing dose (TID) radiation data. Using data from four emitters subjected to controlled thermal testing and corresponding radiation tests, signal features were extracted from 802.11a waveforms and analyzed through statistical metrics including mean, skewness, and kurtosis. Our findings suggest potential similarities in the behavioral trends of CFO under both thermal and radiation stress, which could have implications for cost-efficient testing protocols. This research contributes to understanding whether temperature testing can serve as a proxy for certain aspects of radiation testing, potentially reducing the need for expensive and time-intensive TID experiments.

Keywords:

Specific Emitter Identification (SEI); Radio Frequency (RF); Carrier Frequency Offset (CFO); Signal-to-Noise Ratio (SNR); Software Defined Ratio (SDR)

Mentor(s):

Donald Reising (University of Tennessee Chattanooga)

Other Acknowledgement(s):

Rolando Baltazar (Indiana University); Hope Hunnicutt (Indiana University)

Presentation Available July 27 - August 1

CATHODE SELECTION FOR HIGH-PERFORMANCE, ECONOMICALLY VIABLE SODIUM-ION BATTERY SYSTEMS STEM

Authors(s): Claudia Trevino†

Abstract:

Lithium-ion systems (Li-ion) dominate the current battery market, but present high material costs, limited recyclability, and toxicity concerns associated with lithium extraction and disposal. Sodium-ion batteries offer a promising alternative due to sodium's natural abundance and lower cost, but they typically suffer from lower energy efficiency and shorter cycle life. Improving the sodium-ion battery performance depends in part on selecting and optimizing cathode materials for capacity, structural integrity, and cycling stability. This study investigated the effect of titanium (Ti) doping on the performance of a sodium-ion cathode. Na?.??Mn?.?TixO? (x=0.5 and 0.10). This cathode was synthesized by mixing stoichiometric Na?CO?, Mn?O?, and TiO? ratios, followed by calcination. The resulting powders were made into slurries, cast onto aluminum foil, and dried at 120?°C to form electrodes. Sodium half-cells were assembled with these cathodes and cycled under constant current to evaluate capacity and cycle stability. Results show that 5% and 10% Ti dropping did not significantly improve the electrochemical performance. While Ti was hypothesized to enhance structural stability, these levels proved ineffective in reducing degradation during cycling. These findings suggest that low-level Ti doping may not be beneficial for sodium-ion cathode optimization. Further research into lower Ti levels is needed to develop sustainable, high-performance sodium-ion batteries capable of competing with Li-ion systems.

Keywords:

Sodium-Ion; Battery Efficiency; Titanium Doping; Cathode; Battery

Mentor(s):

Meng Zhou (New Mexico State University)

Presentation Available July 27 - August 1

Microfluidic Analysis of Nanoparticle Binding in the Subarachnoid Space

STEM

Authors(s):

Laine Chapman† (Engineering)

Abstract:

Intrathecal injection of nanoparticle-based therapeutics involves the administration of encapsulated substances into the cerebrospinal fluid (CSF) contained within the subarachnoid space surrounding the spinal cord. This method of drug delivery enables a higher concentration of therapeutic agent to be delivered within the central nervous system while minimizing off-target exposure and toxicity. While these findings are promising, recent biodistribution studies indicate that most nanocarriers remain confined to the leptomeninges after intrathecal injection and fail to reach deeper neural tissues, suggesting the presence of molecular transport barriers within the tissues lining the subarachnoid space. Recent studies have also indicated that nanoparticle interactions with extracellular matrix proteins (ECM) can negatively impact their transport in a tissue-specific manner. However, 1) the specific ECM proteins involved in nanoparticle-ECM interactions after intrathecal injection and 2) the impact of these binding interactions on nanoparticle transport are poorly understood. The chosen research approach aided in building and refining a microfluidic model of the subarachnoid space to study how the ECM of surrounding tissues affects nanoparticle transport and retention. We tested new microfluidic design features under inverted flow conditions and identified nanoparticle binding partners in the ECM using proteomics. Altogether, these in vitro intrathecal delivery models can be used to investigate the impact of nanoparticle-ECM binding interactions on bulk transport in CSF.

Keywords:

Intrathecal; Injection; Nanoparticles; CSF

Mentor(s):

Evelyn Marie Nonamaker (Engineering); Luis Solorio (Engineering)

Other Acknowledgement(s):

Emily R Jakob (HHS)

Presentation Available July 27 - August 1

Musicians Posture Evaluation STEM

Authors(s):

Joseph Issac Getachew† (Science); Ziang Wang* (Science); Michael X Zhang* (Engineering); Benjamin Joseph Taylor* (Engineering|JMHC); Michael Alexander Ikriannikov* (Science)

Abstract:

This research project involves developing a comprehensive mobile app that's aimed at evaluating and classifying a musicians performance. This is done using computer vision and machine learning techniques. Our app addresses the need for real-time posture evaluation in order to prevent long term effects on the body, as well as improving a musicians performance. In our research team, we are divided up into different groups like hands, bow, and UI. This is all under the evaluator category, but specifically the hands team using methods like advanced machine learning models to identify various postures. My contributions to this project have been implementing a shoulder classification function that accurates identifies shoulder levelness. I have also made attempts at reducing noise for all our classifiation models using a sliding window technique, and have contributed to the low elbow identification. The shoulder classification looks at pose estimation data to see its elevation and alignment patterns to then identify shoulder levelness. These classification functions are an integral part of the research project as they allow for immediate feedback on a musicians posture. This will enable correction for bad posture improving health and performance. Our research is contributing to the field of technology-assisted musical training and injury prevention.

Keywords:

[no keywords provided]

Mentor(s):

Yung-Hsiang Lu (Engineering)

Presentation Available July 27 - August 1

Design of an AES Hardware Accelerator in Chisel for Secure SoC Applications

STEM

Authors(s):

Kameron Lee Jackson† (Engineering); Jai Anand Keskar‡ (Engineering); Seongjoong Yim‡ (Engineering)

Abstract:

This research project explores the design of a hardware-accelerated Advanced Encryption Standard (AES) module for secure data processing within a system-on-chip (SoC). The work is part of the Digital Design subteam in Purdue's System-on-Chip Extension Technologies (SoCET) undergraduate research group. The goal is to implement a modular, synthesizable AES encryption unit in Chisel, a hardware construction language embedded in Scala. The design will be integrated into a larger open-source SoC using the FuseSoC build system and verified through simulation and testbench development. The research emphasizes the trade-offs between performance, area, and modularity in hardware cryptographic designs and aims to provide a flexible and reusable core for embedded security applications. This work represents a foundational step in learning real-world ASIC development flows and contributes to Purdue's efforts in undergraduate hardware research and education.

Keywords:

[no keywords provided]

Mentor(s):

Cole Aaron Nelson (Engineering)

Presentation Available July 27 - August 1

Developing a Robotic Drumming System Using BaxterSTEM

Authors(s):

Saadhana Kallampalli Illam† (Science); Bidit Acharyya‡ (Science); Sahil Zahid Shaikh‡ (Science|Graduate); Julie Zalautdinov‡; Yash Sunil Burange‡ (Engineering); Prajitchandar Sathischandar‡ (Science)

Abstract:

This work focuses on the application of robotics within musical expression through the creation of a drumming system using the Baxter robot. The robot will be trained using reinforcement learning to map music in the MIDI (Musical Instrument Digital Interface) format to coordinated drumming actions. The robot will be able to accompany musicians in real-time through precise trajectory planning and synchronization. Ultimately, the aim is to organize a concert with the robot as an accompanying performer, showcasing the creative potential of robotics within the musical field.

Keywords:

Robotics; Baxter Robot; MIDI (Musical Instrument Digital Interface); Trajectory Planning; Motion Control

Mentor(s):

Yung-Hsiang Lu (Engineering); Yeon Ji Yun (Liberal Arts)

Presentation Available July 27 - August 1

Tapeout Preparation and Performance Configuration for a RISC-V System-on-Chip

STEM

Authors(s):

Katelyn Krishan Shah† (Engineering); Minghan Wang† (Engineering); Asavari Deshmukh† (Engineering)

Abstract:

SoCET's research project aims to extend, optimize, and prepare a general-purpose system-on-chip (SoC) for fabrication and testing. The primary objective of the upcoming AFTx08 tapeout is to improve upon the performance and integration metrics of the AFTx07 chip, through improved multi-core CPU functionality, new peripheral extensions, and architectural refinements. As part of the tapeout configuration and testing team, our focus is on integrating key modules, such as the branch predictor developed in Spring 2025, and connecting peripherals on the chip and FPGA levels. Our team is exploring architectural tradeoffs from adjusting cache sizes and interconnect configurations for performance. We are also evaluating simulation data to determine optimal configuration parameters and are preparing benchmark datasets for CPU and memory latency characterization. Currently, the design is in the presilicon integration phase, and subsystems are being validated. Tapeout for AFTx08 is scheduled for Fall 2025, where the chip will make progress to fabrication and post-silicon testing.

Keywords:

System-on-Chip; Tapeout; Performance Optimization; RISC-V; SoCET

Mentor(s):

Mark Johnson (Engineering); Cole Aaron Nelson (Engineering)

Presentation Available July 27 - August 1

An Overview of System-On-Chip Design Flow STEM

Authors(s):

Blake Alexander Andrews† (Engineering)

Abstract:

This presentation will detail steps pertinent to the System-on-Chip design flow process. The flow process begins with hardware description code (SystemVerilog), then proceeds by synthesizing a digital circuit schematic from this code. After the digital circuit, a chip layout will be performed, where the physical placement of hardware is described for the entirety of the chip. Finally, the functionality of the chip is tested during the verification step, after which the chip is ready for manufacturing. Each step will be described for a general flow, discussing the impact of these steps on the flow process as a whole. Optimizations and design considerations will be included at each step. EDA tools (Cadence) will be discussed to show their usefulness in synthesizing and simulating complex chip designs much quicker than humans can manually.

Keywords:

[no keywords provided]

Mentor(s):

Mark Johnson (Engineering); Isaac P Hagedorn (Engineering)

Presentation Available July 27 - August 1

Supercritical Carbon Dioxide Thermal Cycle Design and Fabrication

STEM

Authors(s):

Peter Joseph Bradshaw† (Engineering|JMHC); Ella Renee Moss‡ (Engineering); Emma Loretta Hansen‡ (Engineering|JMHC); Arnav Basu‡ (Engineering); Adiba Alamgir Mrittika‡ (Engineering)

Abstract:

Despite high potential for efficiency, supercritical thermal cycles often fall short due to underutilized energy recovery methods, primarily because of the challenges in operating turbines with two-phase outlets. Testing of new turbine prototypes often requires intentional design of thermal systems to create high pressure drops and large flowrates. This twosemester research experience aimed at designing and constructing a test stand to host an experimental two-phase outlet Tesla turbine. The design of the thermal cycle was intended to improve upon a previous setup by increasing the pressure drop over the turbine as well as enabling the exposure of the turbine to two phase CO2 flow. Calculations in Engineering Equation Solver (EES) were used to model the thermodynamic requirements of the system in order to reach two phase flow at the turbine inlet. The evaporator, condenser, and all secondary components were then chosen to accommodate the pressures and temperatures of the thermodynamic cycle. In the second semester of this experience came the design of structural supports and the assembly of the system using high pressure fixtures and stainless-steel tubing. At the conclusion of my contribution to the project, construction was underway with most of the primary components connected. At this point the project changed hands and is now undergoing calibration and final assembly.

Keywords:

Carbon Dioxide; Thermal Cycle; Test Stand; Supercritical

Mentor(s):

Eckhard A Groll (Engineering); Helber Antonio Esquivel Puentes (Engineering); Devahdhanush Vijayaraju Swathibanu (Engineering)

Other Acknowledgement(s):

Steven Montoya Grajales (Engineering); Xin Ding (Engineering); Mridul Rathi (Engineering)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Available July 27 - August 1

A population viability analysis (PVA) approach to examine the efficiency of conservation strategies in the critically endangered Lehmann

STEM

Authors(s):

Abby Marie Hagan† (Science); Adriana A. Bustos Torres‡ (Arizona State University)

Abstract:

Over the last five decades, wildlife populations decreased by an estimated 73%. Overharvest was the second most significant driver of this decline, which includes the illegal extraction for the pet trade. Poison dart frogs are more abundant in the global pet market than other anurans due to their attractive colors. Many of these species, including Lehmann's poison dart frog (Oophaga lehmanni), have been subject to illegal extraction from the wild into the global pet trade. While these anuran population declines have been attributed to the illicit pet trade. few studies have addressed this problem. Oophaga lehmanni is a critically endangered species found in western Colombia. Here, we aim to predict the future of O. lehmanni by performing a population viability analysis using Vortex10. Based on current knowledge of the life history and demographic traits of this species, we will simulate a baseline scenario that represents the current probability of extinction of protected and unprotected populations. To evaluate the impact of ex-situ supplementation on the probability of extinction, we will simulate various supplementation regimes and contrast those results with current ex-situ conservation efforts by the Zoológico de Cali. We will concurrently simulate these scenarios with low, intermediate, and high yearly harvest rates to account for uncertainty in this parameter and assess its impact on the unprotected populations. This analysis will not only inform future conservation strategies for O. lehmanni but also underscores the need to address the specific challenges that both protected and unprotected populations face.

Keywords:

Illegal Extraction; Oophaga lehmanni; Population Viability Analysis (PVA); Supplementation; Conservation

Mentor(s):

Ana Maria Ospina Larrea (Science); Ximena Bernal (Science)

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Available July 27 - August 1

Inspiring research in Advanced High School Populations: Using the Lean Canvas Approach

Business Case Study

Authors(s):

Mallory Hersh† (Germantown Academy)

Abstract:

Evaluating the feasibility of a startup business presents a valuable opportunity to cultivate a research mindset and develop crucial research skills in pre-college students. The purpose of this research explores the Lean Canvas Business Model (LCBM) as a potent educational methodology to achieve this dual purpose. The LCBM provides a structured analytical framework encompassing nine key components of a business's building blocks: (1) the problem, (2) the solution, (3) key metrics. (4) unique value proposition, (5) the unfair advantage, (6) the cost structure, (7) the revenue streams, (8) the channels to customers, and (9) the customer segments. To simultaneously demonstrate the efficacy of the LCBM as an educational vehicle and inspire research engagement, our high school student developed a hypothetical case study: Retro Roast, a coffee shop concept addressing the challenge of uninspiring, generalized coffee establishments. Through the systematic application of the LCBM's analytical steps to Retro Roast, this project not only illustrates how the framework can be used to evaluate the potential risks and viability of a new venture but also highlights its effectiveness in teaching fundamental research processes and fostering a pre-college interest in conducting rigorous inquiry.

Keywords:

Lean Canvas; Research Mindset of HS Students; Analytic Methodology; Research Approaches

Mentor(s):

Sandra B Sydnor (HHS)

Presentation Available July 27 - August 1

Spin the Wheel: The Random Guesser Test for Al Sequential Decision-Making Systems

STEM

Autho	ors(s)	:
Shun	lde†	

Abstract:

This work proposes a general approach to quantitatively assessing the risk and vulnerability of artificial intelligence (AI) systems to biased decisions. The guiding principle of the proposed approach is that any Al algorithm must outperform a random guesser. This may appear trivial, but empirical results from a simplistic sequential decision-making scenario involving roulette games show that sophisticated Al-based approaches often underperform the random guesser by a significant margin. This work highlights that the algorithms utilized in a modern recommender system may exhibit a similar tendency to favor overly lowrisk options. These results may help to fill the lack of AI misalignment studies in sequential decision-making systems, as well as providing an important precedence for using random-influenced data to address the robustness of AI. It is proposed that this "random guesser test" can serve as a useful tool for evaluating the utility of Al actions, and also points towards increasing exploration as a potential improvement to such systems.

Keywords:

Al Misalignment; Recommender Systems; Thompson Sampling

Mentor(s):

Allison Blunt (Harrison Central School District)

Other Acknowledgement(s):

Djallel Bouneffouf

Presentation Available July 27 - August 1

Sales Forecasting Automation: the case of Girl Scouts of Central Indiana

Business Case Study

Authors(s):

Parth Kapila† (Polytechnic)

Abstract:

The Girl Scouts of Central Indiana relied on static, historical averages for forecasting, resulting in significant demand mismatches and revenue loss. This project replaces that outdated approach with a fully automated machine learning pipeline that transforms the forecasting process into a real-time, data-driven process. To address these challenges, the team implemented a two-phase approach: (1) Automation & Infrastructure Integration and (2) Optimization & Performance Enhancement. In the first phase, the team connected troop-uploaded sales data from Google Drive to a hybrid ML model built in Scikit-learn (Python), set up automated preprocessing, stored predictions in a PostgreSQL database, and deployed a web dashboard on Render to give troop leaders real-time access to forecast results. In the second phase, the focus will shift to improving model accuracy by tuning hyperparameters, experimenting with different algorithms, and refining the training process. The goal is to reach 90% accuracy, up from the current R2 score of 0.877. Key outcomes demonstrated significant improvements in operational efficiency, model accuracy, and usability. The system is projected to save over \$1.08 million in surplus reduction, equal to eliminating 1.35 excess cases per troop-cookie combination. This initiative offers a scalable blueprint for mission-driven organizations aiming to reduce waste, enhance forecasting accuracy, and enhance decision-making through responsible prediction and automation.

Keywords:

Automation; Machine Learning; SQL; Forecasting; Python

Mentor(s):

Davi Cordeiro Moreira (DSB)

Other Acknowledgement(s): Ramya Chowdary Polineni (DSB)

Presentation Available July 27 - August 1

Financial Company Client Segmentation Using Agentic Behavioral Features

Business Case Study

Authors(s): Shreyaa Karan† (DSB)

Abstract:

Financial institutions often struggle to personalize offerings to their diverse client base. They should move beyond demographic segmentation and towards using behavioral personas based on decision styles, since traditional methods fall short of capturing evolving customer behaviors. By understanding client decision-making goals and autonomy levels, banks can offer Al-personalized financial journeys, increasing engagement and upsell. This project explores how agentic behavioral traits, characteristics reflecting intentional, and goal-directed financial activity, can provide a more dynamic and insightful basis for client segmentation.

Using over one million real-world bank transactions, we engineer agentic features such as transaction consistency, frequency, time-of-day usage, etc.. These features were used to cluster clients through unsupervised learning in JMP Pro, comparing k-means and Self-Organizing Map (SOM) algorithms. The resulting clusters revealed distinct financial personas (consistent planners, impulsive transactors, etc.) that aligned with varying levels of agentic behavior.

Model evaluation included cross-validation, silhouette analysis, and interpretability of clusters. Business implications included tailoring digital journeys, recommending budgeting advisors based on behavioral archetypes, and enhancing loyalty through personalized cross-sell strategies.

K-means clustering outperformed SOMs in silhouette score (0.67 vs. 0.49), cluster separation, and real-world interpretability. It produced five actionable personas validated through multivariate analysis. This approach is valuable for banking analysts seeking to personalize user experiences based on intent rather than identity. The clarity of the segments supported stakeholder decision-making and was benchmarked to industry results, estimating a 12-18% increase in product cross-sell success. Future enhancements include applying semi-supervised

learning or time-evolving cluster analysis to anticipate customer lifecycle transitions.

Keywords:

Predictive Modeling; Unsupervised Learning; Behavioral Segmentation; Agentic Features; Cluster Analysis

Mentor(s):

Matthew Lanham (DSB)

Presentation Available July 27 - August 1

Targeted Analysis of Lysosomal Membrane Proteins LAMTOR1 and LAMTOR2 by Immunoprecipitation STEM

Authors(s):

Maria Margineantu† (Science|JMHC)

Abstract:

Lysosomal membrane proteins are critical for various cellular signaling processes and digestion. The Ragulator complex, which includes LAMTOR1 and LAMTOR2 proteins, is essential for mTORC1 activation. This pathway is involved in cell growth and cell metabolism. Post-translational modifications (PTMs) of such proteins may have a significant influence for assembly of the complex and their function. Isolating and examining the LAMTOR1 and LAMTOR2 subunits can lead towards better understanding of their roles in signaling and PTMs. Immunoprecipitation using antibodies specific to both LAMTOR1 and LAMTOR2 were performed using cultured mammalian cells. Western blot analysis then confirmed successful enrichment of both the LAMTOR proteins. These findings support further investigation on how PTMs can regulate lysosomal signaling and may provide insights on their roles in disease related functions.

Keywords:

[no keywords provided]

Mentor(s):

Bryon Shane Drown (Science); Isabella Grace Feltenstein (Science)

Presentation Available July 27 - August 1

Hybrid Parameter Estimation of PMSMs Using Neural Learning and First-Principles Modeling

STEM

Authors(s): Suhani Mathur† (Engineering)

Abstract:

Permanent Magnet Synchronous Motors (PMSMs) are central to modern electrification systems, powering electric vehicles, industrial automation, robotics, and aerospace applications. Their widespread use is driven by their high efficiency, torque density, and precise controllability. This research investigates a hybrid approach that combines physics-based modeling with adaptive neural learning to estimate four key parameters: stator resistance, d- and q-axis inductances and permanent magnet flux linkage. The estimation is implemented within a high-fidelity simulation framework built in MATLAB/Simulink, which emulates real-world motor dynamics under field-oriented control (FOC) using a behaviorally accurate model representative of a digital twin. Leveraging this environment, an Adaline neural network is trained using tapped voltage, current, and rotor speed signals to learn parameter relationships through real-time linear regression. Initial results show that estimator performance is highly sensitive to the operating regime: clean, steadystate intervals enable convergence toward reference values, while transient conditions introduce signal noise and reduce reliability. These early insights highlight the importance of data segmentation, physical modeling, and estimator interpretability in data-driven motor control. While still in progress, this work establishes a foundation for scalable parameter identification that avoids the need for intrusive signal injection or offline calibration. Future development will explore nonlinear models, incorporate thermal and mechanical dynamics, and extend toward a full digital twin architecture capable of real-time estimation and diagnostics. Ultimately, this research supports the development of smarter, selfmonitoring electric drive systems with applications in electric vehicles, robotics, and industrial automation.

Keywords:

Computer Engineering; Neural Networks; Digital Twin; Motor Control

Mentor(s):

Sasikiran v

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Presentation Available July 27 - August 1

Heart Healthy Team

Social Science

Authors(s):

Stephania Petit Homme†; Olamide Gbemisola†; Joeclee Dora Gbasakollie†; A'Mya Antionette Murray Coleman‡; Shaylen Deven

Patel‡; Yasmin Vargas‡

Abstract:

Heart disease is a leading cause of death in the U.S., with high blood pressure as a major risk factor. In communities like Martindale-Brightwood in Indianapolis, limited access to care contributes to higher hypertension rates and lower life expectancy. To address this, the Purdue University Center for Health Excellence, Quality and Innovation partnered with Gennesaret Free Clinic to launch the Heart Healthy Clinic.

The clinic provides free healthcare to uninsured and under-resourced individuals, supported by a pharmacist and community health worker.

We conducted a descriptive analysis of data collected from clinic patients between February 2023 and May 2025. Our goals were to describe the clinic's population and examine whether blood pressure outcomes varied by age, gender, race, ethnicity, and primary language. Using Microsoft Excel, we summarized demographics and compared blood pressure readings across subgroups.

The study included 85 patients with an average age of 52. Most were male (60%), Black (58%), Hispanic (32%), uninsured (75%), and Spanish-speaking (32%). On average, blood pressure decreased by 6 points. Hispanic patients experienced a 10-point reduction, compared to 2 points among non-Hispanics. Women had higher blood pressure than men, but both groups saw a 6-point decrease. Haitian Creole speakers had the highest average blood pressure and the smallest improvement. Further research is needed to understand why Hispanic patients improved the most and Haitian Creole speakers the least.

Community-based care improves blood pressure outcomes and strengthens local health systems. We recommend expanding access through mobile clinics, screenings, and local partnerships to advance health equity.

Keywords:

[no keywords provided]

[†] Presenting Undergrad Author; ‡ Contributing Undergrad Author; * Undergrad Acknowledgment

Mentor(s):

Omolola A Olatunde (Pharmacy); Kourtney Ayanna Dor Byrd (Pharmacy); Ananya Munjaal (Pharmacy); Temitope Folasade Adeoye Olenloa (JMHC)

Presentation Available July 27 - August 1

An Efficient Algorithm for Fusing Permutation Defects in Multi-layer Anyon Models

STEM

Authors(s):

Tayden Aris White† (Science)

Abstract:

Anyons are point-like, particle-like excitations that can arise in (2+1)dimensional quantum systems called topological phases of matter. Permutation defects are similar point-like objects that can arise when there are multiple layers hosting the same anyons stacked on top of each other. The name "permutation defect" comes from the symmetry that permutes the identical layers of the total system. The interactions of these quasiparticles and defects are important to the emerging field of topological quantum computing. The fusion of permutation defects, in which two defects combine to form new ones, is modeled mathematically by an algebraic structure called a fusion ring. An algorithm for this fusion process has been described by my mentor Dr. Colleen Delaney, centering around the annihilation of so-called transposition defects, which form the building blocks of more general permutation defects in the same way that any permutation of objects can be built up from pairwise exchanges, or transpositions. In this project, I work to understand and explain the time complexity of this algorithm. I will show that this is an efficient method for computing the fusion of permutation defects and implement the algorithm using computer algebra software.

Keywords:

Permutation Defect; Time Complexity; Algorithm; Anyons

Mentor(s):

Colleen Delaney (Science)

Presentation Available July 27 - August 1

Exploring and Predicting ChatGPT Usage in EducationBusiness Case Study

Authors(s): Yutian Ye† (DSB)

Abstract:

ChatGPT is increasingly used in academic settings, but educators often lack insight into student usage. This project analyzes survey responses from 215 university students to understand how and why they use ChatGPT for education. We applied machine learning classification models to predict frequent users and used clustering to reveal distinct usage patterns. Logistic regression achieved the best performance (79% accuracy), highlighting key drivers such as academic year and usage purpose. Insights from this study can guide universities in providing better AI-integrated support and help tailor interventions based on user behavior.

Keywords: [no keywords provided]

Mentor(s): Matthew Lanham (DSB)

Other Acknowledgement(s):

Presentation Available July 27 - August 1

TPU Soft Actuator-Enabled Adaptive Grasping for Aerial Robots

STEM

Authors(s): Ethan Andrew Zhang†

Abstract:

This project explores the development of a drone equipped with four 3D-printed Thermoplastic Polyurethane (TPU) based soft actuators controlled by servos. The primary objective of designing and integrating the soft actuators into a drone is to enable adaptive and precise object retrieval, particularly for applications such as delivering med-kits or transporting irregularly shaped items. The soft actuators ensure a secure yet gentle grip on objects. The drone's design maintains stable flight while carrying payloads. Experimental trials assess the drone-mounted soft robotic gripper's ability to grasp and transport various objects under different conditions.

Keywords:

Soft Actuators; Drone; Robotics; 3D Printing; Adaptive Grasping

Mentor(s):

Lixia Cheng (Liberal Arts)













SUMMER SYMPOSIUM NOTES

SCAN FOR ABSTRACT BOOK

SAVE THESE DATES:

NOVEMBER 18-21, 2025: Fall Undergrad Research Expo APRIL 14-17, 2026: Spring Undergrad Research Conference JULY 30, 2026: Summer Undergrad Research Symposium



