SURF

SUMMER UNDERGRADUATE RESEARCH FELLOWSHIP

PURDUE UNIVERSITY

2018

Proceedings

Research Symposium

August 2, 2018

PURDUE UNIVERSITY

Welcome to the 2018 SURF Undergraduate Research Symposium!

The Summer Undergraduate Research Fellowships (SURF) program was launched in 2003 to meet the ever-increasing research demands of academia and industry. Using a portion of an unrestricted gift from Purdue alumnus Patrick Wang, SURF has sought to provide students with a dedicated laboratory experience to strengthen integrated, hands-on learning through discovery.

The core of the SURF program is to provide students across all engineering, science and technology disciplines with an intensive research component that allows them to work closely with professors and graduate students.

For 11 weeks this summer, 137 SURF students from 19 institutions have participated in an intensive research experience on the Purdue University campus. These students received mentorship and guidance from 145 graduate students and post docs, and 124 professors from 22 Schools/Departments in 4 Colleges at Purdue.

We want to thank the professors, post docs, and graduate students who have mentored SURF students this summer. Your time and commitment have been invaluable.

To the SURF students, we congratulate you on the completion of an intensive research program this summer. We honor you today. You should be proud of your accomplishments. We wish you all the best in the future as you pursue your goals and continue on your journey of discovery.

Melba M. Crawford
Associate Dean of Engineering for Research

SURF Symposium Overview—August 2, 2018

Morning Session

8:15 AM – 8:45 AM	**Student Check-in** ……………….…………….	ARMS Atrium
9:00 AM – 9:20 AM	**Symposium Welcome and Instructions** …..	ARMS 1010
9:30 AM – 10:45 AM	**Oral Presentations (5 talks per room)**	
	Sessions organized around common themes:	
	Nanotechnology and Combustion ..………….	ARMS B071
	Biomedical Engineering………………………..	ARMS 1010
	Medical Science and Engineering …………..	ARMS 1021
	Computer and Web Based Applications ……..	ARMS 1103
	Earth and Space Science …………………….	ARMS 1109
11:00 AM – 12:15 PM	**Poster Presentations**	
	Posters organized around common themes….	ARMS Atrium
12:15 PM – 1:15 PM	**Lunch Break**	

Afternoon Session

1:30 PM – 2:45 PM	**Oral Presentations (5 talks per room)**	
	Sessions organized around common themes:	
	Environment and Sustainability ……………..	ARMS B061
	Materials Science ……..……………………...	ARMS B071
	Health and Education ………………….……	ARMS 1021
	Data Trends and Analysis ……………..……...	ARMS 1103
	Biotechnology and Biomedical Engineering …	ARMS 1109
3:00 PM – 4:15 PM	**Poster Presentations**	
	Posters organized around common themes….	ARMS Atrium

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MORNING ORAL PRESENTATIONS

MO

Nanotechnology and Combustion

ARMS B071, 9:30 AM – 10:45 AM

A Security Approach for the Example Sodium Fast Reactor

Christian Young and Robert Bean
Purdue University

Increases in the spread of nuclear technology and the rise of non-state terrorism in the modern era has proved the need for effective security approaches to new nuclear facilities. Many documents about security approaches for nuclear plants are non-public material, however, making it difficult to teach others about the basics of security design. To alleviate this issue, we used available texts in the security realm to design a security approach for the Generation IV International Forum's Example Sodium Fast Reactor. Our approach utilized infrared, microwave, fiber optic, and other advanced technologies to provide security for the special nuclear material present. While this is not meant to be a final approach for any one facility, it serves as an example for those wanting to learn about how to design security systems for both nuclear and non-nuclear plants.

Presentation ID:
MO-01

Room:
ARMS B071

Keywords:
Nuclear, Security, Non-proliferation, Physical Protection, Material Control

Two-Phase Flow Visualization of Evaporating Liquid Fuels at Atmospheric Pressure

Junchao Ma, Terrence Meyer, Venkatasubramanian Athmanathan, and Alber Douglawi
Purdue University

Two-phase flow visualization of fuel sprays is important for the design of better engines because it determines the efficiency and emissions of the combustion process. Simultaneous two-phase flow imaging using techniques such as planar laser-induced fluorescence (PLIF) has been a challenge due to the large variation in LIF signals from the gas and liquid phases. After laser excitation, the liquid signal initially overwhelms the gas phase signal due to its higher number density. However, the liquid signal quenches dramatically due to quenching effects that dominate the liquid LIF signal. By applying the novel concept of temporal filtering, separation of liquid and vapor signal can be achieved using different time delayed camera systems. The optical measurement provides a non-intrusive means of obtaining the liquid and vapor distributions in a spray. The experiment is performed using an ultraviolet beam from a burst-mode Nd:YAG laser in combination with two intensified cameras that are timed to maximize either the liquid or vapor phase signal. The setup is complemented by a drop generator and vaporizer flow system to allow studies of aviation fuels such as Jet-A or JP10, as well as reciprocating engine fuels such as diesel or toluene (as a surrogate for gasoline).

Presentation ID:
MO-02

Room:
ARMS B071

Keywords:
Planar Laser-Induced Fluorescence, Two-Phase Flow Visualization, Spray, Combustion, Laser Diagnostics

Majorana Spin-Flip transition in the ALPHA magnetic trap

Miguel Alarcon[1], Colin Riggert[2], and Francis Robicheaux[3]
Universidad de Los Andes - Colombia[1], University of Oklahoma Norman Campus[2], and Purdue University[3]

Presentation ID:
MO-03

Room:
ARMS B071

The main purpose of the ALPHA collaboration is to trap antihydrogen atoms so that the Charge Conjugation-Parity Transformation-Time Reversal (CPT) symmetry can be tested. The trapping mechanism consists on an octupole magnet that traps the atoms near the magnetic field minima. Once trapped, due to the Majorana spin-flip effect, atoms can escape by changing the orientation of its spin. The magnetic field generated by the octupole magnet present in the trap has multiple zeroes of different orders. These zeroes could affect the probability of a spin flip, and therefore alter the number of escaped atoms. The main problem tackled by the research is how the different zeroes affect the dynamics of the spins, testing if different mathematical descriptions alter significantly the probability of a flip. The utilized method to do this was by computer simulations. First, we developed a program that solved Schrödinger's equation numerically, with error of quadratic order, for the Hamiltonian of a spin that follows a magnetic field adiabatically. We used this program to simulate the dynamics of the spin in the neighborhood of the magnetic field zeroes using different order approximations for the field. To generate statistical data, we performed a Monte Carlo simulation that generated random directions of approach and impact parameters so that we can construct a cross sections for the spin flip probability. We found that there was no significant difference between the cross section generated by the linear approximation of the field and the third order approximation. Additionally, the decay rates were obtained and the associated lifetimes were big enough so that measurements can be performed in them.

Keywords:
CPT Symmetry, Antihydrogen, Atomic Trapping, Antimatter, Computer Simulation

Femtosecond Laser Electronic Excitation Tagging, FLEET, for Combustion and Flow

Trent Murray, Jordan Fisher, Mikhail Slipchenko, and Terrence Meyer
Purdue University

Presentation ID:
MO-04

Room:
ARMS B071

Femtosecond Laser Electronic Excitation Tagging, known as FLEET, can be used to measure the nitrogen gas content within a gaseous mixture. FLEET does not require any trace particles that could affect the combustion reaction or physical properties of the flow. Another advantage is the simple experimental implementation. In this work a 120-femtosecond laser pulse was focused in to the probe volume to dissociate the nitrogen gas via multiphoton process. The intensity of the light emitted after the recombination is proportional to the nitrogen gas to oxygen mass ratio as the dissociated nitrogen bonds with oxygen to form nitric oxide and other reactions, which does not emit light. Intensity of the light from FLEET within a methane-air diffusion flame was used to determine fuel/air ratio. The intensity of FLEET signal was calibrated for different mixtures in test cell in the ranges of pressures to simulate the change of number density due to increase of the temperature in the flame.

Keywords:
FLEET, LIBS, Spectroscopy, Combustion

Processing and Characterization of Poly(vinyl alcohol) Compatibilized Cellulose Nanocrystals/Ethylene Vinyl Alcohol Copolymer Nanocomposites

Kayli DeCocker, Md Nuruddin, Jeffrey Youngblood, and John Howarter
Purdue University

Presentation ID:
MO-05

Room:
ARMS B071

Ethylene vinyl alcohol (EVOH) copolymer films are commonly used in food packaging due to their excellent oxygen barrier properties and melt processability. A drawback to EVOH is the lower water barrier properties, which could degrade food quality, so EVOH is often combined with other layers of polymers. The addition of cellulose nanocrystals (CNC) has been reported to improve the gas barrier and mechanical properties for other polymers. This study will focus on using CNC to improve the water barrier properties of EVOH. Since CNC is water dispersible, but EVOH is not soluble in water, poly(vinyl alcohol) (PVA) was used as a compatibilizer to improve the mixing of CNC within EVOH. Solution casting was used to mix CNC and PVA together by dissolving both in water, then making a solid film by evaporating the water. Melt processing was used to melt the CNC/PVA film with EVOH and forming the nanocomposite into a thin film. Gas barrier and mechanical properties, such as tensile strength, were examined as a function of weight percent of PVA used in each nanocomposite film. Compatibility between PVA and EVOH was determined by examining the thermal properties using differential scanning calorimetry (DSC) analysis, and degradation behavior was determined using thermogravimetric analysis (TGA). It is expected that the addition of compatibilizer, PVA, will improve these properties by making a more even mixture of CNC within the EVOH polymer matrix.

Keywords:
Cellulose Nanocrystals, EVOH, Compatibility, Nanocomposites

Biomedical Engineering

ARMS 1010, 9:30 AM – 10:45 AM

Non-invasive Diagnostic Measures of Sensorineural Hearing Loss in Chinchillas.

Presentation ID:
MO-06

Room:
ARMS 1010

Keywords:
Sensorineural Hearing Loss, Hidden Hearing Loss, Otoacoustic Emissions, Auditory Brainstem Response, Middle Ear Reflex

Hannah Ginsberg, Satyabrata Parida, and Michael Heinz
Purdue University

According to the World Health Organization, disabling hearing loss affects nearly 466 million people worldwide. Sensorineural hearing loss (SNHL), which is characterized as damage to the inner ear (e.g., cochlear hair cells) and/or to the neural pathways connecting the inner ear and brain, accounts for 90% of all disabling hearing loss. More concerning is that significant perceptual and physiological aspects of SNHL remain “hidden” from standard clinical diagnostics. Hidden hearing loss (HHL) manifests as the inability to understand speech in loud, noisy environments (e.g., listening in a noisy restaurant) despite a normal audiogram (i.e., normal detection of soft sounds). Recently, HHL has been suggested to result from cochlear synaptopathy, a significant loss of inner-hair-cell/ afferent-nerve synaptic terminals after an acoustic over-exposure causing “only” a temporary threshold shift (TTS), e.g., after a rock concert. In this study, three physiological non-invasive diagnostic measures of HHL will be evaluated in chinchillas: otoacoustic emissions, auditory brainstem responses, and middle-ear-muscle reflex strength. As a first step, the effect of anesthesia will be evaluated. Four animals will be tested twice while awake and then also twice while under anesthesia (xylazine and ketamine). The repeatability, accuracy, and precision of each measure will be examined. Future work will include collecting these measures before and after TTS-inducing noise exposure. The long-term goal of this study is to establish and characterize reliable and efficient HHL measures in the lab using our noise-induced synaptopathy chinchilla model, and then to translate the animal results into a plausible clinical HHL diagnostic for humans.

Flow Chamber for Confocal Tracking of Particles in Bone

Presentation ID:
MO-07

Room:
ARMS 1010

Keywords:
Lacunar-Canalicular Network, Confocal Laser Scanning Microscopy, Computer Aided Design

Brennan Flannery, Russell Main, and Xiaoyu Xu
Purdue University

Interstitial fluid flow in the lacunar-canalicular system (LCS) of bone is recognized as a potential regulator of bone remodeling. Movement of fluid across bone cells called osteocytes regulates gene expression that leads to either bone formation or resorption. Interstitial fluid moves in response to bone loading during daily activity, and bone growth occurs to compensate for these loads, affecting bone shape and strength. While interstitial fluid flow is thoroughly studied using computational models, there is a critical need to study flow in real bone samples with imaging techniques. Flow velocities determined from imaging will be more accurate than computational models due to the simplifying assumptions that are made when building a model. This study presents a sealed system that allows for imaging of particle flow in bone using confocal microscopy. The flow apparatus was designed in Autodesk Fusion 360 and fluid flow was controlled using an electric constant flow pump. For comparison with experimental data, a computational model based on confocal microscopy images was created to calculate flow velocities in the LCS using ANSYS Fluent. The results of this study will develop a novel method for tracking interstitial fluid flow in the LCS, providing a new strategy to study how fluid flow affects bone remodeling. The ability to measure fluid flow in bone allows for the connection of age or disease related alterations in the LCS to changes in bone mass and structure.

Quantitative Models of Protein Dynamics in Synaptic Plasticity: Analysis of Spatial and Stochastic Effects

Presentation ID:
MO-08

Room:
ARMS 1010

Keywords:
Synaptic Plasticity, Calcium Signalling, Dendritic Spine

Christopher Rust, Tamara Kinzer-Ursem, Matthew Pharris, and Neal Patel
Purdue University

Memory formation within neurons depends on complex protein signaling networks, which become dysregulated in neurological disorders such as Alzheimer's disease. To characterize therapeutic strategies for these disorders, we require a better understanding of the how the protein interactions are regulated. Conventionally, protein interactions are studied by experimental techniques and complemented by computational models. However, most models are deterministic, limiting their biophysical accuracy. First, deterministic models exclude the stochastic effects necessitated by the small protein concentrations often observed within neurons. Second, deterministic models exclude the effects of spatial localizations on neuronal protein binding and activation. Third, many different models exclude an explicit representation of competition for binding to the essential protein calmodulin when multiple calmodulin-binding proteins are known to simultaneously coordinate the regulation of synaptic plasticity. Therefore, here we present a highly detailed model that explicitly accounts for stochastic effects, spatial localizations, and competitive binding, using the open source software MCell. Using our model, we compare against previous models and experimental data to analyze how spatial and stochastic effects determine the dynamics observed. These conclusions will be drawn from the concentrations of various neuronal protein activations and chemical modifications. In the future, our model may be used as a tool to identify and characterize therapeutic targets for neurological disorders.

Applying Machine Learning Techniques for Type2 Diabetes Readmission Prediction Based on Retrospective Data

Presentation ID:
MO-09

Room:
ARMS 1010

Keywords:
Hospital Readmission, Type2 Diabetes, Healthcare, Machine Learning

Abhishek Sharma, Nan Kong, Paul Griffin, Andrés García-Arce, and Munirul Haque
Purdue University

Roughly 9.3% of US population suffer from diabetes and the 30 day readmission rate for diabetes patients range between 14.4 to 22.7%. Hence identifying the risk of readmission is a crucial information for the service providers to not only reduce the healthcare cost but also improve the quality of patient care. This paper models various machine learning algorithms to compute probability of 30-day hospital readmission for type2 diabetes patients. Along with novel pre-processing techniques to identify the challenges of noisy and non-homogenized medical data, we used and compared multiple methods to downsize the feature vector size without sacrificing prediction accuracy. One of our novel machine learning architectures is Conditional Logistic Regression i.e. first splitting the data-set using decision trees and then applying Logistic Regression to the decision nodes. Our method has been implemented on a publicly available dataset from University of California Irvine at https://archive.ics.uci.edu/ml/datasets/diabetes+130-us+hospitals+for+years+1999-2008 which summarizes data from 130 US hospitals within span of 10 years with roughly 100,000 patients.

Signal Evolution Through Clustering of fMRI Data

Presentation ID:
MO-10

Room:
ARMS 1010

Keywords:
fMRI, Activation Extent, Clustering

James Wang, and Yunjie Tong
Purdue University

The human brain is a large, complex organ comprised of billions of neurons and hundreds of trillions of connections, which makes the advanced cognitive functions possible. However, with various techniques including magnetic resonance imaging and electroencephalogram, the complexities in the brain are still largely unknown. In fact, the signals from these technologies are still under heavy debate in regard to their true meanings. In order to explore this problem, k-mean clustering was utilized as a method to evaluate functional magnetic resonance imaging data of subjects that were given repeated visual stimulus (>100 times). It was found (after averaging 100 trials) that subjects had robust signals throughout the brain, which was not limited to just the visual cortex. In this project, clustering methods were applied on these scans to further explore the evolutional features of these signals invoked by visual stimulation. It was found from preliminary results that the evolution of these signals taken by subtracting voxels to adjacent voxels appears may be attributed to 5 different shapes. These shapes ultimately are similar to the base signals found in the gray matter of the brain. This could signify that there is an underlying meaning behind these functional magnetic resonance imaging signals which could have been overlooked.

Medical Science and Engineering

ARMS 1021, 9:30 AM – 10:45 AM

Structural and Functional Characterization of Hyper-Phosphorylated GRK5 Protein Expressed From E. coli

Joseph Krampen, John Tesmer, and Qiuyan Chen
Purdue University

G protein-coupled receptor (GPCR) kinases (GRKs) are proteins in the cell responsible for regulating GPCRs located on the cell membrane. GRKs regulate active GPCRs by phosphorylating them at certain sites which causes them to stop normal signaling on the membrane. This ultimately affects how the cell responds to its environment. GRK5 is a kinase of particular interest due to its involvement in the pathology of diseases such as cardiac failure, cancers, and diabetes. Understanding the structure and function of GRK5 is essential for discovering ways to manipulate its behavior with these diseases, but not much is known about how GRK5 interacts with GPCRs. Although past studies used mammalian and insect cells to produce GRK5, this study aims to use E. coli cells to discover more about GRK5's structure and function. Previous studies revealed E. coli produce a hyper-phosphorylated version of the GRK5 protein. We attempted to crystalize this GRK5 produced from E. coli to reveal its conformation in a phosphorylated state that we hypothesize to be similar to its form when bound to GPCRs. We also tested the functionality of this GRK5 to reveal the effects of phosphorylation. We genetically edited the GRK5 gene in multiple E. coli samples to create GRK5 with less phosphorylation sites and tested activity levels by measuring the phosphorylation of GPCRs mediated by each GRK5 variant. Successfully creating an E. coli system for structural and functional analysis of GRK5 would help reduce time and costs for GRK5 research, and it could speed up the full understanding of the interactions between GRK5 and GPCRs.

Presentation ID:
MO-11

Room:
ARMS 1021

Keywords:
G Protein-coupled Receptor Kinase, GRK5, Crystallography, Phosphorylation, Membrane Binding

Developing strategies to toughen bio-inspired adhesives

Narelli Narciso[1], Samuel Huntington[2], and Jonathan Wilker[2]
University of Pennsylvania[1] and Purdue University[2]

Mussels and other marine creatures adhere very well in underwater environments, having the ability to withstand the force of the sea. These animals have inspired synthetic biomimetic adhesives for wet systems, presenting potential for biomedical applications. However, most current commercial adhesives tend to be brittle, not resisting repetitive movements. This study assesses toughening strategies to improve the mussel-inspired adhesives' ductility while maintaining its strength. The strategies included altering the polymer's chemical structure by changing the percentage of polyethylene glycol (PEG) in the molecule and by adding fillers, such as calcium carbonate, silica and nacre - a calcium carbonate compound found in shells. The dry adhesion of the glues was tested by shear lap tests on standard aluminum samples. The addition of PEG increased the ductility of the polymer considerably, creating a viscous paste rather than a solid. Future advances include analyzing the tensile strength and adhesion of the systems, as well as their resistance in wet environments. Furthermore, the toxicity of both the polymer and potential fillers should be investigated.

Presentation ID:
MO-12

Room:
ARMS 1021

Keywords:
Adhesives, Bio-inspired, Toughening, Strength, Ductility, Mussels, Biomedical

Computational Catalysis: Creating a User-Friendly Tool for Research and Education

Kevin Greenman[1], and Peilin Liao[2]
University of Michigan - Ann Arbor[1] and Purdue University[2]

Catalysis is used in a significant portion of production processes in the industrialized world, including most processing of chemicals and fuels. This makes maximizing the efficiency of catalysts a high priority. However, the immense number of candidates for new catalysts precludes the possibility of testing all of them by experiments. Density functional theory (DFT) has been widely and successfully used to calculate material properties relevant to catalysis and to screen promising candidates for experimental testing, but there currently exists no publicly- available, user-friendly tool for performing these DFT calculations. This work details the development of such a tool for nanoHUB.org using Quantum Espresso and the Atomic Simulation Environment Python library. Testing was performed for a variety of preloaded structures and surfaces to determine the optimal input values for achieving accurate results in minimal time. The tool's capabilities were evaluated by benchmarking its results against those of previous computational work. The close agreement of these results indicates the readiness of the tool for use in research, and the user interface will enable its use in education to teach students about catalysis and to inspire the next generation of researchers in the field.

Presentation ID:
MO-13

Room:
ARMS 1021

Keywords:
Computational Catalysis, Catalyst Design, Heterogeneous Catalysis, Simulation, Density Functional Theory

Structural Analysis of the BamA-B complex in Acinetobacter baumannii

Presentation ID:
MO-14

Room:
ARMS 1021

Keywords:
BAM, AB Complex, Acinetobacter Baumannii, Purification

Abigael Gichaba, Nicholas Noinaj, and Robert E. Stephenson
Purdue University

There are 2 types of bacteria, gram-negative and gram-positive bacteria. Gram-negative bacteria have both a plasma membrane and an outer membrane, while gram-positive only have a plasma membrane. The outer membranes of gram-negative bacteria have outer membrane proteins which are essential for the bacteria's survival. Also located within the outer membrane is a multicomponent protein complex named the beta-barrel assembly machinery (BAM) complex. BAM is responsible for folding and inserting outer membrane proteins into the outer membrane. This protein complex serves an essential role but not much is understood about its function. In this study, two subunits of the BAM complex (BamA and BamB) in *Acinetobacter baumannii* were recombinantly expressed in *E. coli* and then purified, crystallized and analyzed using biophysical methods in order to gain a better understanding of the *A. baumannii* BAM complex structure. In efforts to prepare the BamAB complex, two milligrams of BamA and two milligrams of BamB were mixed in buffer. The sample was ran through a size-exclusion column (Superdex 200 Increase GL) and analyzed for complex formation. Results showed we were not able to obtain a properly assembled complex with the current protocol, however, we will be screening different detergents in hopes of finding one that will foster BamA-B complex formation. The information gained from solving this structure will further aid in understanding the mechanisms of this important protein.

Seeing Beyond: Real-time Ultrasound Image Integration in Augmented Reality Based Telementoring

Presentation ID:
MO-15

Room:
ARMS 1021

Keywords:
Ultrasound Imaging, Telementoring, Augmented Reality, Fiducial Tracking

Mandira Marambe[1], Natalia Sanchez-Tamayo[2], and Juan Wachs[2]
Smith College[1] and Purdue University[2]

Ultrasound imaging, when aptly integrated with augmented reality based medical telementoring, may be beneficial as an assistive tool in a range of trauma procedures including removal of foreign objects from blast injuries and central or peripheral venous access. Expected benefits include reduced procedure completion time, higher efficiency, and higher incision accuracy. This paper describes the implementation strategy selected for the integration of real time ultrasound imaging in the trainee view of a telementoring system. The proposed strategy augments the view of the trainee surgeon by displaying the ultrasound image directly below and parallel to the ultrasound transducer. The developed system features a fiducial marker based tracking approach employing a triplanar geometric fixture. An experiment was designed to demonstrate the system function and validate its performance.

Computer and Web Based Applications

ARMS 1103, 9:30 AM – 10:45 AM

Development of Closures for Collisions Between Realistic Particles

Presentation ID:
MO-16

Room:
ARMS 1103

Keywords:
Granular Flows, Collision Dynamics, Non-spherical Particles, Discrete Element Method

Cary Faulkner, and Aaron Morris
Purdue University

Systems consisting of solid particles can exhibit fluid-like motion and are common in industrial applications such as pharmaceutical or food processing. Such granular flows are often studied using simulation methods. One common simulation method is the discrete element method (DEM), which solves for the motion of individual particles based on Newton's laws. However, large-scale particulate systems are difficult to study using DEM due to excessively long simulation times. The goal of this study is to reduce the computational load of these large-scale simulations. Instead of resolving particle trajectories throughout each collision, a scattering function is developed that directly relates the post-collision state to pre-collision properties. By bypassing the process of fully resolving particle collisions, the measured scattering functions can be used to decrease computational costs. The scattering function was formed by simulating many collisions between randomly oriented identical particles and determining the direction they rebound after each collision. The scope of this study includes the effect of elasticity, friction, and particle shape on the scattering function. The results of this study show elasticity, friction, and particle shape all influence the scattering function. Decreasing the elasticity, which increases the loss of energy in collisions, shows the scattering function favors forward scattering. Friction has the opposite effect on the scattering function as it tends to cause more backward scattering. Finally, collisions between more realistic non-spherical particles result in significant rotation and changes in the scattering behavior as compared to spherical particles.

Exploring Confidentiality Issues in Hyperledger Fabric Business Applications

Presentation ID: MO-17

Room: *ARMS 1103*

Keywords: *Blockchain, Hyperledger, Confidentiality*

Shivam Bajpayi, Pedro Moreno-Sanchez, Donghang Lu, and Sihao Yin
Purdue University

The rise of Bitcoin and cryptocurrencies over the last decade have made its underlying technology (blockchain) come into the spotlight. Blockchain is a secure ledger of linked records called blocks. These records are cryptographically immutable and any tampering with the block is evident through a change in the cryptographic signature of the block. Among the blockchains deployed in practice today, Hyperledger Fabric is a platform that allows businesses to make use of blockchains in their applications. However, confidentiality issues arise with respects to the blocks in this blockchain network due to the fact that blocks might contain sensitive information accessible to all peers with a copy of the blockchain. In this work, we aim to address the confidentiality issue present in current Hyperledger Fabric. Our current approach consists of leveraging cryptographic techniques to ensure the confidentiality of the shared data in the blockchain along with crafted access control policies so that only authorized peers can access the otherwise concealed data. This becomes a crucial requirement especially with business models that require their transaction information to be concealed. Recent results show that the use encryption along with interesting access control policies allow obfuscation of data for desired outside entities, although more work is required.

Incorporating collisions and resistance into the transition from field emission to the space charge regime

Presentation ID: MO-18

Room: *ARMS 1103*

Keywords: *Collisions, Field Emission, Fowler-Nordheim, Child-Langmuir, Mott-Gurney, External Resistance*

Samuel Dynako, Adam Darr, and Allen Garner
Purdue University

Advancements in microelectromechanical systems (MEMS) and microplasmas, particularly with respect to applications in combustion and biotechnology, motivate studies into microscale gas breakdown to enable safe system design and implementation. Breakdown at microscale deviates from that predicted by Paschen's law due to field emission—the stripping of electrons from the cathode in the presence of strong surface field—and follows the Fowler-Nordheim (FN) law. As injected current increases at this length scale, electrons accumulate in the gap and FN electron emission becomes space charge limited, leading to the Child-Langmuir (CL) law at vacuum and the Mott-Gurney (MG) law at high pressure. While theoretical studies link CL to FN and CL to MG, none links all three to simultaneously assess the importance of pressure and external resistance (perturbation) on electron emission. This study extends existing theory to elucidate the transition between these regimes as a function of applied voltage, gap distance, electron mobility, and external resistance, and in particular, derives asymptotic equations illustrating the transitions between the three. It also demonstrates the presence of a triple point, where one theoretically encounters FN, CL, and MG at once, and characterizes the importance of gap pressure and distance on these regimes, especially when MG dominates at non-vacuum pressures. The sensitivity of the triple point to external resistance, representative of the effects of perturbations in system parameters on electron emission, receives special attention.

Deep Machine Learning for Mechanical Performance and Failure Prediction

Presentation ID: MO-19

Room: *ARMS 1103*

Keywords: *Deep Learning, Machine Learning, Artificial Intelligence, Statistics, Data Science, Neural Networks, Algorithm*

Elijah Reber[1], Nickolas Winovich[2], and Guang Lin[2]
Penn State University[1] and Purdue University[2]

Deep learning has provided opportunities for advancement in many fields. One such opportunity is being able to accurately predict real world events. Ensuring proper motor function and being able to predict energy output is a valuable asset for owners of wind turbines. In this paper, we look at how effective a deep neural network is at predicting the failure or energy output of a wind turbine. A data set was obtained that contained sensor data from 17 wind turbines over 13 months, measuring numerous variables, such as spindle speed and blade position and whether or not the wind turbine experienced a failure at that time. It was found that the deep neural network was able to predict the failure and energy output with a high degree of accuracy, with an average residual of -0.005 for key predictors, thus validating its use as a potential predictor of energy production or safety hazards caused by mechanical failure.

Validation of Lateral Gap Leakage Objective Function for Use in Multi-Objective Optimization of Gerotor Pumps

Presentation ID:
MO-20

Room:
ARMS 1103

Keywords:
Lateral-Gap Leakage, Reynolds Equation, Gerotor, Pump, Multi-objective Optimization

Kevin Cohen, Andrew Robison, and Andrea Vacca
Purdue University

Gerotor pumps are a common pump choice used in the automotive, agricultural, and construction fields for their low cost and durability. Recently, demanding applications have called for significant design improvements in gear geometry. To address these design challenges, multi-objective optimization has been applied to gear geometry. The goal of this work is to introduce minimizing of lateral-gap leakage to the multi-objective optimization. An objective function for evaluating lateral-gap leakage based on 1D, pressure driven flow is proposed. This simplified approach is compared to CFD simulation solving of Reynolds equation with two pressure boundaries. Comparison of the simplified relation and the CFD simulation are used to validate the objective function for use in optimization.

Earth and Space Science

ARMS 1109, 9:30 AM – 10:45 AM

Hawaiian Lava Tubes with Extraterrestrial Habitat Applications

Presentation ID:
MO-21

Room:
ARMS 1109

Keywords:
Extraterrestrial habitats, Morphology and Formation, Stability of Lava Tubes, Moon, Skylight

Jacob Just, Audai Theinat, Amin Maghareh, Antonio Bobet, and Shirley Dyke
Purdue University

One of the next major steps in space exploration, as noted by agencies such as NASA and SpaceX, is the creation of extraterrestrial habitats. Most current extraterrestrial habitat designs focus on above-surface solutions and do not consider all the hazards that can impact this habitat. However, the existence of lava tubes on the moon, supported by data from Gravity Recovery and Interior Laboratory (GRAIL), SELenological and ENgineering Explorer (SELENE), and NASA's Lunar Reconnaissance Orbiter (LRO), could impact extraterrestrial habitat designs. To support life, a prospective habitat must be safe from the harsh conditions of space, including meteorite impacts, radiation, and fluctuating temperatures. Lunar lava tubes, cave-like structures created during volcanic eruptions, can house a prospective habitat. This paper provides an understanding of lava tube morphology and formation methods on Earth which gives insight into extraterrestrial lava tubes, specifically their structure, stability, and formation methods. By studying lava tubes in Hawaii, a better understanding of these qualities is formed. This knowledge provides for a more accurate model in which stability is further investigated. Several factors are investigated in this model, including size and geometry. Using a case study of the Kaumana Cave and Thurston's lava tube in Hawaii, it is found that stable terrestrial lava tubes share many similarities with extraterrestrial lava tubes. This shows the stability of lava tubes a few kilometers wide on the Moon. By knowing more about the stability of lunar lava tubes found through this research, future extraterrestrial habitat engineering designs will be impacted.

Space Architecture Assessment Using System-of-Systems Methodologies

Presentation ID:
MO-22

Room:
ARMS 1109

Keywords:
System of Systems, Space Exploration, Operability, System Dependency

Liam Durbin, Cesare Guariniello, and Daniel DeLaurentis
Purdue University

As technologies in the space exploration community are further developed, mission complexity and the associated risks have become greater. Dozens of complicated system interactions may result in unexpected, potentially dangerous emergent behaviors. Early efforts are underway by NASA to map potential system architectures (collections of systems which fulfill design requirements) for future human space exploration missions. However, current mission complexity requires the determination of emergent behaviors, as well as time requirements, and safety levels of complicated space exploration architectures, which current analysis methods in use cannot address. To that end, a newer technique has been developed—System Operability Dependency Analysis (SODA). This technique uses a combination of expert input and past data analysis to create a model of system interactions, to properly complete the required study. By gathering a broad variety of data and opinion through literature survey and interaction with subject matter experts, and modeling interactions between systems, obtaining estimations for the feasibility and features of a variety of architectural variations becomes possible. This study compares a small set of architectures/variations to determine which best meet the requirement metrics designated by the user. The resultant data includes sets of feasibility data and specialized data plots which denote the relative feasibility of each architecture. The knowledge learned from this study is intended as an initial guide for the development of future human space exploration missions.

Design of selectively compliant morphing wind turbine blade section using bistable laminate for passive load alleviation

Presentation ID:
MO-23

Room:
ARMS 1109

Keywords:
Wind Turbine, Passive Load Alleviation, Bistablity, Aeroelasticty, Selective Compliance

Abhishek Chopra[1], Andres Arrieta[2], Janav Udani[2], and Jose Padilla[2]
Rutgers University - New Brunswick/Piscataway[1] and Purdue University[2]

The design of passively controlled compliant morphing structures for large scale wind turbine blades has been of interest due to the inherent advantages of lower mass and reduced complexity over their active counterparts. Previous studies have indicated that embedding a locally bi-stable element within the turbine blade section successfully allows for achieving passive load alleviation. The embedded bi-stable member switches from one stable state to another at a critical aerodynamic load. This local structural change results in a global shift in the aeroelastic response of the blade section. Building on these preliminary results, this research investigates a two- dimensional wind turbine morphing airfoil as a lumped aeroelastic model with three degrees of freedom. An aeroelastic analysis is performed with plunge, pitch and flap deflection degrees of freedom while considering the trailing edge flap as a bistable torsional spring. The nonlinearity in flap torsional spring is designed to qualitatively capture the behavior of a bistable element embedded within the trailing edge of morphing blade section. The results presented demonstrate alleviation of the aerodynamic load acting on the blade section by shifting between the two stable states of the bistable spring. Based on this study, a morphing mechanism can be developed for a full-scale wind turbine blade that counteracts cyclic loads by cambering a trailing edge flap. This design approach has the potential to reduce cyclic blade fatigue on horizontal axis wind turbines.

Desalination In Extraterrestrial Systems

Presentation ID:
MO-24

Room:
ARMS 1109

Keywords:
Desalination, Space Exploration, Habitat, Vapor Harvesting, Planetary Science

Anirwin Yekkala Naga Venkata, and David Warsinger
Purdue University

In space, water and energy are keystone resources for survival. Water is a primary input for food, energy and industry, and the balance between water supply and energy requirements will indicate whether an environment is suitable for humans. Over the past few years, there have been traces of water found in the form of ice under the surface of several planets, water vapor in atmospheres of the system or salty water bodies found on surfaces of planets. Energy needs for water production play a key role for habitability in space, but this has not been investigated thus far. Thus, this article investigates the variation of least work of separation in extreme conditions such as those on Mars, Venus, Europa, etc. This includes calculating the energy consumption of obtaining water from ice, liquid water, or atmosphere and comparing the impact of temperature, pressure, salinity and phase. In the case of obtaining water from ice, the energy required to melt, desalinate and bring it to an ambient temperature is considered. A comprehensive breakdown of energy requirements for obtaining pure water in extreme conditions is presented to better guide space agency's research in the pursuit of systems capable of supporting the needs for human sustenance.

Extra-terrestrial Habitat Systems: Safety, Reliability, and Resilience

Presentation ID:
MO-25

Room:
ARMS 1109

Keywords:
Resilience, Reliability, Failure Analysis, Extra-terrestrial Habitat, Probabilistic Risk Assessment

Jory Lyons, Amin Maghareh, Audai Theinat, Shirley Dyke, and Antonio Bobet
Purdue University

The creation of extra-terrestrial habitats is considered the next step for future space exploration. Developing a resilient extra-terrestrial habitat with regards to long-term reliability and safety from hazards including radiation, meteorites, and quakes is necessary to ensure human survival during interplanetary exploration. The objective of this study is to examine conventional aerospace safety and reliability analysis techniques to investigate whether they are sufficient to achieve resilience in extra-terrestrial habitats. These results will be obtained to complete a strengths, weaknesses, opportunities, and threats (SWOT) analysis of compiled techniques to design a sustainable habitat system. Failure modes, effects, and criticality analysis (FMECA) and probabilistic risk assessment (PRA) with their past applications will be assessed to provide the SWOT analysis for requirements for a resilient analysis technique capable of measuring safety and reliability. An in-depth analysis of aerospace engineering analysis techniques will be investigated for historical successes and failures and then applied to a simple case study. The research findings can help determine the feasibility of living in other extra-terrestrial environments, including different settlement concepts in surface habitats or lunar lava tubes, by refining conventional safety and reliability analysis procedures. Techniques including FMECA and PRA can determine necessary improvements to increase safety but may lack long-term resiliency. For this reason, there is a need to create a merge of existing risk-based techniques and other design considerations to contain long-term reliability and resilience.

MORNING POSTER PRESENTATIONS

MP

Sensing and Measurement

ARMS Atrium, 11:00 AM – 12:15 PM

Selecting Trusted Nodes for Resilient Distributed State Estimation of Linear Time Invariant Systems

Presentation ID:
MP-01

Room:
ARMS Atrium

Xingchen Wang, Shreyas Sundaram, and Aritra Mitra
Purdue University

Keywords:
Trusted Nodes, Networked Dynamical Systems, Resilient Distributed State Estimation

We study estimation of the state of a dynamical system via a network of nodes (or sensors). Such networks are vulnerable to malicious adversaries that compromise some of the nodes and cause them to deviate from the estimation algorithm. It is thus vital to increase the robustness of the system against such attacks. We consider the problem of allocating enough budget to make a small fraction of the nodes attack-immune, thereby making them “trusted”. These nodes must be chosen carefully so that the entire network is capable of reliably estimating the state of the system. We prove that this problem is computationally hard and thus unlikely to admit a fast algorithm that will find an optimal solution. We propose an intuitive greedy algorithm, which iteratively and myopically chooses trusted nodes, and identify certain network topologies where the greedy algorithm performs optimally or poorly. Furthermore, we study various aspects of the proposed greedy algorithm based on three popular random graph models that are often used to represent large-scale complex networks.

Purdue Air Sense: A Methodology for Improving the Accuracy of Ambient Aerosol Mass Concentration and Size Distribution Measurement with Low-Cost Optical Sensing Techniques

Presentation ID:
MP-02

Room:
ARMS Atrium

Rishabh Ramsisaria[1], Satya Patra[2], and Brandon Boor[1]
Purdue University[1] and Indian Institute of Technology Madras[2]

Keywords:
Low-cost Sensing, Air pollution, Environment, Sensors, Internet of Things

There is a global lack of a means for monitoring air pollutant levels at a local level due to expensive and bulky instrument requirements. It is important to monitor toxic gas levels, as well as particulate matter levels, in the atmosphere to study their effects on human health and to further develop city- and community-level air pollution solutions. In this study, with the means of a Raspberry Pi, low-cost Alphasense Optical Particle Counter and gas sensors, and methodical calibration techniques, we built a portable 3-D printed module powered by clean electricity generated by an on-board Voltaic solar cell that measures concentrations of ozone, NOx, CO and CO2 as well as coarse and fine particulate matter (PM) in ambient air. To calibrate these sensors, we used laboratory-grade reference instruments as the benchmark and set it up so that the calibrated data is displayed on the Purdue AirSense website in real time. We also accounted for temporal and humidity variations and generated PM size distribution plots under 0.3 microns in diameter, which the low-cost sensors are not able to detect, using regression techniques. This module can be used in many remote areas for air monitoring and implementing localized solutions to the air pollution problem. Moreover, due to portability, it can also be used on vehicles for vehicle pollution monitoring, and in classrooms, for educating the public about air quality monitoring.

Remote sensing using I-Band and S-Band signals of opportunity

Presentation ID:
MP-03

Room:
ARMS Atrium

Keywords:
Remote Sensing, Soil Moisture, Signals of Opportunity, I-Band, S-Band

Kadir Efecik, Benjamin Nold, and James Garrison
Purdue University

Measurement of soil moisture, especially the root zone soil moisture, is important in agriculture, meteorology, and hydrology. Root zone soil moisture is concerned with the first meter down the soil. Active and passive remote sensing methods used today utilizing L-band(1-2GHz) are physically limited to a sensing depth of about 5 cm or less. To remotely sense the soil moisture in the deeper parts of the soil, the frequency should be lowered. Lower frequencies cannot be used in active spaceborne instruments because of their need for larger antennas, radio frequency interference (RFI), and frequency spectrum allocations. Ground-based passive remote sensing using I-band(0.1-1GHz) signals of opportunity provides the required sensing depth and solves the problems that come with the spaceborne remote sensing instruments using I-band reflectometry. A dual monopole antenna setup was used with one on the ground for direct signal and one 30 m above ground for the reflected signal. The reflectivity and therefore the soil moisture was obtained from the differences between direct and reflected signals. Initially, an S-band (2-3GHz) signal was used as a proof of concept and its ease of implementation because of its higher transmitted power and stationary satellite. This experiment provides conclusions about the root zone soil moisture based on our observation and comparison of direct and reflected satellite signals of two different frequency bands and determination of reflectivity.

Micro-Manipulation Using Learned Model

Presentation ID:
MP-04

Room:
ARMS Atrium

Keywords:
Micromanipulation, Machine Learning, Automation, Manufacturing, Modeling

Matthew Lyng, Benjamin Johnson, and David Cappelleri
Purdue University

Microscale devices can be found in applications ranging from sensors to structural components. The dominance of surface forces at the microscale hinders the assembly processes through nonlinear interactions that are difficult to model for automation, limiting designs of microsystems to primarily monolithic structures. Methods for modeling surface forces must be presented for viable manufacturing of devices consisting of multiple microparts. This paper proposes the implementation of supervised machine learning models to aid in automated micromanipulation tasks for advanced manufacturing applications. The developed models use sets of training data to implicitly model surface interactions and predict end-effector placement and paths that will yield a desired part trajectory. Conclusions and recommendations are based on evaluations of a collection of machine learning models and the effects of training data size and hyperparameter tuning on a collection of error metrics.

Real-Time Non-Contact Road Defect Detection Using Inexpensive Sensors

Presentation ID:
MP-05

Room:
ARMS Atrium

Keywords:
Road Defect Detection, Pavement Distress, Pothole Detection, Inexpensive Sensors, Deep Learning, Sensor Fusion

Zhao Xing Lim, Mohammad Jahanshahi, Tarutal Mondal, Da Cheng, Shutao Wang, Mohammad Sweidan, Aanis Ahmad, Omar Abouhussein, and Xi Chen
Purdue University

Road defects such as potholes, humps, and road cracks have become one of the main concerns for road and traffic safety worldwide. Pavement defect detection is crucial to ensure road safety. However, current solutions to this problem are either too time-consuming or too expensive to be employed large-scale. We propose a novel approach which has the ability to autonomously detect potholes in real-time using cost-effective sensors. Inexpensive sensors are mounted on a vehicle and a deep learning algorithm is used to identify road defects. The detection system is paired with a GPS and positional sensors to map the location of the pothole. The data that is collected is annotated and used to train deep learning networks to learn the patterns of potholes. This approach is low-cost, accurate and time-saving. It can potentially be employed in large-scale crowdsourcing of road condition data where normal road users constantly update the road conditions as they use the roads.

Remote Sensing of Soil Moisture using S-band Signals of Opportunity: Model Development and Experimental Validation

Presentation ID:
MP-06

Room:
ARMS Atrium

Keywords:
Remote Sensing, Signals of Opportunity, S-band, Signal processing, Fresnel Coefficients, Soil Moisture, Polarization, Aliasing

Marvin Jesse, Benjamin Nold, and James Garrison
Purdue University

Root zone soil moisture (RZSM) is a vital aspect in meteorology, hydrology, and agriculture. There are currently some methods in passive and active remote sensing at L-band, but these methods are limited to a sensing depth of approximately 10 cm. Observing RZSM (water in the top meter of soil) will require lower frequencies, thus presenting significant difficulties for a spaceborne instrument, because of the required antenna size, the presence of radio-frequency interference (RFI), and competition for spectrum allocations (in the case of active radar). Bistatic radar using Signal of Opportunity (SoOp) (e.g. digital satellite transmitters) provides an opportunity for remote sensing using powerful signals, which already occupies bands allocated for communications.Recently, a tower experiment has been conducted at Purdue Agronomy Center for Research and Education (ACRE). Linearly polarized measurements were made over bare soil, observing a strong reflected signal. Corn is being planted on the field and measurements will be made throughout the growing season. These measurements focus on measuring the soil properties, such as the weight and dielectric constant, as well as the vegetation characteristics.

Computer and Web Based Applications

ARMS Atrium, 11:00 AM – 12:15 PM

A Divide-and-Conquer Approach to Syntax-Guided Synthesis

Presentation ID:
MP-07

Room:
ARMS Atrium

Keywords:
Program Synthesis, Divide-n-Conquer, Linear Integer Arithmetic

Peiyuan Shen, and Xiaokang Qiu
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Program synthesis aims to generate programs automatically from user-provided specifications. One critical research thrust is called Syntax-Guideds Synthesis. In addition to semantic specifications, the user should also provide a syntactic template of the desired program, which helps the synthesizer reduce the search space. The traditional symbolic approaches, such as CounterExample-Guided Inductive Synthesis (CEGIS) framework, does not scale to large search spaces. The goal of this project is to explore a compositional, divide-n-conquer approach that heuristically divides the synthesis task into subtasks and solves them separately. The idea is to decompose the function to be synthesized by creating a set of auxiliary functions. In this way, the whole synthesis task can be reduced to synthesizing the auxiliary functions. The auxiliary functions are of bounded size and hence can be encoded into a logic constraint in linear-integer arithmetic and solved by modern Satisfiability-Modulo-Theories (SMT) solvers. In each iteration of the synthesis algorithm, an auxiliary function is synthesized and added into the syntax for synthesizing other auxiliary functions. The algorithms repeats until a syntax-correct implementation equivalent to the reference implementation is found. Preliminary experimental results show that this approach is promising.

Virtual Reality for Baseball Batting

Presentation ID:
MP-08

Room:
ARMS Atrium

Keywords:
Virtual reality, Virtual Environment, Baseball Training, Recognition Training, Sports Simulation

Fengchen Gong, Tianjie Jia, Hong Tan, and Casey Kohr
Purdue University

Nowadays, researchers explore the applications of Virtual Reality in different aspects of people's lives. A few studies of Virtual Reality focus on applications in sports training. In this research area, one of the most important benefits is that athletes can focus on the training of one specific skill at one time. This SURF project focuses on the development of the virtual reality environment by designing targeted training for baseball batters, with the goal to achieve sufficient realism as judged by the Purdue baseball coaches. With the Virtual Reality training, baseball batters can practice and perfect a specific skill without a real pitcher or the limitation of the weather. Targeted training includes recognition speed, determination if the ball hits the strike zone, and judgement of baseball path realized by Unity as game engine. The project involves simulating different baseball paths, adding difficulties by changing the ball's color to fulfill the training need. Future work will collect data on Purdue baseball players and provide recommendations based on the comparison of accuracy and recognition time after a period of training. Ultimately, we will collect data on how Virtual Reality training impacts baseball team's performance during the subsequent game season.

Developing Successful iOS Applications

Presentation ID:
MP-09

Room:
ARMS Atrium

Keywords:
iOS, Mobile, Application, Development, Software, Swift, Objective-C

Kousei Richeson[1], and Trevor Stamper[2]
New Mexico State University[1] and Purdue University[2]

Have you ever wanted to publish a popular iOS application? If so, this paper discusses the successful characteristics in successful iOS mobile applications, as well as the characteristics to avoid when developing. This information is gathered from multiple academic journals and interviews with professionals in the field. This paper highlights the importance of applying all the important key characteristics in an organized manner. Using simple software engineering techniques such as using the MVC (Model-View-Controller) are the key driving forces in developing successful iOS mobile applications. This paper also puts emphasis on data-driven applications and brings up common mistakes to avoid when developing it. Finally, the importance of using native applications opposed to cross platform applications is emphasized. These are the keys to a successful iOS application and should be utilized in each application.

Expected Length of the Longest Chain in Linear Hashing

Presentation ID:
MP-10

Room:
ARMS Atrium

Keywords:
Hashing, Hashing with Chaining, Linear Hashing, Two Choices Paradigm, Power of Two Choices

Pongthip Srivarangkul, and Hemanta Maji
Purdue University

Hash table with chaining is a data structure that chains objects with identical hash values together with an entry or a memory address. It works by calculating a hash value from an input then placing the input in the hash table entry. When we place two inputs in the same entry, they chain together in a linear linked list. We are interested in the expected length of the longest chain in linear hashing and methods to reduce the length because the worst-case look-up time is directly proportional to it.The linear hash function used to calculate hash value is defined by ax+b mod p mod m, for any $x \in \{0,1, . . . , p-1\}$ and a, b chosen uniformly at random from the set $\{0,1, . . . , p-1\}$, where p is a prime and $p \geq m$. This class of hash functions is a 2-wise independent hash function family. For any 2-wise independent hash functions, the expected length of the longest chain is $O(n^{1/2})$. Additionally, Alon et al. (JACM 1999) proved that when using a similar class of 2-wise independent hash function, the expected length of the longest chain has a tight lower bound of $\Omega(n^{1/2})$. Recently, in 2016, Knudsen (FOCS 2016) showed that the upper bound of the expected length of the longest chain of the linear hashing function is surprisingly $n^{1/3+o(1)}$. This bound is strictly better than $O(n^{1/2})$, which, due to Alon et al.'s result, is already known to be tight for 2-wise independent hash functions. Consequently, there are exclusive properties of the linear hashing function, in addition to being 2-wise independent, that results in this phenomenon. Even though Knudsen's upper bound on the expected length of the longest chain is remarkable, it is still unknown whether it is tight. In other words, does there exist a set of n inputs such that, when hashed using the linear hash function, the expected length of the longest chain is roughly $n^{1/3}$. If Knudsen's bound is not tight, then there is an additional motivation to study further and tighten the upper bound. Another focus of our research is to reduce the expected length of the longest chain by using the load balancing power of "two choices." The idea is, instead of choosing one bin (hash table entry) for a ball (input), to choose two or more bins and put the ball in the bin with the least load at that moment. Mitzenmacher et al. proved that the power of two choices exponentially improves the expected max-load (from $\Theta(\log n/\log \log n)$) to $\Theta(\log \log n)$) for the hash table that uses two truly random hash functions. We shall conduct an empirical study by simulation with SageMath (System for Algebra and Geometry Experimentation) to verify whether similar improvements are observed for the linear hash function as well. We anticipate that the length of the longest chain of our linear hash table can be significantly improved when used with two linear hash functions.

Image Analysis of a Vesicle to Calculate the Bending Modulus

Presentation ID:
MP-11

Room:
ARMS Atrium

Keywords:
Vesicle, Bending Modulus, Image Processing, Spherical Harmonics

Pheobe Appel, Charlie Lin, and Vivek Narsimhan
Purdue University

The cell membrane is an essential component of living cells and the dynamics of the membrane will provide insight into how a biological cell reacts to mechanical strain. Membrane mechanics are important in a variety of cellular processes like secretion, trafficking, signaling, and storage. Giant unilamellar vesicles are a model system for cellular membranes since the major component of all membranes is a phospholipid bilayer. Giant unilamellar vesicles allow one to examine physicochemical processes that occur in all cellular membranes, such as fusion, budding, and fission in a more controlled fashion. Contour fluctuations of the vesicles are analyzed to calculate the bending modulus of the lipid bilayer, which will provide insight to the cell membrane's rigidity. An image processing program was developed that traces the thermal fluctuations of the vesicle membrane through edge detection. Theory of spherical harmonics was then applied to calculate the elastic properties of the bilayer based on the measured fluctuations.

Understanding Suspend/Resume Path of Linux Device Drivers

Presentation ID:
MP-12

Room:
ARMS Atrium

Keywords:
Operating System, Kernel hacking, Linux Device Drivers, Mobile Devices, Power management

Yi Qiao and Felix Xiaozhu Lin
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Suspend/Resume (S/R), stands for putting mobile devices into sleep mode and wakes them up. Such a S/R process is heavily used in mobile devices today. While controlling by the operating system (OS), S/R process consumes a dominating portion of energy. In order to minimize the power consumption, we have to understand what happens on the S/R Path of modern device drivers so that further solutions reducing the overhead in that process can be found. In a modern OS, device drivers can make up over 70% of the source code, while still heavily dependent on the rest of the OS. Such a property made analyzing the driver code an extremely complicated and important task. We built a static code analysis tool and using the tool, we were able to quantitatively analyze the S/R path of Linux device drivers. By comparing different versions, we observed the evolution of Linux S/R path over time. In this paper, we present a quantitative analysis of Linux driver codes on the S/R path and show how they evolve over time.

Data Trends and Analysis

ARMS Atrium, 11:00 AM – 12:15 PM

Time-Series Clustering For Medication Adherence

Presentation ID:
MP-13

Room:
ARMS Atrium

Keywords:
Time-series Clustering, Medication Adherence, Clustering

Ruhana Azam[1], Nan Kong[1], Laura Downey[2], and Kathy Huff[2]
Purdue University[1] and Concordance Health Solutions[2]

Medication adherence is the measure of how well a patient can comply with the instructions to their prescription. If patients are non-adherent, this can have a major consequence to their health. SmartMedReminder medication bottle caps have provided a way to measure information about when a patient takes their medication on a day-to-day basis. Given this data, patients can be clustered into groups to better understand patterns in medical adherence. This paper will focus on exploring various time-series clustering methods to gain a better understanding of patient groups. The study will explore different feature selections, similarity/dissimilarity measures, and clustering methods. And then, evaluate the significance of the different clusters. Clustering patients will give a better understanding of the heterogeneity of patients' medication usage overall and within specific groupings. The findings for this work can help tailor interventions to patients to improve overall adherence in the future.

Mass Spectrometry Image Creator (MSIC): Ion Mobility / Mass Spectrometry Imaging Workflow in Python

Presentation ID:
MP-14

Room:
ARMS Atrium

Keywords:
Mass Spectrometry Imaging, Nano-DESI, Ion Mobility, Skyline, Python, Data Visualization, Lipidomics, Mass Profiler

Stephen Creger, Julia Laskin, and Daniela Mesa Sanchez
Purdue University

Mass spectrometry (MS) is a powerful characterization technique that enables identification of compounds in complex mixtures. Acquiring mass spectra in a spatially-resolved manner (i.e. over a grid), allows the data to be used to generate images that show the spatial distribution and relative intensities of every compound in a sample. These images can be used to monitor and identify biomarkers, explore the metabolism of compounds within tissues, and much more. However, the limitations of mass spectrometry can result in ambiguous compound identifications. Another characterization tool, ion mobility spectrometry (IM) can be integrated into existing MS routines to address this problem; measuring an ion mobility spectrum along with a mass spectrum over the grid results in more accurate compound identification in imaging experiments. While many software solutions exist for visualizing MS data, none of them support ion mobility. Thus, we have developed a novel program to incorporate this new dimension of data called Mass Spectrometry Image Creator (MSIC). Using existing software within a Python shell, MSIC creates images from raw IM-MS data through a semi-automated and batch-capable pipeline. Additionally, it includes several post-processing tools for further analysis and error correction.

Predict the Failure of Hydraulic Pumps by different Machine Learning Algorithms

Presentation ID:
MP-15

Room:
ARMS Atrium

Yifei Zhou, Monika Ivantysynova, and Nathan Keller
Purdue University

Keywords:
Fluid Power, Pump failure, Prognostic, Machine Learning, Classification, Neural Network

Hydraulic pump failure can cause a huge property loss and even the workers' lives. However, traditional methods to prevent the pump failure are time-consuming, expensive, and even dangerous. The pump manufacturers desire an efficient way to predict pump failures. In this research, different machine learning algorithms were applied and evaluated to monitor abnormal conditions of the hydraulic pump and predict its failure. We installed many thermal sensors, pressure sensors, and position sensors into a good condition pump and a damaged pump to measure their parameters. Then, we chose 10 of these parameters and put their data into the classification, which is a type of Machine Learning. We trained several classification models by different machine learning algorithms including Decision Tree, K-Nearest Neighbor Algorithm and Neural Network and etc. These classification models can detect the "unhealthy" state of the pump from real-time data. Finally, we evaluated these models by different metrics including Accuracy, Precision, Recall, Specificity and etc. The result of this research is the evaluation of these classification models. And the conclusion is the best Machine Learning Algorithm for predicting the pump failure.

EFVS Effects on Pilot Performance

Presentation ID:
MP-16

Room:
ARMS Atrium

Michael Campbell, Nsikak Udo-Imeh, and Steven Landry
Purdue University

Keywords:
Aviation, EFVS, Human Performance, Sensing

Flight tests have been conducted at Purdue University using a computer-based flying simulator in an attempt to determine and measure the effects of Enhanced Flight Vision Systems (EFVS) on the performance of pilots during landing. Knowledge of these effects could help guide future design and implementation of EFVS in modern commercial aircraft, and further increase pilots' ability to control the aircraft in low-visibility conditions. The problem that has faced researchers in the past has revolved around the difficulty in interpreting the data which is generated by these tests. The difficulty in making a generalized conclusion based on the large amount of data containing various increases, decreases, and absences of difference has led to many either contradicting or inconclusive results. A close look was taken at previously obtained sets of data in order to potentially discover any new statistically significant correlations between the use of EFVS and pilot performance. The data included multiple sets detailing errors, deviations, and eye fixation. Results of these tests were summarized in order to look for patterns in the data which indicated a distinct difference between flying with and without EFVS. Most tests failed to find a correlation, but there was a higher frequency of a test finding or almost finding a statistically significant difference when testing the standard deviation of a sample of measurements than when testing the sample means. These results suggest that, with further testing, a connection between EFVS use and the variance of measurements of pilot performance could potentially be discovered.

Nanotechnology

ARMS Atrium, 11:00 AM – 12:15 PM

High Performance Mortar with 100% Recycled Aggregate using Titanium Dioxide Nanoparticles

Presentation ID:
MP-17

Room:
ARMS Atrium

Molly Schrager, Vito Francioso, Arjun Kadakia, and Mirian Velay-Lizancos
Purdue University

Keywords:
Sustainability, Mortar, Recycled Aggregate, Titanium Dioxide Nanoparticles

Concrete and mortar are the most commonly used materials in construction. In an effort to increase the sustainability of these materials, the idea of creating recycled aggregates (sand and rock) from ground old concrete and using it to make mortar and concrete has become more common. This method has two sustainability advantages: it reduces the need to mine for raw materials and lessens the amount of old and defective concrete that is typically put in landfills. But, the use of recycled concrete aggregate lowers the strength of mortars because the residual compounds in the recycled sand reduces bonding with the cement paste. This research studies the use of Titanium Dioxide nanoparticles (TiO_2) as a potential admixture which could increase the strength of the mortar with recycled aggregate and improve the bonding. Using mixtures with 100% recycled aggregate and different percentages of TiO_2 by the weight of cement (0.5%, 1% and 2%) the compressive and flexural strength will be studied. Additionally, the effect of TiO_2 on the microstructure of the mortar will be investigated. These results will be compared to the results of two reference mortars: one with 100% recycled sand and plain mortar with natural sand. It was found that titanium dioxide at 0.5% increased the flexural and compressive strength compared to the sample with just recycled aggregate. The 2% TiO_2 sample showed improvement with flexural strength but not compressive strength and the 1% TiO_2 sample did not have any improvements.

Measurement Platform for Assessment of Semiconductor-Superconductor Hybrid Systems

Presentation ID:
MP-18

Room:
ARMS Atrium

Keywords:
Condensed Matter Physics, Quantum Computing, Semiconductor Physics, Heterostructures, Cryogenics

Molly Newquist and Michael Manfra
Purdue University

A major obstacle in the advancement of quantum computers is the susceptibility of quantum bits (qubits) to decoherence. Decoherence occurs when a system of qubits encounters local noise like gamma radiation and heat due to incomplete isolation from its surroundings. The noise causes the qubits to change their states, thereby losing information. A new type of quantum computer, called a topological quantum computer, will be built with qubits that use inherent properties to protect against decoherence. Excitations in two-dimensional electron systems can act as this type of qubit. Realizing such a system requires confining electrons to two-dimensional planes inside structures of semiconductor and superconductor layers. A variety of low temperature measurements can be taken in order to evaluate the quality and characteristics of structure samples. These measurements can take many hours at the temperatures necessary to evaluate the sample's properties. To streamline this process, a cryogenic measurement platform was designed that will allow for rapid assessment of new structures before they are measured at lower temperatures. A probe and a 32-pin sample mount were designed and constructed for the system. A 48 switch BNC panel was machined and wired, and magnet cables were made to charge the 5 Tesla magnet inside the cryostat. A 40-pin sample mount will also be constructed, and the system will be cooled to 4K to take measurements. This cryostat is expected to speed up the sample assessment process greatly.

Investigation of ITX Derivative Photoinitiators for Depletion Lithography

Presentation ID:
MP-19

Room:
ARMS Atrium

Keywords:
Direct Laser Writing, Stimulated Emission Depletion, Two-photon Polymerization, 3D Printing

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Direct laser writing (DLW) with two-photon polymerization (TPP) allows for fabricating 3-dimensional nano-scale polymer structures by focusing an ultrafast laser inside a photoresist system consisting of a monomer and photoinitiator. The photoinitiator is excited by the laser and triggers the polymerization process of the monomer. Stimulated emission depletion (STED), which was designed for resolution enhancement for microscopy, could be applied to this process and inhibit the polymerization with an additional laser for depletion. This STED process can be used to increase the resolution of the 3D printing. However, the photoresist for STED-DLW should contain a photoinitiator that is sensitive to both the writing laser and the depleting laser, and very few initiators currently exist which meet these strict requirements. Previous studies on 7-diethylamino-3-thenoylcoumarin (DETC) and isopropyl thioxanthone (ITX) have revealed their initiation and depletion capabilities. However, some derivatives of ITX also have the potential to be used as STED inspired photoinitiators. The behaviors of these derivatives are tested by varying the power of both the writing and depleting lasers and the writing speed. Comparisons are made between the different photoresist systems by investigating the writing and depletion thresholds as well as printed structure quality. Results show that ITX derivatives have good writing performance at low writing power, but they have poor response to the depletion laser.

Thin Film Cocaine Sensors

Presentation ID:
MP-20

Room:
ARMS Atrium

Keywords:
Sweat Sensor, Drug Monitoring, Opioids, Organic Electronics, Flexible Sensor

Datta Sheregar, Vick Hung, Jenna Walker, Orlando Hoilett, Jacqueline Linnes, and Robert Nawrocki
Purdue University

To help in the current Drug War by providing data about illegal opioid use among human beings, a thin film sensor is to be developed to detect the amounts of cocaine consumed by an individual by reading the contents in sweat droplets secreted from its skin. First a layer of PVP (poly 4-vinylphenol) is prepared beforehand and then spin coated onto a piece of glass. This adhesive coated glass will act as a substrate for evaporating silver through a specifically designed stencil, which contains 1mm by 10mm rectangles, in a vacuum sealed chamber. The resulting rectangles, or electrodes, are sent into the biomedical lab, where it will run through tests to verify if it can successfully conduct a stable current and react to specific solutions effectively. After the electrodes passed their tests, this proves that the evaporation process produces stable electrodes, and so another specially designed stencil is made to evaporate both gold and silver using the same method to make an electrode that is sent to the biomedical lab, where it will run through more tests to finally react with a cocaine solution, making the first prototype that can successfully react to cocaine.

SPICE based compact model for electrical switching of antiferromagnet

Presentation ID:
MP-21

Room:
ARMS Atrium

Keywords:
Compact model, SPICE, Spin Transfer Torque, Exchange Coupling, Landau-Lifshitz-Gilbert (LLG) Equation, Antiferromagnet (AFM)

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A simulation framework that can model the behavior of antiferromagnets (AFMs) is essential to building novel high-speed devices. The electrical switching of AFMs allows for high performance memory applications. With new phenomena in spintronics being discovered, there is a need for flexible and expandable models. With that in mind, we developed a model for AFMs which can be used to simulate AFM switching behavior in SPICE. This approach can be modified for adding modules, keeping pace with new developments. The proposed AFM switching model is based on the Landau-Lifshitz-Gilbert equation (LLG). LLG along with an exchange coupling module is implemented with conventional electrical circuit elements like voltage-dependent current sources and capacitors. This proposed simulation can be performed for different user defines magnet parameters and initial magnet configurations. The model is carefully benchmarked with experiments. It can be used to study different AFM structures and corresponding switching capabilities. This provides the simulations required with good accuracy for high performance memory applications of AFM in high speed devices.

DNA and Depletant Based Control of the Collective Motion of Gliding Microtubules

Presentation ID:
MP-22

Room:
ARMS Atrium

Keywords:
Microtubule Gliding Assay, Motor Protein, Depletion Force, DNA, Nanotechnology

Caleb Conlisk, Feiran Li, and Jong Choi
Purdue University

Motor proteins, like kinesin, transport cargo within biological cells by transforming chemical energy into mechanical energy through the hydrolysis of adenosine triphosphate (ATP). Kinesins walk across small tracks called microtubules. Recent studies have found that these concepts can be applied in vitro by attaching the motors to a glass substrate, on which microtubules can then glide across. These systems could be useful for many applications, such as targeted drug delivery and efficient, easy medical diagnosis. However, the motion of traveling microtubules is randomly ordered, and methods for controlling it are often hard to implement and recreate. One promising approach is to use depletants, or unreactive macromolecules, that can align microtubules in the same direction by forcing them to move together. This study aims to improve control of microtubule collective motion by using DNA as a signal to increase the effect that depletants have on the microtubule system. This is done by attaching bulky DNA molecules to the filaments, thus increasing their volumes. By comparing the organization of the system before and after the modification of the microtubules, the effects can be analyzed at many concentrations. This study provides an assessment of the relationship between the use of altered microtubules and the concentration of depletants within a gliding assay to induce an ordered collective motion.

Biotechnology and Biomedical Engineering

ARMS Atrium, 11:00 AM – 12:15 PM

Tissue Clearing as a Mechanism to Identify Changes in Fibronectin Structure During Breast Cancer Metastasis

Presentation ID:
MP-23

Room:
ARMS Atrium

Keywords:
Tissue Clearing, X-CLARITY, Fibronectin, Breast Cancer Metastasis, Whole Organ Clearing, 3-D Tissue Imaging

Maryam Nuru, Kelsey Hopkins, and Luis Solorio
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With metastasis accounting for approximately 90% of breast cancer deaths and an alarming number of over 300,000 new breast cancer cases to be diagnosed by the end of 2018, there is growing need to understand the process of breast cancer. Changes in the extracellular matrix (ECM) of the tumor microenvironment play an essential role in this deadly tumor progression. Specifically, the glycoprotein fibronectin (FN), has been identified to be up-regulated in patients with worse clinical outcomes. During tumor progression fibronectin undergoes conformational changes that aid in metastatic dissemination. In order to analyze the dynamic changes in FN expression and evaluate architectural changes within the metastatic niche, electrophoretic tissue clearing was used to image changes in whole murine lungs that have undergone breast cancer metastasis. The X-CLARITY tissue clearing system utilizes electrophoresis which removes the lipid compounds from tissues to make them optically transparent. Coupling this with the c-PRESTO immuno-labelling technique and confocal light microscopy allows imaging of FN expression and structure in whole murine organs. In this study, a tissue clearing, and staining protocol was developed and used to visualize the 3D FN structure in whole murine lungs. Future studies will evaluate changes in FN expression and structure over time during cancer progression. This would contribute to on-going research on the development of more effective breast cancer drugs that aim to combat metastasis.

Targeted Epigenetic Editing Using Optogenetic Tools

Presentation ID:
MP-24

Room:
ARMS Atrium

Keywords:
Epigenetics, DNA Methylation, CRISPR, Optogenetics

Joshua Hahn, and Chongli Yuan
Purdue University

Epigenetics markers, such as DNA methylation and histone post-translational modifications, are modifications to the structure of DNA that impact gene expression without altering the genetic code. Among them, DNA methylation plays a critical role in various biological processes including the differentiation of stem cells, regulation of gene expression, and adaptation to environmental signals. The ability to modify DNA methylation at particular genes in various cell types is thus desirable for engineering specific cell phenotypes. Although technologies exist that can alter DNA methylation at target genes, these techniques lack spatial and temporal resolution and are not able to selectively edit individual cells within a cell population, which poses issues when trying to create new disease models and understand cell development. In this work, we incorporate spatiotemporal control to epigenetic editing tools via the use of optogenetic proteins CIB1 and CRY2. CIB1 and CRY2 form a multimer when exposed to blue light of wavelength 390-480 nm. To create a targeted DNA methylation editing system, CIB1 was fused to dCas9, which guides the editing tool to the site of interest, while CRY2 was fused to DNMT3a, a DNA methyltransferase. Upon exposure to blue light, CRY2 is recruited to CIB1, bringing DNMT3a close to the targeted gene and adding DNA methylation at specific locations. This optically controlled system holds potential as it can be readily adapted to modify different genes and different epigenetic markers with spatiotemporal precision.

Magnetically Actuated Cell Stretching Platform to Induce Phenotypic Changes in Metastatic Cells

Presentation ID:
MP-25

Room:
ARMS Atrium

Keywords:
Magnetic Actuator, Cell Stretching Platform, Mechanical Stimuli, Breast Cancer, Tumor Microenvironment

Yong Gyun Cho, Hyunsu Park, Hyowon Lee, and Sarah Libring
Purdue University

Although metastasis is responsible for about 90% of cancer deaths, only few in vitro models can be used to evaluate dynamic behaviors of metastatic cancer cells. Many studies have shown that mechanical stimuli can trigger various cellular responses such as gene and protein expression, which could lead to changes in cellular phenotype. Similarly, metastasized breast cancer cells in the lung tissue are constantly stretched by cyclic mechanical stress due to breathing, which alters cellular morphology and proliferation state. Such transitions can make the secondary tumors resistant to the chemotherapy used to effectively treat the primary tumors. In this work, we developed an in vitro tumor microenvironment that simulates in vivo respiration to investigate the mechanism of the phenotypic changes of metastatic breast cancer cells due to mechanical stimulation. We designed and fabricated magnetic microactuators using maskless photolithography technique to stretch tumor cells. Next, we coated fibronectin fibrils over the gaps of microactuators to mimic natural ECM environment and seeded tumor cells on the fibronectin mesh to generate a tumor microenvironment. As a result, the amount of strain that our microdevice could apply on the fibronectin mesh corresponded to the amount of strain experienced during normal respiration. In conclusion, the magnetically actuated in vitro cell stretching platform can provide precise strain control over a large actuation range to mimic mechanical stimulation in the lung. In the future, we will evaluate potential changes in metastatic cell phenotype and provide additional insights on the mechanism of secondary tumor drug resistance.

High-Throughput Nanoliter Dispensing Device for Biological Applications

Presentation ID:
MP-26

Room:
ARMS Atrium

Keywords:
Dispensing, Small-Volume, Bacteria Identification, High-Throughput, Solenoid Valves, and Five-bar Mechanism

Cole Reynolds, Euiwon Bae, and J. Paul Robinson
Purdue University

Pathogen identification is a field that can contribute largely to the prevention of the spreading of illness and disease. In the past, pathogen identification has been a long and arduous process due to the time-consuming processes and steps that requires technician's time and effort. With new technologies emerging however, screening of bacteria colonies can be done in a quick and high-throughput way. The problem is that using the current methods, bacteria cannot be transferred to petri dishes fast enough to keep up with the new screening methods. The current study focuses on exploring different methods to create an ergonomic device that can dispense and inoculate bacteria cells onto petri dishes in a fast, repeatable, and high-throughput manner. The testing of bacteria in liquid allows for the most versatility because bacteria already suspended in liquid could be tested or bacteria could be suspended in liquid from a solid if needed. Different methods of dispensing liquid were tested such as solenoid valves, and different methods of dispenser movements in the X-Y plane around the surface of the petri dishes were tested such as a five-bar mechanism controlled by two rotary motors. It was found that a small solenoid valve in combination with either a five-bar mechanism with two motors or a simple XY stage were both ergonomic and able to provide high-throughput dispensing of bacteria colonies. Based on the devices performance, it can dispense 86 microliter droplets with 8 millimeters of spacing in 69 seconds (1.25 drops per second).

Genome Analysis of Multiple Mycobacteriophage

Presentation ID:
MP-27

Room:
ARMS Atrium

Emily Kerstiens, Kari Clase, Yi Li, Gillian Smith, and Sarah Bell
Purdue University

Bacteriophage are viruses that infect and kill bacteria. They can be used as treatments for antibiotic resistant bacterial infections, but more knowledge is needed about phage and how they interact with bacteria in order to develop safe and effective phage therapy treatments. This study examines the genomes of eighteen mycobacteriophage that were isolated from the environment on and surrounding Purdue University. Phage genomes were annotated using several bioinformatics software, including DNA Master, GeneMark, and PECAAN. Evidence was examined to determine the correct location within the genome and the potential function. Approximately two thousand genes were annotated in this study. A variety of functions were predicted that help mediate the interactions with bacteria, such as DNA replication and structural protein. There were also many potential proteins from that phage where the function could not be predicted. Future studies will include other methods beyond annotation to determine the function of the predicted gene products and their impact on bacteria. The outcomes from this research can help provide new knowledge in biotechnology that can ultimately lead to new therapeutic treatments for infectious diseases.

Keywords:
Bacteriophage, Microbiology, Genomics, Genetics, Bioinformatics

Creating a Mammary Duct Model to Study the Effects of Cancer Heterogeneity on Tumor Metastasis

Presentation ID:
MP-28

Room:
ARMS Atrium

Megan Hofstetter, Mazin Hakim, and Luis Solorio
Purdue University

During tumor progression, the process of clonal evolution gives rise to a variety of cell subpopulations that cause differential sensitivity to drugs and give rise to cell populations with the ability to metastasize, there are many mouse models available that can be used to study tumor progression and metastasis. However, there is a lack of models to study the effect of tumor heterogeneity using human cancers. Xenograft based systems require the use of immunodeficient mice, which limits the use of the model to evaluate microenvironmental factors involved in metastatic dissemination. Humanized mouse models with established human immune systems have been developed. However the high cost, and deficiencies in the immune system limit their clinical utility. One way to combat these issues is through tissue-engineered models. A mammary duct model was created to study the effects of breast cancer cell heterogeneity on metastasis. A 3D printed mold was fabricated to create a lumen, representative of the hollow mammary duct using type I collagen. After lining the interior of the lumen with Matrigel to mimic the basement membrane, normal human epithelial cells (HMLEs) were seeded into the lumen. Future studies will use this physiologically relevant tissue model to systematically evaluate microenvironmental factors that drive human breast tumor initiation, progression, and metastasis. This model can further be used to study the effect of cancerous oncogenes that are activated by the presence of a common cancer drug, such as doxycycline, as well as systematically investigate the role of the tumor microenvironment on tumor progression.

Keywords:
Mammary Duct Model, Metastasis, Collagen Lumen

Improving Biomanufacturing Production with Novel ELP-Based Transcriptional Regulators

Presentation ID:
MP-29

Room:
ARMS Atrium

Juya Jeon, Logan Readnour, and Kevin Solomon
Purdue University

Microbes can be used to produce valuable drugs, chemicals, and biofuels, but their potential has not been fully realized due to low production yields. To improve biomanufacturing processes and yield, we are developing novel, transcriptional regulators using biosynthesis technology in order to improve cellular health and overall production. Our regulator contains elastin-like polypeptides (ELPs), which make ideal sensors since they exhibit a sharp, inverse phase transition to indicators of cell health such as intracellular pH and ionic strength, and external stimuli such as temperature. We hypothesize that ELP can be fused to transcription factors to control expression of target genes. As proof of concept, Tet repressor protein (TetR) was fused to ELP to control expression of the red fluorescent protein mCherry, which was cloned under a Tet repressible promoter. The ability of TetR-ELP to control expression was determined by measuring fluorescence above and below the transition temperature (Tt) of ELP. Below the Tt, TetR is free to repress mCherry production, but above the Tt, ELP should aggregate, preventing TetR from repressing mCherry. However, our results showed that fluorescence was not affected as expected. We hypothesize that the observed behavior is due to either TetR having temperature sensitivity or that the binding affinity of TetR to DNA is much stronger than ELP aggregation. Further steps include proving this hypothesis and finding alternative transcription factors to test. These tested gene regulators will allow us to optimize production yield of microbe and bring development in manufacturing of drugs, chemicals, and biofuels.

Keywords:
Microbes, Elastin-like Polypeptides, Biosynthesis, Gene Expression, Biomanufacturing

Engineering Bioluminescent Sensors of Cyclic AMP to Study Opioid Signaling

Presentation ID:
MP-30

Room:
ARMS Atrium

Keywords:
Fluorescent Protein, BRET, Live-cell Imaging, cAMP, Kappa Opioid Receptor, Bioluminescence

Alexander Tesmer, Alexander French, and Mathew Tantama
Purdue University

Opioids are small signaling molecules which bind to opioid receptors on the surface of cells. The kappa opioid receptor (KOR) is one of three major types of opioid receptors found in human neurons. When an opioid binds to a KOR, a variety of biochemical signaling pathways are activated inside the cell. Each of these pathways are associated with different physiological effects of KOR activation. The production of a small signaling molecule, cyclic adenosine monophosphate (cAMP), is known to be inhibited during KOR activation of the analgesic (pain-killing) signaling pathway. The ability to interrogate the individual responses of KOR signaling pathways in a living mammal would greatly improve our understanding of how opioids work in the brain. To this end, we have developed a biosensor functioning via bioluminescent resonance energy transfer (BRET) as a tool for both fluorescent and luminescent ratiometric quantification of cAMP. We couple two fluorescent proteins, emitting at different wavelengths, to a luciferase which provides chemiluminescent excitation energy for the complex. The intensity of the two emitted wavelengths vary inversely to each other in response to the presence of cAMP. Calculating the ratio of the two emission intensities creates a metric for cAMP concentration that is normalized to the concentration of our sensor, allowing quantitative comparison across trials. The application of our sensor for dual-color live-cell microscopy was demonstrated in mammalian cells using fluorescence and bioluminescence microscopy. Further proof-of-principle studies in KOR-expressing mammalian cells demonstrates the viability of our sensor for live-cell KOR signaling.

Cost-effective Paper-based Diagnostic Using Split Proteins to Detect Yeast Infections

Presentation ID:
MP-31

Room:
ARMS Atrium

Keywords:
Yeast Infections, Paper-based Diagnostics, Split Proteins, Cheap Diagnostics, Synthetic Biology, Biotechnology, Biological Engineering, Biomedical Engineering

Zachary Berglund, Kevin Solomon, Mohit Verma, Moiz Rasheed, Zachary Hartley, Kevin Fitzgerald, Kok Lee, Janice Chan, Julianne Dejoie, Makayla Schacht, and Alex Zavala
Purdue University

The common yeast infection, vulvovaginal candidiasis, affects three out of four women throughout their lifetime and can be spread to their child in the form of oral candidiasis (thrush). This disease is caused by the fungal pathogen *Candida albicans*, which is also a major cause of systemic candidiasis, a rarer but deadly disease with up to a 49% lethality rate. Current widely-used diagnostic methods include cell cultures, pH tests, and antibody detection, to assist effective treatment. Despite availability of various diagnostic methods, there is no inexpensive, rapid, and accurate way to detect *C. albicans* infection. This project aims to develop a paper-based diagnostic test for *C. albicans* that is, cost-effective, quick, and precise. The test detects the specific biomarkers farnesol and tyrosol produced by *C. albicans* by binding them to the split proteins pqsR and tyrosinase, respectively. Upon binding, a split horseradish peroxidase catalyzes and produces an amplified colorimetric signal by oxidizing the substrate tetramethylbenzidine (TMB) turning the paper blue. This test will produce a colorimetric output for a simple-to-understand diagnosis without any infrastructure. We predict that this device can give a response in under 2 minutes while costing around an estimated 10 cents per device This test may provide a way for an easy and cheap way to diagnose candidiasis worldwide, reducing the abuse of antifungals and provide an accurate way to treat vulvovaginal candidiasis and systemic candidiasis.

Flow Analysis and Processing
ARMS Atrium, 11:00 AM – 12:15 PM

Characterization of Bubble Detachment Process

Presentation ID:
MP-32

Room:
ARMS Atrium

Keywords:
Bubble Detachment/Formation, PLIF, Velocity Field

Wentao Zhong, Weixiao Shang, Puyuan Wu, and Jun Chen
Purdue University

Detachment of gas bubbles and its subsequent rise in liquid affect the chemical and petrochemical system significantly. Also, the principal of bubble detachment is very important in the study of cavitation and many electrochemical devices. Understanding the transport and transfer process in gas-liquid phase can help to better estimate the interfacial area and thus improve the device performance. Planar Laser Induced Fluorescent (PLIF) was applied in the experiment to measure the velocity field of bubble's detachment from the glass tube in a water tank. The water tank was seeded with small particles that obeyed fluid dynamics and can emit fluorescent when illuminated by a specific laser. A high-speed camera was used to capture a sequence of digital images with particles on it. Cross-correlation algorithm was applied to calculate the velocity field by analyzing the differences between two successive pictures. The experiment shows that the velocity magnitude around the bubble increases as the bubble detaching from the outlet. Streamlines from the tip of the bubble to the tail of the bubble was also observed. The result sheds light on the principal of the detachment process which helps in many engineering systems.

Bacteria Movement Near Surfaces

Presentation ID:
MP-33

Room:
ARMS Atrium

Shulin Wang, Adib Ahmadzadegan, and Arezoo Ardekani
Purdue University

Keywords:
Hydrodynamic Interaction, Escherichia coli, Biodegradation

Understanding the behaviors of bacteria near surfaces is crucial in many biological and ecological applications. This knowledge can be used to hinder undesired biofilm formation on medical instruments and wounds. On top of that, it could also provide further insights in biodegradation of dispersed oil. In this work, the behavior of *Escherichia Coli* near a surface was experimentally studied. We utilized an inverted microscope in the phase filed illumination mode and processed acquired images to track the motions of bacteria near surfaces with high accuracy and repeatability. Distribution of the cells when they reached a steady state shows that the number of bacteria near solid surfaces increases, which is consistent with previous studies.

Stability of the Interface Between Two Immiscible Liquids During Injection Into a Tapered Hele-Shaw Cell

Presentation ID:
MP-34

Room:
ARMS Atrium

Zihao Lin, Ivan Christov, and Daihui Lu
Purdue University

Keywords:
Viscous Fingering, Multiphase Flow, Interfacial Instabilities, Variable Flow Geometry

In the early twentieth century, petroleum and mining engineers noticed that water does not displace oil uniformly. This phenomenon, when water penetrates through oil, is now known as viscous fingering. This discovery and the following extensive research have contributed to enhancing oil recovery. In this paper, we describe a numerical study conducted on the stability of the interface between two immiscible liquids in converging and diverging Hele-Shaw cells with varying gradients. Hele-Shaw cells are narrow flow geometries that mimic the properties of a porous medium with fixed permeability. By using computational tools built on the OpenFOAM platform, the multiphase flow dynamics can be accurately resolved and observed at small scales. The flow is computed in several designed tapered cell, which emulate natural heterogeneity in an actual porous medium. By analyzing the finger length under the same time period in both parallel cells and tapered cells, we found that the diverging cell relatively decreases the growth compared with the converging cell. Our primary conclusion, confirming previous theoretical predictions, is that the gradient of the tapered geometry variation has an effect on the sign of interfacial growth rate, which means the interface could be destabilized or stabilized depending on the absolute value of the gradient.

Flow Measurement Using Electron Beam Flourescence

Presentation ID:
MP-35

Room:
ARMS Atrium

Richard Brookes, Andrew Strongrich, Anthony G Cofer, and Alina Alexeenko
Purdue University

Keywords:
Electron Beam Fluoroscopy, Electron Fluorescence, Low Density Gas Flows, Flow Measurement, Gas Dynamics

Low density, high-speed flows are of interest to many research areas including, spacecraft thrusters, hypersonic vehicle control, and atmospheric re-entry studies. Measurement of low-density gas flows by traditional methods such as Schlieren Photography or Particle Image Velocimetry is often not possible. In order to yield new information about gas behavior at low densities the technique of electron beam fluorescence is being re-evaluated. By recreating previous electron beam fluorescence setups used to measure density, the experiment operating parameters including beam strength and density ranges are assessed and a foundation can be built for further experimentation. Comparing intensity plots of imaged flows against expected luminosity of fluoresced gases provides correlation data to assess necessary experiment conditions. Future work includes, using spectroscopy to determine gas density, composition, velocity and temperature.

Materials and Structures

ARMS Atrium, 11:00 AM – 12:15 PM

Characterization And Modeling Of Discontinuous Fiber Composites

Presentation ID:
MP-36

Room:
ARMS Atrium

Keywords:
Composite Materials, Discontinuous Fibers, X-ray Micro-computed Tomography

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University of Puerto Rico, Mayagüez[1] and Purdue University[2]

Composite materials, which are light and strong, are of great interest to engineers in the aerospace industry. Specifically in this work, a discontinuous short fiber reinforced polymer composite whose matrix is Polypropylene and fibers are Electric-glass oriented in different directions was studied. The performance of this material is highly dependent on its microstructure, and therefore the objective of this research is to non-destructively characterize the microstructure of the composite material. This includes characterization of its fiber orientation and length, fiber volume fraction, and void volume fraction. To do this, X-ray micro-computed tomography has been used, providing two dimensional cross-sectional images that stack to form a three-dimensional image of the microstructure. Advanced image-processing methods have been used to determine the fiber volume fraction, the void volume fraction, and the fiber length distributions. Characterization of the microstructure will help predict its mechanical properties and establish a general framework for characterizing and predicting the strength of composite materials. Through the advanced characterization and strength prediction methods discussed in this work, engineers will eventually be able to quickly and non-destructively evaluate materials and thereby reduce large scale testing in aerospace applications.

Investigation of the Effects of Solid-State Treatments on the Structure and Mobility of Copper in Zeolites

Presentation ID:
MP-37

Room:
ARMS Atrium

Keywords:
Zeolites, Catalysis, Solid-State Ion-Exchange

Jiayang Wu, Laura Wilcox, and Rajamani Gounder
Purdue University

Zeolites are microporous, aluminosilicate catalysts that play an important role in industrial applications as well as studies for the fundamental understanding of catalysts for emerging reactions of interest. The introduction of aluminum into the zeolite lattice introduces a negative charge on the framework that can be balanced with extra-framework cations. The control of the aluminum distribution and the choice of charge balancing cations allows for the ability to tailor the active sites to facilitate a desired reaction. This research focuses on studying copper active sites in zeolites. Copper oxide was used as a copper precursor to introduce copper ions in zeolites through solid-state ion-exchange (SSIE). Solid-state ion-exchange was studied using both dry air and wet air treatments at elevated temperatures. Three different zeolite topologies were studied: CHA (small pore), ZSM-5 (medium pore), and MOR (large pore). After SSIE, the copper-zeolites were characterized with atomic absorption spectroscopy (AAS) after sodium back exchange to quantify the number of ionic copper species, and temperature programmed desorption (TPD). These characterization techniques were used to understand how many copper ions were mobilized into the zeolites, which are potential active sites in zeolites. Based on current experimental data on Cu-MOR, SSIE using a wet air treatment has a greater impact for mobilizing copper in zeolites compared to a dry air treatment. The same trend is expected to follow on other zeolite topologies, ZSM-5 and CHA, that are still being studied.

Reliability of Lead-Free Solder Joints Under Combined Shear and Compressive Loads

Presentation ID:
MP-38

Room:
ARMS Atrium

Keywords:
Solder Alloys, Lead-Free Solder, Creep, Cyclic Fatigue, Fracture

Ian Bernander, Travis Dale, Yuvraj Singh, and Ganesh Subbarayan
Purdue University

In electronic assemblies, solder joints are used to create electrical connections, remove heat, and mechanically support the components. When an electronic device is powered on, the solder joints and the board they are attached to heat up, expanding at different rates. Due to the difference in expansion, shear stress is imposed on the solder joints. As the device is powered on and off, this shear stress can eventually fracture the solder joint, causing the device to fail. Therefore, to increase the lifespan of electronics, it is important to investigate the mechanical properties of solder alloys. The present study investigates how the SAC 305 solder alloy (96.5% Tin, 3% Silver, 0.5% Copper) degrades under simultaneous compressive loading and shear cycling. The effect of compressive load on solder joint life has not been systematically studied in prior work but is critical to understand as large heat sinks are bolted onto increasingly large electronic assemblies, adding compressive stress on solder joints. To gather data, we constructed a custom shear tester. Shear loads were applied using a programmable motor. A pulley system applied compressive loads. Tests were conducted on a large number of samples under varying shear and compressive loads. The data showed that, for compressive loads below 30N, increasing the compressive load decreased the rate of damage to the sample. However, at the highest compressive load of 45N, the sample fractured immediately. This suggests that applying small compressive loads to critical components of electronic devices could improve their long-term reliability.

Study of the Effective Thermal Conductivity of Polymer Composites with Varying Filler Arrangements

Presentation ID:
MP-39

Room:
ARMS Atrium

Keywords:
Thermal Conductivity, Polymer Composites, Percolating Networks, Effective Medium Theory, Electronics Thermal Management

Debraliz Isaac Aragones[1], Rajath Kantharaj[2], Aaditya Candadai[2], and Amy Marconnet[2]
University of Central Florida[1] and Purdue University[2]

Alternative thermal management solutions for electronic devices are being widely explored due to the increasing heat concentration that results from shrinking sizes and increasing power of modern electronics. Clearly, there is a need to spread the heat effectively in these systems, and polymer composites can potentially provide high thermal conductivity at low filler fraction while maintaining desirable mechanical properties for electronic packaging. The present study aims to investigate the effective thermal conductivity of various copper filler arrangements in a polymer matrix. The polymer composites are fabricated using laser cut acrylic templates to embed aligned copper rods in epoxy and create different configurations, from ordered to random arrangements, while maintaining a constant volume fraction. Heat conduction through the cross-section of the composites is studied using an infrared (IR) camera that enables 2D mapping of temperatures. The effective thermal conductivity of the composites is obtained using a simplified 1-D reference-bar type technique. The experimentally obtained effective thermal conductivity is validated using both simulation software and relationships from the effective medium theory. The resulting effective thermal conductivity of the different configurations are compared to obtain an optimum filler configuration. Furthermore, the experimental and simulation results help provide an understanding of the effect percolation networks have on the effective thermal behavior of composite materials. Such polymer composites, with enhanced conductive properties, can be implemented in electronic packaging as an alternative to conventional heat dissipation methods (i.e. mechanical fans, heat sinks, fins, etc.).

Spatial Variation of Surface Residual Stress in Metallic Materials

Presentation ID:
MP-40

Room:
ARMS Atrium

Keywords:
Shot Peening, Residual Stress, Predictive Model, Non-destructive Testing

Chengyang Zhang, David Bahr, Siavash Ghanbari, and Raheleh Rahimi
Purdue University

Shot peening is commonly used to reduce fatigue failures in industrial parts by introducing compressive residual stress into the surface of a material. However, it is challenging to assess the performance of the parts without destroying them. Solving this problem requires a combined model that predicts both recrystallization and residual stress using experimental measurements and predictive computational modelling. Experiments were performed to prove that the surface properties of materials after thermal treatments can be accessed, and the spatial variation of residual stress in metallic materials, including the relationship between surface and subsurface behavior can be evaluated. This process involves investigating the surface residual stress profile using a spatially sensitive X-ray diffraction technique, followed by other procedures such as cutting and investigation of microstructure and subsurface residual stress. With a model like this, the performance of industrial parts can be assessed in a non-destructive way. It is crucial that the parts can still serve the original purpose after being tested.

Examining the Effects of Amino and Thiolate Ligands on the Reactivity and Selectivity of Palladium on Carbon in Hydrogenation Reactions.

Presentation ID:
MP-41

Room:
ARMS Atrium

Keywords:
Catalysis, Palladium, Heterogeneous Catalyst, Hydrogenation, Ligand Effects.

Eric Liu, and Christina Li
Purdue University

Heterogeneous catalysts are used widely by chemical and energy industries because they show high reactivity but often suffer from lack of selectivity. On the other hand, ligands are commonly used in homogeneous catalysts to control the reactivity and selectivity; however, the effects of the ligands on the steric and electronic properties of heterogeneous catalysts are less understood. We examine the effects of four different ligands: 1-adamantanethiol, 1-adamantylamine, 1-dodecanethiol, and 1-dodecylamine, for the commercial hydrogenation catalyst palladium on carbon. Hydrogenation reactions are used as a screening tool to see the behavior that the different catalysts exhibit in the presence of unsaturated functional groups. Specifically, we study the hydrogenation of alkynes, carbonyls, nitriles, and nitro functional groups as well as the reductive amination between an aldehyde and an amine. Trends across the reactions are observed and are related back to the properties of the different ligands. In the hydrogenation of diphenylacetylene, the catalyst with 4 equivalents of 1-adamantanethiol as the ligand with respect to palladium shows 73% selectivity towards the alkene product whereas the non-ligated palladium on carbon goes 100% to alkane. This shows how ligands can affect the selectivity of heterogeneous catalysts. As ligands effects are understood more thoroughly, more effective catalysts can be designed for industrial reactions.

Using Vesicular Dispersion for Stabilizing Suspensions of Dense Colloidal Particles against Sedimentation

Presentation ID:
MP-42

Room:
ARMS Atrium

Keywords:
Vesicles, Dispersant, Colloidal Dispersion

Hanlin Zhu, An-Hsuan Hsieh, David Corti, and Elias Franses
Purdue University

Colloidal dispersions, like inks and paints, are often required to remain stable for long times, i.e., the dispersed colloidal particles should remain suspended. In most cases, a stable dispersion requires preventing the agglomeration of the suspended colloidal particles. If the particles agglomerate, their sizes will increase and rapid sedimentation will occur. Nevertheless, many colloidal particles of commercial interest have high densities. Thus, they quickly settle even without agglomeration. One novel approach to preventing the settling of high density particles is the use of close-packed vesicular dispersions (CPVDs) made of the surfactant DDAB (didodecyldimethylamine bromide). Previous work demonstrated the ability of these CPVDs to prohibit the settling of high density titania particles. However, only a limited range of particle sizes that were found to remain stable with CPVDs were investigated. Also, the effects of the method of preparation of the CPVDs was not fully explored, as an effecitve CPVD should be generated from the smallest possible amount of added DDAB. Thus, the impact of various preparation methods on the resulting properties of the DDAB vesicular dispersions are examined. DDAB vesicular dispersions are generated via stirring only to form primarily liposomes, sonication to break down large multi-layer vesicles, and extrusion through membranes to obtain specifically sized vesicles. Various light scattering and absorbance techniques are also used to probe the structure of the vesicular dispersions, important information needed for improving the ability of CPVDs to stabilize against sedimentation a broader range of colloidal particle sizes.

Device Design

ARMS Atrium, 11:00 AM – 12:15 PM

Design Modifications for a Small, Affordable Low Intensity Focused Ultrasound Device

Presentation ID:
MP-43

Room:
ARMS Atrium

Keywords:
Focused Ultrasound, Device Design, Low Intensity, Fabrication

Sui Shen, Kelsey Bayer, and Pedro Irazoqui
Purdue University

Depression is a prevalent and serious medical illness, and while there are antidepressant drugs to mitigate depressive symptoms, 10 - 30% of patients either do not respond or develop a tolerance to these medications. Literature supports that there is an interrelation between the inflammatory response and treatment-resistant depression. A promising method to tackle depressive symptoms is to block the inflammatory signaling pathway with vagus nerve stimulation (VNS), reducing pro-inflammatory cytokine levels. Although electrical VNS devices exist, they are invasive, expensive, and have side effects including voice alteration, dyspnea, and cough. Low intensity focused ultrasound (LIFU) is a promising method that can stimulate a desired region noninvasively and without long term negative side effects. Nonetheless, the existing LIFU devices can be expensive, cumbersome, and large. The Center of Implantable Devices designed a prototype called the SonicNode that incorporates a transducer, matching network, and an amplifier into a 50 mm x 57 mm x 76 mm package. We modified the transducer head and created an intensity map of the focal region to demonstrate the improved performance of the device. The SonicNode and LIFU technology can be employed for long term, noninvasive treatment of a variety of neurological disorders.

Full Baseband to RF Reader Design for a Passive RFID Tag With Multiple Environmental Sensors

Volkan Arslan[1], Yuhang Zhu[2], John Peterson[2], and Saeed Mohammadi[2]
Sabanci University[1] and Purdue University[2]

Radio-frequency identification (RFID) readers are being widely used for automatically receiving information from chips or tags. The RF reader in this project will be used for reading the previously designed self-powered sensors on plants for agriculture. The design has two main components, the analog frontend and digital baseband. Transceiver is operating at 1.2GHz. For digital baseband, Field-programmable gate array (FPGA) is used for catching data coming from RF Frontend circuit. FPGA decodes, process then stores the Miller encoded data. The data rate of reader is 333 kbps. By this design, temperature and humidity information of plants could be received.

Presentation ID:
MP-44

Room:
ARMS Atrium

Keywords:
RFID, RFID Reader, RF Frontend, Transceiver, RF Reader

AFTERNOON ORAL PRESENTATIONS

AO

Environment and Sustainability

ARMS B061, 1:30 PM – 2:45 PM

Electronic Effect of Platinum Alloy Catalysts on Olefin Hydrogenation Kinetics

Colin Reedy[1], Jeff Miller[2], and Stephen Purdy[2]
Creighton University[1] and Purdue University[2]

Dehydrogenation of alkanes is the first step in transforming light hydrocarbons into liquid fuels and chemicals. This process has traditionally used platinum alloys as catalysts. Alloys are used industrially because they have a greater selectivity than monometallic platinum. Alloying platinum with an inactive promoter modifies the crystalline structure of the surface (geometric effect), and the 5d electrons in platinum responsible for chemistry (electronic effect); both have been suggested to be primarily responsible for dehydrogenation selectivity in platinum alloys. Alloy catalysts have been synthesized using early 3d transition metal promoters with the same Pt_3M crystal structure. X-Ray Absorption Spectroscopy (XAS) was used to quantify the electronic changes between the different catalysts and platinum. Reaction orders and activation energies for the hydrogenation of ethylene were collected to quantify how the electronic effect modifies the kinetics of a structure insensitive reaction. Comparing the results of platinum and the alloys, we found that these promoters' electronic effect had a significant effect on the apparent kinetics of the reaction. The implications of these results on selectivity of platinum alloys for dehydrogenation are discussed.

Presentation ID:
AO-01

Room:
ARMS B061

Keywords:
Energy, Catalysis, Shale Gas, Alkane Transformation

Fluidic Control with Wax Valves for Paper-based Diagnostics

Emilie Newsham, Elizabeth Phillips, Katherine Clayton, and Jacqueline Linnes
Purdue University

Paper-fluidic devices are a common platform for point-of-care disease detection in under-resourced areas because of their low cost and minimal instrumentation requirements. Limited fluidic control in paper-fluidic devices has hindered the incorporation of multistep reactions that are necessary for more sensitive disease detection. One potential fluidic control mechanism is the incorporation of thermally actuated wax valves to separate assay stages. Such valving would expand the detection capabilities of these devices by permitting fluid obstruction for sustained reactions and facilitating controlled volume release within a fully-automated, self-contained device. Despite the potential to exploit wax valves for innovative paper-fluidic diagnostics, a thorough, quantitative analysis of how they can best be used has not been performed. Here, in parallel macroscopic and microscopic analyses, we show that wax valves' geometry and surface area in paper test strips influence flow behavior when thermally actuated. Macroscopic analysis evaluated the flow rate past the valves of the visible fluid front across the width of the membrane; microscopic analysis used particle image velocimetry to evaluate trends in particle flow before and after valve actuation. Preliminary results indicate that geometry and size influence valve opening times and the rate of fluid flow past the valves. Future analyses will compare the macroscopic and microscopic velocity profiles in various assay spaces and times to provide quantitative insight to the inner workings of paper-fluidic devices. This information will facilitate intelligent and efficient design of multistep paper-fluidic detection technologies with potential applications in lateral flow immunoassays, two-dimensional paper networks, and other point-of-care diagnostics.

Presentation ID:
AO-02

Room:
ARMS B061

Keywords:
Lateral Flow Assay, Multi-step, Fluidic Control, Paper Fluidics, Flow Analysis

Effect of salts on the deadly amphibian chytrid fungus Batrachochytrium dendrobatidis

Presentation ID:
AO-03

Room:
ARMS B061

Keywords:
Chytridiomycosis, Road Salts, Frogs, Salt

Mariah Burgmeier, Spencer Siddons, and Catherine Searle
Purdue University

The amphibian chytrid fungus *Batrachochytrium dendrobatidis* (Bd) is a parasitic fungus that infects and kills amphibians worldwide. Bd causes electrolyte imbalance by destroying the keratin in the skin and causes cardiac arrest. Past studies have shown that Bd growth and motility can be inhibited by increased NaCl concentrations. In most studies, NaCl is the only type of salt used but Bd is exposed to other types of salts. In North American wetlands, runoff from road salts during winter and spring when Bd hosts (amphibians) often experience high levels of infection prevalence. This study investigated how different road salts at various concentrations affect the growth and motility of Bd. We predict that Bd growth will be inhibited more by road salts that contain more de-icing chemicals such as $CaCl_2$ and that Bd growth will be the greatest in salts that are more environmentally friendly, such as Beet salt. Bd was reared in NaCl, $CaCl_2$, and Beet salt at concentrations of 0.5, 1.0, 1.5, and 2.0 ppt. Growth was then quantified through counting and measuring of the area of growth and compared across treatments. Bd growth is greater in the absence of any salt than in the presence of either Beet salt, $CaCl_2$, or NaCl. Bd growth at 14C was greater than at 22C. Our findings suggest several types of roads salts may have negative effects on Bd life history traits that could translate to lower infections in amphibians. Future studies should explore how road salts affect amphibians exposed to road salts, and how infection dynamics change when both host and pathogen are in the presence of these salts.

Waste heat recovery from a vented electric clothes dryer utilizing a finned-tube heat exchanger

Presentation ID:
AO-04

Room:
ARMS B061

Keywords:
Waste Heat Recovery, Heat Exchangers, Fin-and-tube Heat Exchangers, Thermodynamic Modelling, Clothes Dryers

Abdul Raheem Shaik, Stephen Caskey, and Eckhard Groll
Purdue University

Conventional residential clothes dryers continuously vent moist, hot air during the drying process. The vented air leaves the home but still has useful temperature and humidity that could be recovered to offset other heating demands in the home. A study is carried out to quantify the amount of heat extracted from the waste heat stream of a conventional, vented clothes dryer. To extract the heat, a water cooled, fin-and-tube heat exchanger is located within the exhaust duct. A steady state thermodynamic model was built in Engineering Equation Solver (EES). The model accounts for the heat exchanger's geometry and applies a dimensionless heat and mass transfer analogy (Colburn-j-factor) determined empirically to calculate an overall heat transfer coefficient for both dry and wet areas of the coil. Assuming water and moist air inlet temperatures, a rate of heat transfer and outlet temperatures of both air and water steam are predicted. The EES simulation explores what factors impact the rate of heat recovery from the moist air stream. Comparing the model prediction to experimental results identifies necessary modifications to the model and improves its accuracy. Using the tuned model, design improvements are identified to improve the overall rate of heat transfer, and thus the amount of waste heat recovered.

Short-term organic carbon release and chlorine disinfectant decay for cross-linked polyethylene (PEX) plumbing pipes

Presentation ID:
AO-05

Room:
ARMS B061

Keywords:
PEX, Plastic, Plumbing, Water Quality, Polyethylene

Miriam Tariq[1], Christian Ley[2], Maryam Salehi[2], and Andrew Whelton[2]
Louisiana State University and Agricultural and Mechanical College[1] and Purdue University[2]

The use of cross-linked polyethylene (PEX) plumbing pipes has grown in popularity for residential applications in an attempt to decrease metal content in tap water. However, PEX pipes can leach organic material into water that enable biofilm growth and form disinfection by-products (DBP) upon contact with chlorine disinfection residual. Also, different PEX pipe brands have varied manufacturing processes, which may add to the complexity of organic materials released from the pipes. In this study, the extent of carbon leaching from three brands of PEX pipes was monitored through water quality analysis. Seven different migration cycles were conducted with varying initial chlorine concentrations for type A (PEX-a), type B (PEX-b), and a type C (PEX-c) brand. Pipes were exposed to chlorinated tap water synthesized in the lab for up to five days. Water exposed to these pipes was analyzed to determine total organic carbon (TOC), assimilable organic carbon (AOC), total chlorine, and free chlorine concentrations. The different brands of PEX pipes were expected to have varying organic carbon release behaviors and reaction rates with the chlorinated water due to their distinct chemical compositions.

Materials Science

ARMS B071, 1:30 PM – 2:45 PM

Experimental Validation of a Numerical Phase Change Model for Microchannel Slug Flow Boiling

Presentation ID:
AO-06

Room:
ARMS B071

Keywords:
Flow Boiling, Microchannel, Phase Change, Simulation, Two-phase Flow

Christian Retter, Todd Kingston, Justin Weibel, and Suresh Garimella
Purdue University

Thermal management of high-power electronic devices continues to be a critical challenge. Flow boiling in microchannel heat sinks has been demonstrated to be an effective method for removing high heat fluxes from these devices owing to utilization of the latent heat of the fluid and the large surface area enhancement for heat exchange. However, microchannel flow boiling technologies have yet to be broadly implemented due to a lack of experimentally validated prediction and design tools. The goal of this study is to use high-fidelity experimental data to validate a previously developed numerical phase change model, to help enable physics-based prediction of flow boiling heat transfer characteristics and reduce the reliance on empirical-based correlations. A novel experimental facility was used to generate archetypal microchannel slug flow boiling and capture high-speed flow visualizations for a range of heat fluxes and flow rates. Image processing of the flow visualizations was performed to extract time-resolved hydrodynamic and heat transfer parameters, such as vapor bubble length and liquid film thickness. The experimental boundary, initial, and operating conditions are input into the numerical model, implemented via a user-defined function in a commercial finite-volume software package, to predict the vapor bubble growth by phase change and the liquid film thickness. A direct comparison of the model prediction and experimental results is performed and good agreement is obtained.

Load Distribution of Adjacent Prestressed Concrete Box Beam Bridges

Presentation ID:
AO-07

Room:
ARMS B071

Keywords:
Load Distribution, Bridges, Box Beam, Prestressed Beams, Shear Keys

Luis Urrego[1], Ryan Whelchel[2], Robert Frosch[2], and Christopher Williams[2]
Universidad de Los Andes – Colombia[1] and Purdue University[2]

One of the most common bridge types is the adjacent prestressed concrete box beam bridge because the system is economical and simple to build; over 43,000 are currently in service within the US. However, they are highly susceptible to strand corrosion and concrete deterioration which can result in early loss of load capacity. Therefore, an experimental program sponsored by the Indiana Department of Transportation (INDOT) was initiated to determine the behavior of deteriorated beams and develop recommendations for load rating and design of this bridge type. Displacement sensors were installed on a bridge in service to measure its deformation under load. Modifications of the bridge condition were made in phases. These phases included the initial condition, removal of the asphalt layer, cutting of the shear keys (beam joint), and construction of a concrete deck. The bridge used in this project was constructed of seven adjacent box beams, with a length of forty feet. Finally, after comparing the results, the change in load distribution was evaluated to determine how much the shear keys contribute to this, and if the addition of a concrete deck was an appropriate rehabilitation solution for the structure.

InGaN/GaN/ZnO Thermoelectric Properties

Presentation ID:
AO-08

Room:
ARMS B071

Keywords:
Thermoelectric Power, Energy, Nanotechnology, Material Science

Elizabeth Bell, Na Lu, and Yining Feng
Purdue University

The ability to harness waste heat and convert it into electricity via thermoelectric devices is a major breakthrough in green energy. Thermoelectric devices use the Seebeck effect to directly convert a temperature difference into a voltage output, or they can perform active cooling by running a current through the device. They have a wide range of applications, from portable refrigeration to power generation from an exhaust pipe or even body heat. However, the cost, scarcity, and inefficiency of current materials (i.e. Bi2Te3, SiGe) has limited the potential of thermoelectric power. With the discovery of better materials, it will be possible to use thermoelectric devices for more applications, increasing the use of renewable energy. The purpose of this study is to determine the thermoelectric properties indium gallium nitride grown on zinc oxide with a gallium nitride buffer layer (InGaN/GaN/ZnO), materials that are more cost effective and environmentally friendly, to determine their feasibility in thermoelectric devices. Several material properties were tested and reported, including the X-ray diffraction scan of the material structure, electrical properties such as conductivity and Seebeck coefficient, and the power factor, which determines the ability of the material to produce voltage. Based on this study, InGaN/GaN/ZnO has shown considerable potential as a material for thermoelectric generators due to its favorable power factor of up to 680·10-4 W/mK2 at room temperature. In the future, this material should be further tested within thermoelectric devices, and p-type doping methods should be explored to enable the device level performance.

Bringing Particle Scale Properties into Descriptions of Powder Behavior through the Enhanced Centrifuge Method

Presentation ID:
AO-09

Room:
ARMS B071

Andrew Roginski, Caralyn Coultas-Mckenney, Contessa Norris, and Stephen Beaudoin
Purdue University

Keywords:
Hamaker Constant, Enhanced Centrifuge Technique, Particle Adhesion, Powder Characterization

Inconsistent powder behavior introduces problems such as agglomeration, poor flowability, dust hazards, and segregation that decrease efficiency in powder processing environments. Understanding how a powder interacts with a surface at the particle scale provides insight into how to accommodate individual particle properties and avoid process deficiencies. This project uses an enhanced centrifuge technique to evaluate the adhesion between a stainless-steel surface and a powder comprised of fluorescent particles. Particles are deposited onto stainless steel plates which are rotated in a centrifuge. The adhesion properties are monitored by tracking the rotational speed at which particles of a known size are removed from the steel. To model the adhesion, a simulator was produced in MATLAB to map an ideal model to the experimental observations. In reality, the particles and steel are rough, and the particles are nonuniform in shape. The ideal case assumes the particles are smooth spheres and the steel is smooth. A modified van der Waals force model describes the observed forces. Within this model, a Hamaker constant, which usually describes only the effect of composition on the van der Waals force, is tuned to also describe the effects of the non-uniformity of the particles. This creates a distribution of 'effective Hamaker constants' that describes particle scale effects on the adhesion between the bulk powder and the stainless steel. This approach will allow industry to account for the effects of surface roughness, particle shape, and particle size when designing powder processing operations.

Determining the Optimal Traffic Opening Time Using Piezoelectric Sensors

Presentation ID:
AO-10

Room:
ARMS B071

Adlan Amran, Yen-Fang Su, and Na Lu
Purdue University

Keywords:
Piezoelectric Sensor, Electromechanical Impedance (EMI), Non-Destructive Testing (NDT), Early Age Strength

The Indiana Department of Transportation (INDOT) requires a reliable method of determining the early age quality of concrete to improve traffic opening time. We propose to develop an in-situ method that enables an accurate, efficient, and non-destructive health monitoring of concrete using the electromechanical impedance (EMI) technique coupled with a piezoelectric sensor named Lead Zirconate Titanate (PZT). The test was conducted by mounting a PZT sensor on mortar samples. The PZT sensor was then excited by a voltage to track the strengthening of samples. The data obtained from the EMI technique was refined using the Root Mean Square Deviation (RMSD) model. Simultaneously, identical mortar samples underwent a compressive test to measure sample strength in a destructive manner. Both tests were repeated by varying the mortar sample's cement type and water-to-cement ratio. Finally, both tests were compared to one another via regression analysis. The outcome has shown a significant correlation between the compressive strength and the EMI data. This indicates that the PZT based EMI technique can potentially be used to non-destructively measure the early age concrete strength for optimizing traffic opening time.

Health and Education
ARMS 1021, 1:30 PM – 2:45 PM

"I Don't Belong with All the Really Smart Kids Here": Student Characterizations of Belonging in Engineering

Presentation ID:
AO-11

Room:
ARMS 1021

Lisa Musselman[1], Jacqueline Rohde[2], Brianna Benedict[2], and Allison Godwin[2]
University of Dayton[1] and Purdue University[2]

Keywords:
Belongingness, Fit, Engineering Identity, Retention, Qualitative Methods

This research paper is a qualitative study of how students with diverse demographics, mindsets, and identities describe what it means to belong in engineering. Engineering students' sense of belonging has a significant impact on students' decisions to leave engineering. Talented students who feel that they do not belong in engineering are more likely to leave than their peers. Previous studies have focused on belonging for underrepresented students in engineering (e.g., women or minorities) or specific factors contributing to student belonging (e.g., classroom performance). However, few have explored how students describe what it means for them to belong in engineering to understand how this attitude may be formed and internalized by diverse students. To address this gap, thirty-five interviews were conducted with first-year engineering students at four universities under a semi-structured interview protocol to learn about students' experiences and perceptions of engineering. Interview transcripts were analyzed using inductive and deductive thematic coding to develop broader themes about how a diverse set of undergraduate students describe their sense of belonging in engineering. Student responses were compared to one another while being sensitive to potential differences in students' demographic or latent diversity (i.e., mindsets, beliefs, and values). Emerging results show differences in how students evaluate belonging relative to their peers. This research can inform and influence engineering faculty to serve students holistically by understanding how students describe belongingness and provides actionable implications to develop and support their sense of belonging. These efforts may support student retention of diverse students across engineering.

A Case Study of Engineering Students' Experiences with the Co-Op Application Process

Presentation ID:
AO-12

Room:
ARMS 1021

Keywords:
Cooperative Education, Personnel Selection, Engineering

Laura Long, Xinrui Xu, and Joyce Main
Purdue University

Engineering faculty and advisors emphasize the importance of obtaining industry experience in addition to academic learning. One way universities encourage their students to obtain hands-on work experiences is through cooperative education (co-op) programs. Previous studies have examined the advantages and disadvantages of co-op participation, but the application process for students has not been closely examined. Studying this process will show how academic institutions and companies can potentially enhance the student experience of applying for a co-op position. This study examines student experiences with the co-op application process based on interviews with engineering students at a research-intensive university in the Midwestern U.S. Results indicate that barriers to co-op participation include conflicting offer deadlines established by companies and unclear processes for students in employer matching. Research findings regarding the co-op application and placement process can potentially inform universities and companies on how students use resources designed to help students during the co-op application process, as well as the challenges some students encounter.

Targeting Pro-Inflammatory Function of Microglia Using Small Molecules to Combat Neurodegeneration

Presentation ID:
AO-13

Room:
ARMS 1021

Keywords:
Microglia, Cytokine, Neuroinflammation, Alzheimer's

Gabrielle Williams, Gaurav Chopra, and Priya Prakash
Purdue University

Microglia are the brain's resident immune cells that are responsible for maintaining homeostasis in healthy conditions. During injury or infection, resting microglia get activated and produce pro-inflammatory cytokines such as IL-1b, IL-1a, IL-6, etc. along with reactive oxygen species like nitric oxide (NO) to combat neuroinflammatory diseases such as Alzheimer's disease (AD). Inflammation is characterized by the activation of resident-immune cells in the brain called microglia that respond to the eat-me signals released by the toxic amyloid beta peptides as well as the dying neurons in the microenvironment. Recent studies have shown that activated microglia induce neuronal death by secreting IL-1a, TNF-a, and C1q. However, the cellular and molecular mechanisms in this process are not well understood. Furthermore, it has been previously shown that IL-1a and TNF-a promote neuronal death via the activation of astrocytes during inflammation. We used BV2 mouse microglia to investigate the IL-1a and TNF-a cytokine production in response to LPS activation using enzyme-linked immunosorbent assay (ELISA). In addition, the viability of the cells along with their NO production was evaluated using cell titer blue assay (CTB) and Griess assay. In this study, we show that small molecules can be used in single treatment and in combination to combat the inflammatory functions of microglia. These small molecules that modulate microglial functions may play an important role in developing new therapeutics for neuroinflammation.

Does STAT5a Have an Effect on BMAL1 Levels in Mammary Epithelial Cells?

Presentation ID:
AO-14

Room:
ARMS 1021

Keywords:
Mammary Gland Development, Lactation, Circadian System, Prolactin

Clare Aduwari, Aridany Suarez-Trujillo, Karen Plaut, and Theresa Casey
Purdue University

The mammary gland is a very important organ for reproduction in mammals because it produces milk which serves as the primary source of nutrients for newly-born offspring. Previous studies suggest that its development is regulated by circadian clocks, biochemical oscillators that generate circadian rhythms (the body's internal clock). The circadian system plays a major role in homeostasis, coordinating the body's internal physiology and synchronizing it with the external environment. Our lab showed that levels of the BMAL1 protein, a core clock component, increased in the mammary gland at the onset of lactation. Treatment of mammary epithelial cells (HC11) with the hormone prolactin significantly increased BMAL1 levels. We hypothesize that the secretion of prolactin during lactogenesis induces expression of BMAL1 in the mouse mammary gland through the STAT5a signaling pathway. The objective of the project was to determine the effect of different amounts of STAT5a protein on BMAL1 levels with and without prolactin treatment. For this experiment, western blot analysis was used to measure STAT5a and BMAL1 levels in wild type HC11 cells and in HC11 cell lines that were genetically modified to: 1) express very high levels of STAT5a (STAT5a-OE), 2) express a mutant form of STAT5a that is inactive (STAT5a-dnl), and 3) delete the BMAL1 gene (BMAL1 KO). Our first round of analysis showed that overexpressing STAT5a increased BMAL1 protein levels, especially in cells differentiated by prolactin. Results from this experiment would allow us to better understand the relationship between mammary gland development and the circadian system.

Effects of Circadian Disruption on NEFA Concentrations in Transition Period Dairy Cows

Grace Wernert, Aridany Suarez-Trujillo, and Theresa Casey
Purdue University

Presentation ID:
AO-15

Room:
ARMS 1021

Keywords:
Circadian Disruption, Non-esterified Fatty Acid, Dairy Cow

Eighty-percent of dairy cattle experience metabolic diseases during the transition period, three weeks preceding and following calving, resulting in decreased milk production. We hypothesize the circadian timing system functions to maintain homeostasis and regulates the physiological changes that occur during this time period. Our objectives were to determine the normal circadian rhythms of non-esterified fatty acids (NEFA) and blood glucose, and the effect of disrupting the circadian system on variables during the transition period. Five weeks before expected calving (BEC) multiparous cows (n=32) were moved to a tie-stall barn and divided into two treatments: control (n=16; 16 h light: 8 h dark) or phase-shifted (PS, n=16), a chronic jet lag paradigm which shifted the light-dark phase 6 h every 3 days, until parturition. All cows were exposed to control lighting after calving. Blood samples were taken every 4 hover 48 h at three time points: 23 BEC, 9 BEC, and 5 days postpartum (PP). NEFA, glucose, and beta-hydroxy butyrate levels were measured using colorimetric assays and the Centrivet monitor. Neither group exhibited rhythms pre-partum, however circadian rhythms were evident in control group for NEFA and glucose at 5PP. Centrivet analysis of blood glucose showed levels significantly higher ($P<0.05$) control versus PS group. NEFA levels were higher in PS cows. BHBA levels were raised in the PS group, but did not reach significance. We recommend keeping dairy cattle on a regular LD cycle to maintain homeostasis and eliminating unnecessary abrupt changes in the environment that could disrupt the circadian system.

Data Trends and Analysis

ARMS 1103, 1:30 PM – 2:45 PM

Developing an Electromechanical Carbon Dioxide Sensor for Occupancy Monitoring

Joshua Jenkins, Allison Murray, and Jeffrey Rhoads
Purdue University

Presentation ID:
AO-16

Room:
ARMS 1103

Keywords:
Sensing, Energy-efficiency, HVAC control, Vapor sensing

The Energy Information Administration reported in 2012 that heating and cooling processes consume nearly 35% of the total energy used by commercial buildings. In an effort to limit the amount of energy wasted in conditioning empty buildings and rooms, various occupancy detection techniques have been developed that can be paired with a smart heating, ventilation, and air conditioning (HVAC) control system. This work focused on the development of a novel carbon dioxide detector that is sensitive enough to accurately determine if, and when, a room is occupied. To test the new sensor design, a customized chamber with gas inlets was used to isolate the sensors in a controlled environment. The sensors were tested in this chamber alongside various commercial-off-the-shelf options for the purpose of both validating the developed sensors and observing if they exhibited increased sensitivity and selectivity over previous designs. Following these tests, the overall performance of the sensors was compared. The results of this comparison were subsequently used to assess the capabilities of the sensor designs and to identify areas for further improvement.

Sort vs. Hash Join on Knights Landing Architecture

Victor Pan, and Felix Lin
Purdue University

Presentation ID:
AO-17

Room:
ARMS 1103

Keywords:
Hash Join, Sort Merge Join, Knights Landing, Intel Xeon Phi, Database

With the increasing amount of information stored, there is a need for efficient database algorithms. One of the most important database operations is “join”. This involves combining columns from two tables and grouping common values in the same row in order to minimize redundant data. The two main algorithms used are hash join and sort merge join. Hash join builds a hash table to allow for faster searching. Sort merge join first sorts the two tables to make it more efficient when comparing values. There has been a lot of debate over which approach is superior. At first, hash join was mainly considered to be faster in most cases, but with the advancements in modern hardware, there is a lot more debate. We look at sort merge vs. hash join on Intel’s Xeon Phi 7210 processor with Knights Landing Architecture. Both algorithms are optimized to utilize the increased hardware capabilities. Our study compares the speed and efficiency of the two algorithms and provides conclusions and recommendations based on our observations.

Mechanical Properties of Interlocking Assemblies on a Rhombille Tiling

Presentation ID:
AO-18

Room:
ARMS 1103

Keywords:
Geometry, Topological Interlocking, Materials and Structures, Modeling and Simulations, Plane Tessellations

Kristoffer Sjolund, Andrew Williams, and Thomas Siegmund
Purdue University

The use of glue-less assembly methods has permitted the construction of rigid structures for centuries. Japanese interlocking wood joints and stereotomic structures by repetitious stacking of unit blocks are classical examples. The implementation of interlocking structures occurs when materials such as mortar and nails are unavailable or undesired. There has been a recent revival of interest in these construction methods as modern manufacturing tools enable new form and function. As humanity continues to innovate, materials possessing mechanical properties such as heightened flexibility without compromising strength or increased resistance to fracture will be needed. As one such example, this work examines interlocking assemblies emerging from a rhombille tiling. Rhombille tilings are formed by using three rhombuses to create a regular hexagon, then tessellating those hexagons. The resulting assembly is one of disphenoids and has either triangular or hexagonal symmetry. The elements are arranged such that the assembly forms a hexagonal plate with two thirds the density of a solid plate of equal thickness. Rotation free and restricted states are realized. The mechanical properties of this interlocked assembly are examined in finite element analysis and experiments performed on physical models realized by 3D printing. Initial results suggest a chiral response to loading paths in the hexagonally symmetric arrangement. Triangularly symmetric arrangements suggest load paths based on concentric or patterned hexagons. These load patterns are distinctly different from those in comparable solid plates. All assemblies have shown fracture resistance where damage is localized to few elements, leaving the remainder of the plate intact.

Autoencoder for Continuous Representation of Discrete Chemical Data

Presentation ID:
AO-19

Room:
ARMS 1103

Keywords:
Autoencoder, Chemical Space, Deep Neural Network, Fuel Cell

Mariana Rodríguez[1], Nicolae Iovanac[2], and Brett Savoie[2]
Universidad de Los Andes – Colombia[1] and Purdue University[2]

Fuel cells are a promising alternative energy source that are capable of efficiently producing energy by reacting hydrogen and oxygen to generate clean water vapor as the only byproduct. However, one of the major bottlenecks in fuel cell research is the limited operating range, environmentally hazardous synthesis, and high cost of the membrane material. However, the investigation of alternative membrane chemistries has been slow due to the cost associated with synthesizing new polymers and only a small number of alternatives have been studied. Here we address this challenge by utilizing physics-based quantum chemistry and machine learning to accelerate the discovery of novel membrane materials. We trained an autoencoder, which is a deep learning architecture, to reversibly convert discrete molecular structures into a continuous vector representation that is amenable to machine learning. The training of this autoencoder is coupled with a predictor that estimates chemical properties, including pKa, from this vector space. This chemical autoencoder combined with computational chemistry methods allows us to implement searching and optimization procedures to discover promising membrane material candidates.

Investigating Dataset Distinctiveness

Presentation ID:
AO-20

Room:
ARMS 1103

Keywords:
Computer Vision, Deep Learning, Dataset bias

Andrew Ulmer, Kent Gauen, Yung-Hsiang Lu, Zohar Kapach, and Daniel Merrick
Purdue University

Just as a human might struggle to interpret another human's handwriting, a computer vision program might fail when asked to perform one task in two different domains. To be more specific, visualize a self-driving car as a human driver who had only ever driven on clear, sunny days, during daylight hours. This driver – the self-driving car – would inevitably face a significant challenge when asked to drive when it is violently raining or foggy during the night, putting the safety of its passengers in danger. An extensive understanding of the data we use to teach computer vision models – such as those that will be driving our cars in the years to come – is absolutely necessary as these sorts of complex systems find their way into everyday human life. This study works to develop a comprehensive meaning of the style of a dataset, or the quantitative difference between cursive lettering and print lettering, with respect to the image data used in the field of computer vision. We accomplished this by asking a machine learning model to predict which commonly used dataset a particular image belongs to, based on detailed features of the images. If the model performed well when classifying an image based on which dataset it belongs to, that dataset was considered distinct. We then developed a linear relationship between this distinctiveness metric and a model's ability to learn from one dataset and test on another, so as to have a better understanding of how a computer vision system will perform in a given context, before it is trained.

Biotechnology and Biomedical Engineering

ARMS 1109, 1:30 PM – 2:45 PM

Thienoisoindigo Oligomers as N-Type Small Molecules

Natalie Kadlubowski, Xuyi Luo, and Jianguo Mei
Purdue University

Organic field effect transistors (OFETs) offer many advantages compared to traditional inorganic transistors, such as flexibility and solution processability. In this study we design and synthesize two thienoisatin-based organic semiconducting small molecules, then investigate their electronic properties in n-type OFETs. To introduce n-type charge transport, electron-withdrawing dicarbonitrile moieties were installed on thienoisoindigo and bis-thienoisatin molecules, which led to a quinoidal conjugation on thienoisoindigo, while maintaining an aromatic conjugation on the bis-thienoisatin. Following the syntheses, the molecules were characterized to determine highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO) levels via cyclic voltammetry, as well as any potential radical properties.

Presentation ID:
AO-21

Room:
ARMS 1109

Keywords:
Organic Electronics, Semiconductor, Bis-thienoisatin, Thienoisoindigo

Adhesive Methods for Scaffold-aided Repair of Spina Bifida

Sadid Khan, Renxiang Tang, Sean Bucherl, and Eric Nauman
Purdue University

Spina bifida aperta is a serious birth defect involving the protrusion of the spinal cord outside the spine that can lead to partial paralysis, inability to control the urinary tract, and often death, before or after birth. On average, medical treatment related to spina bifida costs the United States $1,176,000,000 each year. Advancements in existing treatment options, namely fetal surgery, can greatly decrease neurological injury and related costs, but can also lead to birth complications and have lasting effects on both the mother and child. The application of tissue scaffolds to aid closure of the gap left after fetal correction have been in development, but advancements in adhesive methods for the scaffolds are needed to decrease surgery time and increase deformity coverage. This study compares strengths of different adhesive methods in a simulated amniotic fluid environment through peel tests and determines the viability *in vitro* of a lab-produced collagen patch as a scaffold to cover the spina bifida defect.

Presentation ID:
AO-22

Room:
ARMS 1109

Keywords:
Spina Bifida, Myelomeningocele, Fetal Surgery, Tissue Engineering, Tissue Adhesive

Characterization and Quantification of Fibrin Gel Mechanics with Fibroblast Invasion

Nicklaus Iavagnilio, Sarah Calve, and Adrian Buganza-Tepole
Purdue University

Cutaneous wounds undergo an intricate healing process stimulated by a variety of local mechanical and biological stimuli that lead to patterns of growth and remodeling. Despite significant research in dermal wound healing, pathological scarring is still common particularly in wounds closed under mechanical stress, or large wounds left to heal by secondary intention. The purpose of this study is to utilize previously established wound healing models using fibrin gels and fibroblasts to better understand the functional relationships of the biological processes of normal compared to abnormal wound healing. Increases in uni-axial strain and transforming growth factor beta-1 concentration have been shown to have an increased effect on fibroblast action, leading to increased collagen deposition and overall gel stiffness. This in vitro model will help in the construction of a computational model to be used in future research.

Presentation ID:
AO-23

Room:
ARMS 1109

Keywords:
Wound Healing, Fibrin Network, Mechanical Properties, Biomechanics, Remodeling

Neural coding of an auditory pitch illusion

Presentation ID:
AO-24

Room:
ARMS 1109

Keywords:
Huggins Pitch, Neural Coding, Binaural Unmasking, Auditory Illusion

Maria Barrera[1], Mark Sayles[2], and Ravinderjit Singh[2]
University of Los Andes, Colombia[1] and Purdue University[2]

Pitch is an important perceptual dimension in audition, supporting auditory object segregation, melody recognition and lexical distinction. Huggins' pitch, for example, is a phenomenon evoked by two sources of broadband noise presented binaurally with an inter-aural phase shift over a narrow frequency band. Huggins' pitch and other dichotic pitches have been studied extensively using perceptual experiments. Several models have been proposed to explain and predict the perception of pitch; however, no studies have tried to record in vivo neuron responses to Huggins' pitch (HP) nor have tried to explain how the HP is coded by neurons. The existence of pitches arising from the detection of binaural temporal cues may suggests that at least some of the "pitch neurons" involved must be linked to binaural unmasking: a phenomenon whereby binaural processing enhances the perceptual signal-to-noise ratio in noisy environments. To evaluate the neural coding of HP, in vivo recordings of chinchilla auditory nerve (AN) and medial superior olivary (MSO) axons were made. Monoaurally and binaurally spike trains were gathered from AN and MSO axons respectively. Computational simulation was used to predict the output of HP input (AN) and then it was compared to the recorded output (MSO). It is expected to obtain an anticorrelated coefficient using cross-correlation analysis of HP stimulus near the center frequency of MSO axons and ANFs. Therefore, by understanding the neural basis of binaural pitch, this work might shed light on the novel role of binaural neural circuits in pitch processing and neural coding of pitch in general as a result of binaural unmasking mechanism.

Method Validation of Functional Magnetic Resonance Imaging and Electrophysiological Recording to Investigate Mechanisms of Vagus Nerve

Presentation ID:
AO-25

Room:
ARMS 1109

Keywords:
Functional Magnetic Resonance Imaging, Vagus Nerve Stimulation, Neural Activity, Brain Connectivity

Christina Hendren, Jiayue Cao, and Zhongming Liu
Purdue University

Vagus nerve stimulation (VNS) is used clinically to treat epilepsy and depression, but its mechanism of action is unknown. Useful techniques to study this are functional magnetic resonance imaging (fMRI) and the local field potential (LFP). fMRI relies on oxygen use in the brain to show areas where neurons are active. The LFP is an electrical signal created by neuron action potentials and other current moving across cell membranes. The most information can be gained when the two methods are used simultaneously, however, this is difficult to do. This study seeks to validate the technique of fMRI-LFP as applied to study the mechanism of VNS. The rat is used as an animal model. Previously collected data is analyzed to determine effects of stimulation on respiration, since this will affect oxygen levels in the blood. Recording electrodes of different materials are tested to find the artifact size created in an MRI environment. Iridium electrodes were found to have the smallest artifact and therefore the best performance. It is unclear whether the stimulation used affects respiration, so a simultaneous fMRI-LFP experiment is needed to interpret fMR images. More work needs to be done before fMRI-LFP recordings can be taken during VNS.

AFTERNOON POSTER PRESENTATIONS

AP

Biology

ARMS Atrium, 3:00 PM – 4:15 PM

Expression of Carbohydrates Biosynthetic Genes in Developing Soybean Seeds

Presentation ID:
AP-01

Room:
ARMS Atrium

Keywords:
Soybean, Carbohydrates, Stachyose, Raffinose

Jayden Rosen, and Karen Hudson
Purdue University

An essential part of livestock diets is soybean meal, which is a major source of protein, but which also consists of antinutritional carbohydrates. Antinutritional carbohydrates such as raffinose and stachyose lead to irritation to the gut for monogastric livestock as well as unhealthy weight gain. A major objective of soybean genetics is to reduce these antinutritional carbohydrates within the seed and increase the levels of good carbohydrates. This will lead to healthier livestock and better meat quality. To select genes potentially responsible for variation in carbohydrate levels in seeds, the expression of genes encoding several biosynthetic enzymes was measured during soybean seed development. Genes were selected on the basis of working knowledge of the raffinose/sucrose biosynthetic pathways. Soybean plants were grown in controlled conditions within the growth chamber and seeds were collected at five defined intervals during seed development. RNA was extracted from the seeds and expression of genes of interest were measured using quantitative RT-PCR. Expression of these genes were compared between wild type soybean and the lab's carbohydrate composition mutants and from lines from the soybean genetic stock center that differ from commodity soybean by having higher levels of sucrose.

Rapid Sample Processing of Foodborne Pathogens Using Cross-Flow Microfiltration

Presentation ID:
AP-02

Room:
ARMS Atrium

Keywords:
Foodborne Pathogens, Irrigation Water, Biofilms, Microfiltration, Pathogen Detection, Pretreatment

Casey Bomrad[1], Michael Ladisch[1], Linda Liu[2], Jessica Zuponcic[1], and Eduardo Ximenes[1]
Purdue University[1] and LORRE[2]

Foodborne illnesses are a prominent issue, causing 48 million illnesses annually. The *Escherichia coli* O157:H7 outbreak in romaine lettuce is a recent example. The source of the pathogen was contaminated irrigation water. The most common methods for detecting foodborne pathogens involve cultivation and enrichment of food samples. The enrichment steps are time-consuming, taking 24 to 72 hours to complete. Our study aims to accelerate irrigation water sample preparation for pathogenic microorganism fast detection through cross-flow microfiltration. This is accomplished by a device called a continuous cell concentration and recovery device (C3D). The C3D uses cross-flow microfiltration in a hollow fiber module containing a polyethersulphone membrane with 0.2 µm pore size. This is small enough that the liquids and dissolved particles in the sample will be leaked out into a waste container, and any microorganisms present will be trapped. After concentration, the trapped microorganisms are returned into a sample recovery vial, effectively reducing the sample from 500 mL down to a 5-10 mL sample. Further concentration is achieved by centrifugation to a final volume of 0.5-1.0 mL. This concentrates environmental and pathogenic bacteria that may be present in a water sample to a detectable level. A C3D with four separate hollow fiber modules was developed and calibrated to further increase efficiency. Overall, this process has the potential to decrease the time needed for the sample to reach a detectable level from up to 72 hours down to just 6-8, which is within the window of a single shift of a plant.

Effect of Carbohydrates on the Gut Microbiome

Presentation ID:
AP-03

Room:
ARMS Atrium

Keywords:
Microbiome, Carbohydrates, Anaerobic, Bacteria, Gut

Maciej Filar, and Mohit Verma
Purdue University

The microbiome within the gut is directly linked to biological processes within a person, influencing factors such as metabolism, signaling pathways, and available nutrients. Long term dieting is known to alter ecological conditions within the gut, allowing certain types of microbes to flourish. Therefore, the overall health of an individual is ultimately influenced by shifts in the microbial community state caused by persistent dieting. This study investigates the connection between diet and the microbiome and draws an understanding of how common carbohydrates in food can affect bacterial composition. Using KBase software, anaerobic bacterial growth was investigated for bacteria subject to a defined media with distinct sugars. Common bacteria found in young children were studied as microbiome development begins post-partum. The results show that only certain carbohydrates have a crucial impact on bacterial growth while others are inert. In future studies, it is recommended that co-cultures of bacteria are studied in the sugar additive media to determine relative abundance and how different bacterial strains can dominate one another.

Mutational Analysis of the Putative Dimer Interface of DNA Methyltransferase 3b

Presentation ID:
AP-04

Room:
ARMS Atrium

Keywords:
Epigenetics, Cancer, DNA Methylation

Amie Michie, Allison Norvil, Nicole Forstoffer, and Humaria Gowher
Purdue University

DNA methylation is an epigenetic process involved in gene regulation that is key for cell differentiation and viability. DNA methyltransferase 3a and 3b (Dnmt3a andDnmt3b) are two enzymes that establish this epigenetic modification during early cell development. These two proteins have been linked to many cancers such as worsening the prognosis of patients with acute myeloid leukemia (AML), due to mutation of Dnmt3a. Over-expression of Dnmt3b has been shown to be involved in Immunodeficiency Centromere instability and Facial abnormalities syndrome (ICF). The crystal structure of Dnmt3a catalytic domain shows that it forms a tetramer and it was shown to methylate multiple sites on DNA by a cooperative catalytic mechanism. In absence of structural details of Dnmt3b, very little is known about the catalytic properties of this enzyme. Based on previous studies showing Dnmt3b to be non-cooperative, we hypothesize that Dnmt3a and Dnmt3b may differ in their oligomer state. We hypothesize that unlike Dnmt3a, Dnmt3b does not oligomerize and to test this hypothesis, we performed mutational analysis of the conserved residues in Dnmt3b that are critical for Dnmt3a tetrameric structure. These variant proteins were overexpressed in bacterial overexpression system and purified by affinity chromatography. Next, the catalytic activity of the variant enzymes will be compared to the wild-type enzyme. Determining the catalytic mechanism of Dnmt3b will help design specific inhibitors that can be potentially used as anti-cancer agents.

Structural Characterization of the DEP Domains of P-Rex1

Presentation ID:
AP-05

Room:
ARMS Atrium

Keywords:
P-Rex1, DEP Domain, Structure, X-Ray Crystallography

Samantha Allgood, John Tesmer, and Sandeep Ravala
Purdue University

P-Rex1 is a guanine nucleotide exchange factor for Rho-GTPases, which is indirectly involved in the regulation of cell migration and proliferation. It contains a tandem DH/PH domain archetypal of the Dbl family of GEFs, two DEP and two PDZ domains, and a C-terminal end with weak homology to inositol polyphosphate 4-phosphatase. P-Rex1 is regulated by both intra-domain interactions and interactions with other proteins such as G-protein beta gamma, PKA and phosphatidylinositol (3,4,5)-trisphosphate. Upregulation of P-Rex1 has been found in multiple human cancers, making it a potential target for anti-cancer drug therapies. Therefore, structural characterization of P-Rex1 is critical. Currently, only the structures of the DH/PH tandem and PDZ1 domains of P-Rex1 have been determined. The goal of this project is to determine the structures of the DEP1 and DEP2 domains using X-Ray crystallography. P-Rex1-DEP1 (409-499 aa) protein was expressed in *Escherichia coli* and purified using affinity and size exclusion chromatography. The purified protein was then concentrated and used to set various crystallization screens. Small, well defined needles were observed and showed UV absorption, indicating that they consist of protein, and thus represent promising leads for a future structure determination. Optimization is in progress to grow bigger crystals or establish new conditions. Attempts are still being made to purify P-Rex1-DEP2 (500-602 aa), which thus far shows tendencies to aggregate.

Medical Science and Engineering
ARMS Atrium, 3:00 PM – 4:15 PM

Muscle Activity Correlation With Surgeons' Self-Reported Workload And Performance In Robotic Training

Presentation ID: AP-06

Room: *ARMS Atrium*

Keywords: *Electromyography (EMG), Muscle Activity, Robotic Surgery, Workload, Ergonomics*

Xiayu Cai[1], Jackie Cha[1], Denny Yu[1], Hamed Asadi[1], Jay Sulek[2], and Chandru Sundaram[2]
Purdue University[1] and Indiana University[2]

Studies have shown that muscle activity levels reflect work demands of operators performing physically and mentally tasks. Identifying work demands during the robotic surgery training is essential to ensure usability of teleoperation equipment and prevent surgeon musculoskeletal injuries and fatigue. The purpose of this project is to use physiological muscle activity sensors (electromyography (EMG)) to measure surgeons' work demands during robotic training and to quantify the relationship of these metrics. Eight surface EMG sensors were used to collect upper body muscle activity. Signals from eight participants (all right-hand dominant) during multiple training sessions were collected while performing simulated robotic assisted tasks on the da Vinci skills simulator. Subjective workload measurements (i.e. NASA-TLX) and performance scores were also collected. The results showed muscle activity for neck, shoulder, and left forearm are significantly correlated with self-perceived workload and negatively correlated with performance. This may be due to increased muscle fatigue, which may cause higher workload and lower performance score. These results provide insight to surgeons' workload and to help optimize their performance.

Validation of Wrinkling-to-Delamination Adhesion Measurement Technique

Presentation ID: AP-07

Room: *ARMS Atrium*

Keywords: *Adhesion, Surface Buckling, Polymer Thin Film, Surface Energy*

Allison Chau, Hyeyoung Son, and Chelsea Davis
Purdue University

Polymer thin films have a wide range of applications that span several different industries. Their optical clarity as well as their mechanical rigidness result in their versatile use in applications such as contact lenses, wearable sensors, and flexible electronics. These applications require precise adhesion, so the need for a simple, quantitative adhesion measurement technique is critical. Several methods have already been developed that quantify the adhesion of flexible thin films attached to rigid substrates. However, when the thin films are rigid and the substrates compliant, these methods are insufficient. In the authors' previous work, an adhesion measurement technique was developed that took advantage of well-characterized surface buckling instabilities that formed when the system was placed in lateral compressive strain, exploiting the wrinkling to delamination transition that occurred. This technique was proven to work for a narrow range of materials. Therefore, the focus of this paper was to validate this wrinkling to delamination adhesion measurement technique by utilizing a variety of film-substrate systems with varying surface energies and substrate moduli. In the authors' previous work, the technique was validated using polystyrene (PS) and poly(methyl methacrylate) (PMMA) as high surface energy polymer thin films and poly(dimethyl siloxane) (PDMS) as a low surface energy substrate. In this work, Teflon AF 1600, a polytetrafluoroethylene copolymer, was utilized as a low surface energy thin film and bovine gelatin as a high surface energy substrate to determine the limitations of this adhesion technique.

Solid Solution Strengthened Fe Alloys

Presentation ID: AP-08

Room: *ARMS Atrium*

Keywords: *Materials Science, Fe Alloys, Mechanical Properties, Hardness, Sputtering Deposition, Thin Films, Alloy Design*

Sidharth Krishnamoorthi, Ruizhe Su, Yifan Zhang, and Xinghang Zhang
Purdue University

Iron (Fe)-based alloys (such as steel) are widely used structural materials in industry. Numerous methods have been applied to improve their mechanical properties. In this study, we used a technique know as magnetron sputtering to deposit various Fe-based binary alloy coatings to investigate the influence of solutes on solid solution hardening. Several factors contribute to the solid solution hardening of the alloys, such as composition, atomic radius, modulus, and lattice parameter. After preliminary calculations and analysis, we selected several solutes, including molybdenum (Mo), niobium (Nb), and zirconium (Zr). The compositions of solutes were varied to be 2.5, 5, 8 atomic %. Our nanoindentation hardness measurements show that among the three solid solution alloys, Fe-Zr has the highest hardness. The influences of solutes on microstructural and hardness evolution in these solid solution alloys are discussed.

Steady-State Method to Measure the In-Plane Thermal Conductivity of Thin Sheet Materials

Presentation ID:
AP-09

Room:
ARMS Atrium

Keywords:
Detector Design, Silicon Detector, Materials, Carbon Fiber, Thermal Conductivity, High-precision Calibration.

Evgeny Pakhomenko[1], Andrew Wildridge[2], Abraham Koshy[2], Souvik Das[2], and Andreas Jung[2]
Coe College[1] and Purdue University[2]

A new generation of silicon pixel detectors is required to cope with the unprecedented luminosities at the high-luminosity phase of the Large Hadron Collider (HL-LHC) in 2025. The HL-LHC provides a high radiation, high interaction rate environment for the innermost detector region of the CMS detector. This can lead to an uncontrolled increase in temperature of the detector that can destroy the silicon pixels. Moreover, too high operating temperature can add noise to the data obtained from the detector and can slow the read out cheap down. Therefore, the Phase II upgrade to the Compact Muon Solenoid (CMS) experiment requires an improved heat removal scheme. This challenge can be solved by using carbon fiber as one of the materials for silicon detector support structure. This material has relatively high thermal conductivity and structural stability. To properly simulate the behavior of a support structure in the experiment environment, it is crucial to know the thermal conductivity of these materials. The thermal conductivity of carbon fiber is anisotropic, meaning that it is different for different directions through the material. Therefore, we measure the thermal conductivity along and perpendicular to the fibers. To measure the in-plane thermal conductivity of thin sheet carbon fiber, the "steady-state" method is employed. The validation of the apparatus is done with two materials of known conductivity. In-plane thermal conductivity measurements of several thin carbon fiber sheets are performed. Measurement results show the Carbon Fiber K13D2U thermal conductivity of 515 W/mK in the plane and along the fiber.

Insights into the dehydrogenation selectivity of alloys through hydrogenation kinetics

Presentation ID:
AP-10

Room:
ARMS Atrium

Keywords:
Catalysis, Materials, Alkane Transformation, Energy, Shale gas

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University of New Mexico[1] and Purdue University[2]

Platinum alloy catalysts have a multitude of industrial applications due to their superior selectivity compared to pure platinum catalysts. The two properties believed to be responsible for high alloy selectivity in dehydrogenation are the electronic effect and the geometric effect. Currently, both effects are cited as the predominant effect leading to alloy selectivity. Our research seeks to quantify how the electronic effect of alloying changes the kinetics of hydrogenation, and to relate these changes to the observed olefin selectivity in dehydrogenation by alloys. We measured and compared apparent kinetics of ethylene hydrogenation on platinum and a Pt3V alloy catalyst of the same particle size. X-Ray Absorption Spectroscopy (XAS) was used to characterize the electronic changes that occur upon alloy formation. The similarity in reaction orders and activation energies between platinum and the alloy suggests that the electronic effect influences the kinetics of ethylene hydrogenation. The implications of this result on dehydrogenation selectivity are discussed.

Biotechnology and Chemistry

ARMS Atrium, 3:00 PM – 4:15 PM

The Exciton Spectra Simulator of Photosynthetic Protein-pigment Complex

Presentation ID:
AP-11

Room:
ARMS Atrium

Keywords:
Exciton Spectra, Photosynthetic Protein-pigment Complex, Exciton Spectra Simulator, Energy Transfer Pathway, Bacteriochlorophylls, Couplings, Absorption Spectra

Qifeng Chen, Yongbin Kim, Danil Kaliakin, and Lyudmila Slipchenko
Purdue University

The solar energy is one of the most successful alternative energy sources because of its unlimited availability and environmental friendliness. However, the energy transfer rate in artificial solar devices is significantly lower than the energy transfer rate in plants and bacteria. The key factor that governs efficient energy transfer is the electronic couplings between photosynthetic pigments within living organisms. We are applying quantum mechanical / molecular mechanical (QM/MM), quantum mechanical / effective fragment potential (QM/EFP) and fragment molecular orbital (fmo) methods to elucidate the energy transfer pathway in Fenna-Matthews-Olson (FMO) complex through computing the site energies of bacteriochlorophylls and the electronic couplings between them. Based on the values of site energies and couplings computed with QM/MM, QM/EFP and fmo methods we generate the multiple electronic Hamiltonians describinga the energy transfer within the FMO complex. In this research, I am focusing on the improving the algorithm and developing the GUI for computing emission and absorption spectra for molecular systems with multiple chromophores. After taking the Hamiltonians matrixes as inputs, the researchers were able to predict the theoretical absorption and circular dichroism spectra. By comparing these spectra to experimental data, we managed to compare the efficiency and accuracy of the chosen methods and demonstrate the importance of accurate description of protein environment when studying the energy transfer within the pigment-protein complexes.

Polyrotaxane Variants and Their Effects on the Cholesterol Efflux in Patients Suffering from Niemann Pick type C

Presentation ID:
AP-12

Room:
ARMS Atrium

Sydney Smith, Zach Struzik, and David Thompson
Purdue University

Keywords:
Niemann Pick type C, Lysosomal Storage Disorder, Polyrotaxane

Niemann Pick type C disease (NPC) is a rare lysosomal storage disorder characterized by a progressive accumulation of cholesterol in the late endosomal/lysosomes compartment leading to cellular dysfunction and organ failure. Symptoms include ataxia, dysarthria, cognitive dysfunction, and seizures. Although average life expectancy is below 20, there are no FDA approved treatment available making it a serious unmet medical need. Clinical trials with 2-hydroxypropyl-beta-cyclodextrin (HP-beta-CD) has shown promise in cholesterol normalization within NPC cells. However, HP-beta-CD treatment has been shown to cause ototoxicity in NPC patients at high dosages. Supramolecular complexes known as polyrotaxanes have been synthesized in hopes of decreasing the amount of free HP-beta-CD in the body that will lead to hearing loss. The solubility of rotaxanes threaded with only HP-beta-CD in aqueous systems is low, but has seen an increase with the addition of sulfobutyl-beta-cyclodextrin (SBE-beta-CD). In this study, polyrotaxanes with varying amounts of HP-beta-CD and SBE-beta-CD were synthesized and used to treat NPC1 fibroblasts. Filipin staining and fluorescent imaging were performed on these fibroblasts to assess the levels of cholesterol after treatment thus finding the optimum ratio of HP-beta-CD to SBE-beta-CD.

Overproduction of Aromatic Amino Acids from Cyanobacteria

Presentation ID:
AP-13

Room:
ARMS Atrium

Shujun Dong, Arnav Deshpande, and John Morgan
Purdue University

Keywords:
Microalgae, Cyanobacteria, L-phenylalanine, L-tyrosine, L-tryptophan

L-phenylalanine, L-tyrosine and L-tryptophan are aromatic amino acids that are widely used in industrial, agricultural and pharmaceutical applications. Currently, heterotrophic microorganisms are fed require an organic source of carbon to produce amino acids, photosynthetic bacteria are investigated. Mutagenesis by methyl methanesulfonate followed by selection on aromatic amino acid analogues produced mutants that are able to overproduce aromatic amino acids. Two mutant strains were investigated: TA1, which is a better L-phenylalanine overproducer, and 5FT1, which overproduces L-tryptophan. To test the influence of growth conditions on amino acid production, we grew mutant strains of Synechocytis sp. 6803 under enhanced CO2 or glucose-rich conditions. We quantified the amount of each aromatic amino acid synthesized intracellularly and transported to extracellular medium by high performance liquid chromatography. We analysed the transient production of the aromatic amino acids to see if it is a growth related process. If it is growth related, the recommended growth method would be a fed batch reactor or a turbidostat to keep the cells at the exponential phase. If it is not growth related, we would recommend to use a batch reactor to allow cells reach stationary phase and harvest after maximum production.

Targeting Neuropeptides to Bone Fractures for Accelerated Healing

Presentation ID:
AP-14

Room:
ARMS Atrium

Nicholas Young, Jeffery Nielsen, and Philip Low
Purdue University

Keywords:
Pituitary Adenylate Cyclase-Activating Polypeptide, Vasoactive Intestinal Peptide, Bone Fracture, Targeted Therapeutics, Neuropeptide

In patients over the age of 65 especially, bone fractures represent a significant disease burden. Non-invasive drug therapies are not available for bone fractures which represents a problem for this population. Vasoactive intestinal peptide (VIP) and Pituitary Adenylate Cyclase-Activating Polypeptide (PACAP), two neuromodulator peptides in the glucagon superfamily, have demonstrated positive regulation of osteoblast proliferation and activity. Using acidic oligopeptides, we have developed ligands that target to and accumulate at fracture sites. These targeting ligands can be synthesized in sequence with bone anabolic peptides to minimize off target effects and increase potency at the fracture site to create safer and more efficacious therapeutic molecules. The conjugation of PACAP and VIP to acidic oligopeptide targeting ligands results in compounds that demonstrate significant improvements in regeneration of bone at fracture site *in vivo* in terms of strength and mineralization of fracture callus.

Water Temperature and Harmful Algal Bloom Rate

Presentation ID:
AP-15

Room:
ARMS Atrium

Keywords:
Algae, Cyanobacteria, Fertilizer, Isotopes

Geoff Bright, Greg Michalski, and Benjamin Wilkins
Purdue University

Harmful algal blooms, made up of cyanobacteria, is an increasing problem in Midwestern lakes. Nitrogen and phosphorus fertilizers used in crops such as corn and soybeans run off into streams and eventually lakes. Nitrogen and phosphorus in the form of nitrate and phosphate respectively is then used by cyanobacteria as a food source, allowing them to bloom at an alarming rate. Massive bloom events can be hazardous to both human health and the natural environment because of the release of neurotoxins, hepatotoxins and others into the air and drinking water. We set out to find if different water temperature can affect the rate at which cyanobacteria can use nitrate. Six different species of cyanobacteria were analyzed. For each species, two solutions with known amounts of nitrate and excess phosphate were mixed, with one solution kept at 31 degrees Celsius and the other kept at room temperature. Overtime, the concentration of nitrate was measured. We found that, on average, the species kept at a higher temperature were able to use nitrate faster than their colder counterpart.

Engineering DUB-deficient Viral Proteases from FIPV and PEDV Coronaviruses

Presentation ID:
AP-16

Room:
ARMS Atrium

Keywords:
Coronaviruses, Papain-like Protease, Viral Proteases, Immune Response, Ubiquitination

Daniel Wesenberg, Jozlyn Clasman, and Andrew Mesecar
Purdue University

Coronaviruses form a class of viral pathogens lethal to humans and livestock. This issue is compounded by a lack of commercially available treatments or vaccines. In 2014, porcine epidemic diarrhea virus (PEDV) emerged in the United States and accounted for an estimated 7 million porcine deaths. Deaths of humans, companion animals, and livestock caused by coronaviruses highlight the need for therapeutic strategies to combat this devastating disease. One strategy involves engineering papain-like protease 2 (PLP2), an enzyme conserved among coronavirus species that is critical for virus replication and pathogenesis. PLP2's de-ubiquitinating (DUB) activity aids in the suppression of the host's innate antiviral immune response. By targeting and disrupting ubiquitin binding in PLP2 and thus its DUB activity, the virus would no longer be able to antagonize the innate immune response. To this end, we introduced informed single-point mutations in PEDV and in feline infectious peritonitis virus (FIPV) PLP2s using structure-guided mutagenesis. We then characterized the kinetic activity of the resulting mutants in vitro using fluorescent peptide and ubiquitin substrates. Through these studies, we were able to evaluate the relationship between PLP2-ubiquitin binding and DUB activity. Preliminary data analysis suggests that residues outside the active site of PLP2 and within the ubiquitin-binding interface are necessary for DUB activity; these residues can be selectively disrupted to abolish DUB activity relative to the wild-type. These results describe a series of DUB-deficient PLP2 mutants that can be leveraged as tools for use in future coronavirus research. Such tools will allow creation of an attenuated virus strain that could aid in vaccine and drug design.

Modeling and Simulation

ARMS Atrium, 3:00 PM – 4:15 PM

Localized Strain and Associated Failure of Structural Materials

Presentation ID:
AP-17

Room:
ARMS Atrium

Keywords:
Strain Localization, Corrosion, Aluminum Alloy, Data Analysis, Crack Initiation

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Aircraft are made primarily out of strong and lightweight aluminum alloys, which are relatively low cost, easy to produce, and have allowed for several innovations in the airplane industry. Even though these alloys are highly corrosion resistant, they are susceptible to failure since airplanes experience some of the harshest fatigue and corrosion conditions. Predicting the location of crack initiation on these corroded materials could lead to preventative safety of aluminum components on an aircraft. To study the mechanisms leading to cracking, precorroded AA7050 samples were fatigue loaded to failure, virtually reconstructed form post-mortem characterizations, and modeled accordingly to obtain the micromechanical state of the material. Fatigue indicator parameters were calculated from the resulting stresses and strains. The initial corrosion front was then analyzed at the reconstructed crack plane, using a metric that identifies the most active slip planes per grain. The reconstructed data is masked over onto planes that have the same orientation as the [111] slip planes. Then, the data is analyzed quantitatively for each slip plane, looking for the highest median fatigue indicator parameter value. The slip plane on the grain closest to the crack initiation site was found to have a slip plane roughly parallel to the crack plane. On this plane, many significantly larger fatigue indicator parameter values were found, with the highest value pinpointing the region where crack initiation was experimentally observed.

Predicting and Optimizing Solar Cell Performance with Material Characteristics

Presentation ID:
AP-18

Room:
ARMS Atrium

Keywords:
Photovoltaics, Semiconductor Modeling, Simulation

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Renewable energy sources have begun replacing fossil fuels at the utility scale. In particular, photovoltaics has grown rapidly in recent years. To further improve solar technology in terms of cost and efficiency and promote adoption, researchers often seek material and device level advancements. Photovoltaic simulation tools can be utilized to predict device performance before fabrication and experimentation, streamline research processes, and interpret experimental results. Therefore, we developed ContourPV, which simulates various combinations of values of different device characteristics to optimize and predict photovoltaic performance. ContourPV sweeps the inputted range of values for each chosen device or layer characteristic and obtains performance data by utilizing the drift-diffusion solver, ADEPT. ContourPV plots these metrics in contour plots as output. The parameters that can be swept include Shockley-Read-Hall recombination lifetime, doping concentration, radiative recombination coefficient, and surface recombination velocity for front and rear contacts. Open circuit voltage, short circuit current, fill factor and efficiency are available as output. This tool can provide researchers with intuitive simulation results to predict the performance of a solar cell design, determine material properties based on experimental current-voltage measurements, and help predict performance crossover regions between different device designs. Silicon and GaInP are investigated as example materials in ContourPV: silicon because it is the most common material for commercial solar panels, and GaInP because it is a strong candidate for high-efficiency multijunction solar cells. Furthermore, a wide range of other material systems can be simulated in this tool by users of ADEPT.

A PyTorch Framework for Automatic Modulation Classification using Deep Neural Networks

Presentation ID:
AP-19

Room:
ARMS Atrium

Keywords:
Deep Learning, Machine Learning, Automatic Modulation Classification, Neural Networks, PyTorch

Shengtai Ju, Sharan Ramjee, Diyu Yang, and Aly Gamal
Purdue University

Automatic modulation classification of wireless signals is an important feature for both military and civilian applications as it contributes to the intelligence capabilities of a wireless signal receiver. Signals that travel in space are usually modulated using different methods. It is important for a receiver or a demodulator of a system to be able to recognize the modulation type of the signal accurately and efficiently. The goal of our research is to use deep learning for the task of automatic modulation classification and fine tune the model parameters to achieve faster run-time. Different deep learning architectures were investigated in previous work such as the Convolutional Neural Network (CNN) and the Convolutional Long Short-Term Memory Dense Neural Network (CLDNN). Our task here is to migrate the existing framework from Theano to PyTorch to be able to better exploit the available multiple Graphics Processing Units (GPUs) for training the neural networks. The new PyTorch framework yielded similar accuracies with faster run speed by utilizing data parallelism across multiple GPUs compared to the original framework developed using Theano. We found – from experiments so far – that the reduction in run time is linearly proportional to the number of GPUs available.

Deep Neural Network Architectures for Modulation Classification using Principal Component Analysis

Presentation ID:
AP-20

Room:
ARMS Atrium

Keywords:
Deep Learning, Machine Learning, Neural Networks, Signal Modulation, Sub-Nyquist Sampling, Principal Component Analysis

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In this work, we investigate the application of Principal Component Analysis to the task of wireless signal modulation recognition using deep neural network architectures. Sampling signals at the Nyquist rate, which is often very high, requires a large amount of energy and space to collect and store the samples. Moreover, the time taken to train neural networks for the task of modulation classification is large due to the large number of samples. These problems can be drastically reduced using Principal Component Analysis, which is a technique that allows us to reduce the dimensionality or number of features of the samples used for training the neural networks. We used a framework for generating a dataset using GNU radio that mimics the imperfections in a real wireless channel and uses 10 different types of modulations with 128 sampling points where samples are collected at the Nyquist rate. The code implements Principal Component Analysis to reduce the number of features of the samples. We found that using the dataset that uses samples collected at Sub-Nyquist rates obtained using Principal Component Analysis requires drastically lower time to train the neural networks as compared to the time required to train the neural networks with a data set that uses samples collected at the Nyquist rate. Furthermore, the space required for the storage of the samples is also reduced after the application of Principal Component Analysis to the dataset.

Tool for Correlating EBSD and AFM Data Arrays

Presentation ID:
AP-21

Room:
ARMS Atrium

Keywords:
Crystallography, EBSD, AFM

Andrew Krawec, Matthew Michie, and John Blendell
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Ceramic and semiconductor research is limited in its ability to create holistic representations of data in concise, easily-accessible file formats or visual data representations. These materials are used in everyday electronics, and optimizing their electrical and physical properties is important for developing more advanced computational technologies. There is a desire to understand how changing the composition of the ceramic alters the shape and structure of the grown crystals. However, few accessible tools exist to generate a dataset with the proper organization to understand correlations between grain orientation and crystallographic orientation. This paper outlines an approach to analyzing the crystal structure using data collected from atomic force microscopy (AFM) and electron backscattered diffraction (EBSD) scans to build an accurate image of the crystal structure and orientation in the ceramic. The following tool takes data from AFM and EBSD scans of the same surface to create an accessible and easily-manipulatable data organization that stores several parameters relating to the crystallographic information of the surface. While this code was tested using on barium strontium titanate, but can of other materials with crystalline surfaces can take advantage of this analysis tool.

Developing a Machine Learning Tool to Optimize Thermal Transport

Presentation ID:
AP-22

Room:
ARMS Atrium

Keywords:
Thermoelectric, Genetic Algorithm, Superlattice, Crossover, Mutation

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Purdue University

One of the largest problems facing the world today is energy. Not only does much of the world use non-renewable energy, but the majority of that energy is lost as waste heat. One area of study that aims to solve this problem is thermoelectrics. Thermoelectrics encompasses a wide range of methods and materials but this paper will only cover superlattice structures and how they can be used to convert waste heat into electrical energy. There arises a problem in this of what the best structure is. The method used to optimize the superlattice structure is a genetic algorithm. This method mimics natural selection by first, creating a set of structures (initial population), calculating the thermal conductivity for those structures (evaluating fitness), and selecting the best structures to create the next generation (selection), and finally, performing crossover and mutation on the previously selected structures to create the new population (crossover and mutation). The results of this method show a significant improvement in minimizing thermal conductivity from the initial to the final structures, with the final structures showing a thermal conductivity approximately one-fourth that of the initial structures. Not only is there an improvement in thermal conductivity, but as the optimization process goes on, one can see the spread of results for each generation getting smaller. This method will prove to optimize thermoelectric materials, which can be further implemented in real products to reduce waste heat.

Scaling Relationships across Chemically Related Adsorbates for Fast Screening of Alloy Catalysts for Propane Dehydrogenation

Presentation ID:
AP-23

Room:
ARMS Atrium

Keywords:
Catalyst, Dehydrogenation, Density Functional Theory, Scaling Relationships, Alloys, Reactions

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A catalyst is a material which speeds up the rate of a specific reaction. A reaction that is of significant importance to the chemical industry is the selective transformations of light alkanes (ethane, propane), which are largely available in shale gas, to olefins. These olefins can then be converted into higher-value chemicals, materials, and fuels. However, there are several undesired reactions that take place alongside the main dehydrogenation reaction, so a catalyst of high selectivity is desired. Apart from the industrially used PtSn catalyst, work by our experimental collaborators has shown that various other Pt and Pd alloys (In, Zn) are also highly selective and active for propane dehydrogenation (PDH). We aim to use Density Functional theory (DFT) to determine the trends in catalytic reactivity and selectivity across a wider space of alloy catalysts. This can be achieved through the development of linear scaling relationships (LSR), which relate the thermodynamic adsorption properties of chemically related species on various alloys. Initial results on the Pd alloys (Pd_3Sn, PdIn, PdZn) show that the alloys have lower binding energies as compared to a pure metal. These results can have implications on the higher selectivity observed on the alloys experimentally.

Spatial and temporal storm generation from a stochastic view

Presentation ID:
AP-24

Room:
ARMS Atrium

Keywords:
Storm Generation, Stochastic Process, Monte Carlo Simulation, Statistical Distribution

Jiaxiang Ding, Josept Revuelta-Acosta, and Engel Bernard
Purdue University

Precipitation is one of the most important parameters in the study of hydrology and most of the research has been done on daily storm generation. Current weather generation models are used to replicate daily or monthly time resolution, which is not able to show the variability within one day or one month. This project deals with sub-daily storm generation with finer resolution and more accurate estimation, which also requires an independent storm separation method. And the Monte Carlo correlated multivariate simulation is applied to compute the variables. The description is essential for soil erosion and water quality research. Another reason is that the area which has valid data from gaged sites is limited compared to our interested area. By applying krigring method, our interpolation generates an estimated surface and credible estimation for those stations which have no sufficient data and the result will be used for further study. So far we have reliable estimates based on observed data and spatial interpolation shows a promising tool to estimate storms in ungauged locations.

Universality in Viscous Fluid Spreading and Leveling

Presentation ID:
AP-25

Room:
ARMS Atrium

Keywords:
Modeling & Simulation, Environment, Flow Analysis & Processing

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Multiphase fluid flows, or flows where the dynamics of an interface between unlike fluids can be observed, require study to further understand the fundamental relationships of the fluids' properties and their dynamics in multiple applications. The scope of this research project pertains to low Reynolds number flow, a dense fluid spreading through a less dense ambient fluid, with the spreading fluid movement being driven by gravitational buoyancy forces and density differences. The primary investigation involves studying the spreading and leveling of such fluids in shaped geometries, such as subsurface fractures. The objective is to determine the effect of a wide variety of crack geometries on these flows, both in its spreading and leveling phases, or pre and post "closure," respectively. The methods involve understanding the basic governing partial differential equation, the transformation to an ordinary differential equation with the use of a self-similarity variable and requisite, rescaling, and verification of these mathematical predictions through direct simulation of the PDE in MATLAB. Self-similar behavior physically means "universality" holds across all fluid types and fracture geometries, and such behavior can be observed for a variety of crack widths and geometries. We verify the spreading and leveling relationships of viscous fluid flows (determined mathematically using the theory of self-similarity), and further compare these to previous experiments. Future research interests include study of particulate viscous flow in its spreading and leveling phases, the final distribution of particles in the flow, and the effect of varying crack geometries on these flows.

Building Modern Cloud Accessible Tools for Materials Simulations

Presentation ID:
AP-26

Room:
ARMS Atrium

Keywords:
LAMMPS, Rappture, nanoHUB, Molecular Dynamics, DFT

Nicholas Finan, Saaketh Desai, Samuel Reeve, and Alejandro Strachan
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In recent years, commercial computer systems have grown more user friendly, allowing for new users to quickly and easily make contributions. Unfortunately, this trend is not as apparent in the field of computational materials simulations. The tools used by researchers in this field have remained just as esoteric as the systems of the past. While the methods used in materials simulations continue to grow in complexity and accuracy, the user experience has been neglected entirely. This project aims to eliminate the need for hours spent adjusting file formats and searching for preexisting code, and instead allow researchers to focus on analyzing outputs. Such an endeavor requires the use of online repositories, nanoHUB simulations, and various analysis tools demonstrating materials simulations and making use of molecular dynamics, density functional theory and continuum simulations. Given input files following current LAMMPS standards, this tool can calculate the Radial Distribution Function, X Ray Diffraction, and Vibrational Density of States of the system in question while anticipating issues that will lead to erroneous results. Rather than leaving the user to decide much of the fine customization that goes into these types of analysis, the tool implements a series of robust defaults that provide valid results for most systems. While the tool does not provide the user with This tool also offers a high degree of modularity, allowing for easy integration of additional analysis code.

Grain Boundary Motion Analysis

Presentation ID:
AP-27

Room:
ARMS Atrium

Keywords:
Finite Element, Simulation, Grain Motion, Data Visualization

Jeremy Marquardt, Xiaorong Cai, and Marisol Koslowski
Purdue University

Grain growth is a mechanism to relax residual stresses in thin films. These grains grow out of the thin film surface and are known as whiskers. These whiskers can cause short circuits, so developing scalable and cost effective solutions would increase the reliability and utility of tin electronics. A popular of method of examining tin whiskering is microscopic simulation, as it provides an accurate and cost effective way to predict the consequences of proposed models. Specifically examining the evolution of grain boundaries, this paper aims to present the results of grain boundary motion simulations through a generalized program that streamlines and optimizes the analysis process. Various simulations examining the effects of grain boundary energy and mobility were run through Idaho National Laboratory's Multiphysics Object Oriented Simulation Environment (MOOSE), with processing, analysis, and presentation provided by a Jupyter Notebook program that is available online. The Notebook program was found to graph effectively and flexibly, creating results which provide quantitative data and clear visualizations of the MOOSE simulations, providing examples of how the mobility and energy values of grain boundaries of Tin significantly affect grain migration. The Jupyter notebook will be deployed as a tool in nanohub.org.

An Automated Patternator System Development

Presentation ID:
AP-28

Room:
ARMS Atrium

Keywords:
Patternation, Patternator, Droplet Properties, Droplet Measurement, Nozzle Testing

Sanghun Shin, Huitaek Yun, and Martin Jun
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Spray patternation is a quantitative measurement of droplet properties such as size, density, and velocity within a spray. This process is required in industries involved in fuel injectors, thin film coating, agriculture, and consumer products in which faulty nozzles can lead to quality degradation. The patternator from En'Urga incorporate, a ring-shaped device that analyzes droplets through the laser sheets in the middle, is required to make such measurements, and some industries demand a large amount of injectors to be tested before engine assembly. As a result, the development of automated patternation system is paramount to reduce testing time of mass produced products. In this research, the automated nozzle test system using patternators was developed with the construction of 3-axis linear system for the nozzle delivery and a gas supply control system that regulates the flow rate and pressure. With this system, approximately 500 nozzles can be investigated per day. Ultimately, the automated system explained in this paper reduces the nozzle testing time, improving production rate at mass production.

Evaluation and Analysis of Ethane Transformation to Liquid Hydrocarbons Through Steam Cracking

Presentation ID:
AP-29

Room:
ARMS Atrium

Keywords:
Modeling and Simulation, Energy, Natural Resources

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Process design and sensitivity studies for a steam cracking reactor was performed. Steam cracking is commonly employed to convert ethane to ethylene, a building block of many other products. Although this technology is generally employed at large scale (>6 Billion pounds of ethylene per year), understanding the process and its economic performance is critical to set target criteria for other processes under development. Aspen Plus was used to simulate the ethane steam cracking reactor and other process units. Sensitivity analysis was performed to determine the most efficient and cost-effective operation regarding product yield. The results show that the maximum product yield is attained by operating the reactor at 900°C, a pressure of 1.6 bar, and a steam-to-hydrocarbon ratio of 0.3. This study provides conclusions and recommendations based on the sensitivity analysis.

Combustion and Energy

ARMS Atrium, 3:00 PM – 4:15 PM

Experimental Evaluation of a Krypton Propellant Arrangement in a T-100-3 Hall-Effect Thruster

Presentation ID:
AP-30

Room:
ARMS Atrium

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Purdue University[1] and Universidad Carlos III de Madrid[2]

Keywords:
Hall Thruster, Electric Propulsion, T-100-3, Plasma, Krypton, Xenon, Ion Flux, Plume, Thrust

Stationary Hall thrusters are electric, moderate-specific impulse propulsion systems developed in Russia. These devices manipulate electric and magnetic fields to expel ionized gas (plasma) components, resulting in thrust. The success of Hall-effect engines in USSR satellite-transfer missions quickly sparked western interest in the design. Extensive government and academic study commenced shortly after the dissolution of the Soviet Union, when the technology was made available to the United States. The common SPT-100 model was the primary subject of such studies. Unfortunately, limited literature exists for rare and uncommon Hall thruster models. The T-100-3 stationary plasma thruster suffers from this gap; few xenon-propellant datasets are readily available. No exhaustive studies have been published with inexpensive and alternative krypton propellant. Our evaluation seeks to comprehensively record and analyze the performance parameters of a krypton-fed T-100-3 stationary plasma thruster. In particular, the discharge voltage, discharge current, erosion, temperature, thrust, efficiency, and specific impulse were investigated with thermocouples and force-calibrated inverse pendulums. Plume distributions and ion flux were additionally measured, using Langmuir probes and Faraday cups. These variables were analyzed over 2.5 approximate hours of run-time with a large range of flow, magnetic, and power operating conditions. Based on a -47% nominal flow state (25.0 sccm anode flow, 10.0 sccm cathode flow, 8.5 W magnetic field, 1.39 kW discharge supply), the T-100-3 achieved thrust values of 28.1 mN with a corresponding specific impulse of 1313.4 s. Our study suggests the feasibility of krypton in moderate-specific impulse satellite keeping missions.

Progress Toward an Understanding of Wake Ingestion through Experiments in the High Contraction Wind Tunnel

Presentation ID:
AP-31

Room:
ARMS Atrium

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Keywords:
Wake Ingestion, Boundary Layer, BLI, Propulsion, Propeller Efficiency

Recently, there has been a renewed interest at major aircraft and engine companies in increasing the thrust per horsepower of aircraft jet engines by ingesting the aircraft's wake. However, the phenomenon is not well understood and at least four different equations have been published to calculate the propulsive efficiency, defined as the ratio of the power required to the power supplied. The objective of this research is to obtain data that will test these different definitions of propulsion efficiency to improve our understanding of the phenomenon. The approach will be to conduct an experiment to measure the thrust and power of a propeller ingesting the boundary layer from a model aircraft fuselage. Performance metrics will be analyzed using a simple axisymmetric body to generate thick boundary layers at various velocities in the Purdue High Contraction wind tunnel. An electric motor with measurable power input is used to drive a propeller blade to generate thrust equal to the body drag. Power input will be determined using a torque and watt meter. Total pressure profiles downstream of the body and the propeller will be measured using an array of Pitot tubes. The measured propulsive efficiency will be compared to the different definitions of efficiency.

Thermophotovoltaic Devices: Combustion Chamber Optimization and Modelling to Maximize Fuel Efficiency

Presentation ID:
AP-32

Room:
ARMS Atrium

Arnold Toppo, Ernesto Marinero, and Zhaxylyk Kudyshev
Purdue University

Keywords:
Thermophotovoltaics, Energy, Simulation, Modelling, Combustion

Currently, 110 billion cubic meters of natural gas (primarily methane), a potent greenhouse gas, are flared off for environmental and safety reasons. This process results in enough fuel to provide the combined natural gas consumption of Germany and France. The research team developed a thermophotovoltaic device to convert thermal energy to electricity at a high efficiency using proprietary emitters and combustion system. With the current focus being fuel efficiency and the combustion process, the assembly was simulated using ANSYS Fluent modelling software and the following parameters were optimized: air/fuel ratios, flow rates, and inlet sizes. Simultaneously the heat transfer across the combustion chamber was modeled and its geometry was optimized. Higher flow rates resulted in higher temperatures on the combustion chamber walls; lean mixtures with higher air/fuel ratios also resulted in high exhaust gas temperatures. However, the residual curves hint towards a potentially unstable solution and require more iterations in the simulation process. The results of these efforts indicated that the combustion chamber has been optimized yet further work needs to take place to deem the process to be sufficiently fuel efficient.

Platinum-Gallium (Pt-Ga) Intermetallic Alloys for Propane Dehydrogenation

Presentation ID:
AP-33

Room:
ARMS Atrium

Brittany Roopnarine[1], Nicole Libretto[2], Johnny Zhuchen[2], Zhenwei Wu[2], Evan Wegener[2], Griffin Canning[3], Abhaya Datye[3], and Jeffrey Miller[2]
Manhattan College[1], Purdue University[2] and University of New Mexico[3]

Keywords:
Heterogeneous Catalysis, Geometric Structure, Shale Gas, Propane Dehydrogenation

Natural gas is a source of energy for the United States. The Center for Innovative Strategic Transformation of Alkane Resources (CISTAR) plans to use shale gas extracted from shale rock formations as a bridge fuel to replace coal and oil while the US transitions to renewable energy like solar and wind. After methane, the largest components in shale gas are light alkanes such as ethane and propane. These can be catalytically converted to olefins, which can be further reacted to produce fuels, for example. Olefins from alkanes can be accomplished by dehydrogenation by promoted platinum alloys. This study compares the structure and chemical properties of Pt-Ga alloys on silica (SiO2) and ceria (CeO2) supports to determine if the support plays an important role in this chemistry. The catalysts containing different Pt:Ga ratios were synthesized using incipient wetness impregnation. These catalysts were characterized by in situ X-ray diffraction (XRD) and X-ray adsorption spectroscopy (XAS) to determine if an alloy was formed, and if so, the structure of that alloy. Finally, the catalysts were tested in a fixed bed reactor, where it was found that the silica-supported Pt-Ga alloy has a selectivity of >90% towards propylene. Understanding catalyst design can lead to higher catalytic conversion of substances and potentially an improved selectivity for the formation of preferred products. Pt-Ga on ceria is tested for comparison and there appears to behave differently from that on silica demonstrating the importance of the role of the support on these catalysts.

Novel Synthesis of Nanoparticles Using Impurity-Free Precursors for Photovoltaic Applications

Presentation ID:
AP-34

Room:
ARMS Atrium

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Keywords:
Photovoltaic, Solution-processing, Nanoparticles, Binary Compounds, Synthesis

Solution-processing routes for making solar cells have gained momentum due to its ability to fabricate uniform thin films over large area substrates which would reduce the overall cost of production. Current approaches to synthesizing nanoparticles have impurity issues that affect the efficiency of photovoltaic devices. In this paper, a novel impurity-free route is developed, which couples recent amine-thiol chemistry, specifically the ability to dissolve pure metals, with traditional methods of producing nanoparticles. Copper indium disulfide (CIS) nanoparticles, a simpler subset of a greater material system, is used as a proof of concept for this new synthesis method. Reaction parameters are varied to optimize nanoparticle properties which were analyzed through multiple characterization techniques. In addition, binary compounds that are formed prior to the final nanoparticle are investigated to further understand the reaction mechanism. The novel route is successful with the formation of pure phase CIS nanoparticles, although there is difficulty in growing the nanoparticles to a significant size. Different binary compounds are formed at different temperatures, however the final nanoparticles are the same within a certain temperature range. In conclusion, this new synthesis route is viable, warranting future work to extend its applicability to other material systems.

A High-Efficiency Low Power Rectifier for Wireless Power Transfer

Presentation ID:
AP-35

Room:
ARMS Atrium

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Purdue University

Keywords:
Rectifier, Wireless Power Transfer (WPT), Low Power, Efficient

With the number of implantable devices that utilize electronics increasing, there is an increasing need to find alternative ways of powering them. Currently, surgery is required to replace a battery for these devices; however, with advancements in Wireless Power Transfer (WPT) methods, the need for further surgeries will become negated. This paper explores the ability of WPT as an alternative powering method by investigating rectifier Power Conversion Efficiency (PCE). The rectifier converts high frequency waves to Direct Current (DC) energy that can provide usable power to devices requiring electrical power. It is targeted for low power applications centered around a 233 MHz fundamental frequency, and the rectification circuit was designed and simulated in Advanced Design Systems (ADS) following the shunt diode circuit topology. The rectifier has a measured peak efficiency of 59.4% at -3 dBm and displays efficiencies above 40% from -22 dBm up until diode breakdown around 0 dBm. This device will provide a constant DC power source for use in powering devices wirelessly at low power.

Investigation of Alternate Valvetrain Strategies for Implementation of Diesel Engine Cylinder Deactivation

Presentation ID:
AP-36

Room:
ARMS Atrium

Keywords:
Aftertreatment Thermal Management, Cylinder Deactivation, Diesel Engine, Fuel Economy, Oil Accumulation, Variable Valve Actuation

Nishad Damle, Dheeraj Gosala, and Gregory Shaver
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Cylinder deactivation is a technique in multi-cylinder engines where the airflow and fuel injection are deactivated to a few of the total number of the cylinders such that the power demand is met by increasing fuel consumption in the remaining active cylinders. Diesel engine cylinder deactivation has been demonstrated to have fuel savings of 3.4% over heavy duty federal test procedure and approximately 4 – 35% fuel benefit is predicted over the port drayage cycle, while maintaining higher aftertreatment temperatures. Deactivation of cylinders can result in a decay in in-cylinder pressure via heat loss and blowby to the crankcase, which can lead to oil transport from the crankcase to the cylinder. Oil accumulation in the cylinders can deplete the lubricating oil faster and lead to misfiring or poor combustion when these cylinders are reactivated. This study involves the evaluation of different valvetrain strategies to address the issue of oil accumulation in the deactivated cylinders, while maintaining the benefits provided by cylinder deactivation. A commercial engine simulation software GT-Power, experimentally validated with experimental data, will be used in this study for simulation of the novel valvetrain strategies. The study will determine the effects and benefits of various intake and exhaust valve opening by varying the valve lifts, valve closing and opening timings for each of the two intake and two exhaust valves. The simulation results have shown that the valve strategies implemented have helped to maintain the incylinder pressures at around the atmospheric pressure in addition to maintaining the benefits of cylinder deactivation.

Identification of Proximal and Isolated Aluminum Heteroatoms in Zeolites by Infrared Spectroscopy

Presentation ID:
AP-37

Room:
ARMS Atrium

Keywords:
Heterogeneous Catalysis, Zeolites, Infrared Spectroscopy, Oligomerization

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High demand for energy production and limited fossil fuel reserves are two factors that motivate intense research for new alternative energy resources. While we are still far from completely moving to renewable energy solutions, a new solution that replaces crude oil and coal with shale gas is currently under investigation. For this modern technology, new zeolite catalysts need to be developed for the conversion of light hydrocarbons gases to liquid transportation fuels. These catalysts are of special interest in the production of liquid fuels since they exhibit high reaction rates, molecular sieving properties and selectivity behavior. In this work, the effect of sequential ion exchange on the K/Al ratio of ZSM-5, CHA and FER zeolites was investigated. This was done using a 0.5M KNO3 solution to exchange NH4 ions with K ions on the zeolite framework. CHA zeolites used in this work were synthesized and characterized using X-ray diffraction. On the other hand, atomic adsorption spectroscopy was used to determine the K/Al ratio on ZSM-5, FER and CHA zeolites. Our results show that the potassium uptake on the zeolite does not change significantly with sequential ion exchange.

Environment and Sustainability

ARMS Atrium, 3:00 PM – 4:15 PM

Lead in Residential Water Heaters: An Analysis of Lead Dissolution Kinetics in Non-Ideal Aquatic Environments

Presentation ID:
AP-38

Room:
ARMS Atrium

Keywords:
Iodometric Method, UV-Spectrometry, Dissolution Rates, Solid Phase Extraction, Total Lead, Inductively Coupled Plasma Optic Emission Spectrometry (ICP-OES)

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Lead dioxide, a lead corrosion product, is an important contributor to residential drinking water contamination. A neurotoxin and endocrine disruptor, lead poses serious human health concerns. Despite previous research on water distribution pipes, lead in water heating and softening systems is unexplored. Standard tank water heaters and water softeners have significantly different aquatic environments compared to distribution pipes, due to increased temperature and ion concentration levels. This research verifies the iodometric method for lead dioxide detection and quantifies total lead and dissolved lead(IV) ions over time in simulated water heater and softener environments. Initial experiments confirmed the iodometric method for lead(IV) and measured absorbance with UV-spectrometry. Another set of experiments quantified the dissolved lead(IV) cation in a filtered lead-water mixture by applying the iodometric method to batch reactors, and varying water source (DI, synthetic tap water), temperature (25, 55°C), and NaCl concentration (0.175, 0.584 g/L). Furthermore, each sample was analyzed by ICP-OES to determine the concentration of elemental lead present. The iodometric method resulted in an 80% recovery of dosed lead over one hour. Dissolved lead(IV) ion, conversely, had very little recovery after a week in each batch reactor. Overall, the iodometric method is an accurate and rapid tool for quantifying and comparing dissolution kinetics of total lead dioxide. In contrast, at the temperatures and ionic strength levels investigated, lead(IV) cations may exist in such low concentrations that iodometry may not be an accurate detection method. Future research should consider additional lead species for complete lead dissolution models of water heating and softening systems.

Evidence for a new pulsar wind nebula - Late time X-ray emission from Supernova 1970G

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Stars: evolution, supernovae: individual (SN 1970G)

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Core-collapse supernovae (SNe) are among the most powerful explosions in the universe that produce neutron stars, black-holes and some gamma-ray bursts. Late-time X-ray observations of SNe can provide important information about the critical phases a massive star evolves through as it approaches core collapse. Here we present new Chandra X-ray Observatory observations of the Type II SN 1970G and compare them with prior observations that had suggested its X-ray luminosity experienced a dramatic re-brightening between 2004-2011 breaking from a previous decades long decline. This unexpected increase could potentially be due to a black hole accreting mass or due to a Pulsar Wind Nebula (PWN). Assuming a distance to the host galaxy M101 of 7.4 Mpc, our 2017 observation shows an X-ray luminosity of $(2.34 \pm 1.3) \times 10^{37}$erg/s that is lower than the 2011 observation $(4.1 \pm 1.2) \times 10^{37}$erg/s but still higher than the 2004 value $(1.1 \pm 0.2) \times 10^{37}$erg/s. Our measurement, therefore, strengthens the argument for a potential new source that might be emitting at a constant X-ray output. The observed X-ray luminosity is higher than that of a typical PWN (10^{35} ergs/s), but still consistent with what could be expected from a new PWN, as the pulsar is spinning down. Future monitoring of SN 1970G at radio wavelengths will be crucial to eliminate the possibility of interaction between the supernova's forward blast wave and nearby circumstellar material. Continued X-ray measurements are also required to monitor possible changes in luminosity and to improve spectral fitting.

Modular Scale Process for Sour Gas Removal and Disposal

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Sour Gas, Amine Sweetening, Membranes, H_2S, CO_2, Adsorption

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The purpose of this research is to find methods for removing sour gas, H_2S and CO_2, from shale gas streams and properly dispose of them for small scale gas processing plants. H_2S and CO_2 are both contaminants found in shale gas, and they must be removed in order for the natural gas to meet environmental and gas pipeline regulations. Currently, at regional scale plants, the amine sweetening process followed by the Claus process are used to remove and treat the sour gas, however these do not work for small scale plants. Three alternative methods were explored to accommodate small scale gas processing plants, in order to retrieve the shale gas in remote areas. The first method is the membrane separation process, which uses membranes to separate sour gas from natural gas. The second method is adsorption, which uses amine sorbents to adhere to the sour gas molecules. The third method is the hybrid method, which combines both the membrane separation process and amine sweetening process. Zinc oxide may be able to serve as an alternative to the Claus process for small scale gas processing plants.

Robust Allocation of Funds for Nonstructural Flood Risk Mitigation in Coastal Louisiana

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Keywords: *Flood Risk, Nonstructural Measures, Optimization, Robustness, Risk Mitigation, Sustainable Coast.*

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Coastal Louisiana is a critical economic, ecological and cultural asset, acting as a major hub for waterborne commerce, fisheries, and the petrochemical industry, and also as one of the world's unique wetlands. Unfortunately, this rich environment is in great danger from the threat of hurricanes and storm surge flooding. Direct economic losses are estimated to average \$2.7 billion per year under current conditions, and this could increase to \$12 billion a year, or more, within 50 years if nothing is done. To prevent this catastrophe, Louisiana has developed a Comprehensive Master Plan for a Sustainable Coast, which plans to spend \$50 billion, over the next 50 years, between structural (e.g., levees, floodwalls) and nonstructural (e.g., elevating houses, floodproofing) protection measures, and coastal restoration projects, to reduce flood risk and reduce land loss. However, the state is still in the process of developing a strategy for nonstructural risk mitigation and to define what mitigation standards should be set in different parts of the coast. Therefore, this project utilizes the risk model currently used to assess flood risk in coastal Louisiana to evaluate the impact of different potential nonstructural strategies on risk reduction, accounting for both equity and economic considerations. We estimate the risk reduction and other impacts achieved by each strategy and evaluate how much they vary over a wide range of uncertain future scenarios. We intend to identify a robust strategy for allocating the state's \$6 billion budget for nonstructural risk mitigation that will improve upon the current strategy recommended in the coastal Master Plan.

Estimating Watershed Residence Times in Artificially-Drained Landscapes and Relation to Nutrient Concentrations

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Keywords: *Watershed, Residence Times, Stable Isotopes, Nutrients, Best Management Practices*

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Nutrient runoff from agricultural lands feeds harmful algae blooms that create a variety of problems in freshwater ecosystems. In order to reduce the effects of this nutrient runoff, Best Management Practices (BMPs) are being put in place in agricultural lands. Most of these BMPs focus on slowing down the flow of water through the watershed to give nutrient concentrations time to deplete before the water flows to the stream or river. However, the effectiveness of these BMPs are highly unknown and the process of monitoring nutrient runoff is often complex and costly. The data in this study consists of 7 years of existing water stable isotope data and 9 years of nutrient concentrations collected by volunteers of the nonprofit Wabash River Enhancement Corporation (WREC). Samples are taken twice a year (spring and fall) across a fairly large area draining into the Wabash river. We use stable isotopes, deuterium and oxygen-18 as a proxy for residence times and correlate these residence times with land use and nutrient concentrations.

Indoor Premise Plumbing: The Relationship Between Water Stagnation, Chlorine Decay, and Total Organic Carbon Levels

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Keywords: *Plumbing, Chlorine Decay, Stagnation, TOC, Water Quality*

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Drinking water safety is critical to the health of populations worldwide, and modern plumbing infrastructure can influence drinking water chemical characteristics. Inside residential and commercial buildings however, water use and contact with different plumbing components can vary. For example, water can endure lengthy stagnation periods and residual disinfectant agents like chlorine can decay, leaving the water vulnerable to microbial growth. Plastic cross-linked polyethylene (PEX) pipes have become popular and have shown to influence water quality. While several studies have been carried out on chemical leaching from PEX piping, none were found that examined the role of pipe diameter in relation to chlorine disinfectant decay. The study goal was to better understand chlorine decay in PEX piping associated with stagnation and pipe diameter. Different diameters (3/4", ½") of the same brand of PEX pipe were first obtained and cleaned. PEX pipe were filled with a laboratory prepared synthetic water with about 2 mg/L as Cl_2 at pH 7.3 and stagnated up to 3 days at 50°C temperature. Chlorine disinfectant level, pH, and total organic carbon concentration were characterized periodically. Results will be compared against water samples that were not exposed to PEX pipe for the same time period.

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