Proceedings

Research Symposium

August 1, 2019

PURDUE
UNIVERSITY

Welcome to the 2019 SURF Undergraduate Research Symposium!

The Summer Undergraduate Research Fellowships (SURF) program was launched in 2003 to provide integrated learning-through-discovery in a research environment. Using a portion of an unrestricted gift from Purdue alumnus Patrick Wang, SURF has sought to provide students with a dedicated laboratory experience at the earliest stages of their careers.

For the past 17 years the Purdue SURF program has provides students across engineering, science, and technology disciplines with an intensive research experience that allows them to work under the mentorship of professors and graduate students.

For 11 weeks this summer, 124 SURF students from 15 institutions engaged in research on the Purdue University campus. These students received mentorship and guidance from 117 graduate students and post docs, and 102 professors from 21 Schools/Departments in 3 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. Behind the scenes, there have been additional Purdue staff and graduate students who made the program run as smoothly as possible and their year-round commitment was critical to making SURF 2019 a success.

To the SURF students, we congratulate you on the completion of an intensive summer of research. I am proud of your accomplishments as Purdue researchers and I wish you the best as you pursue your individual goals and continue on a journey of discovery.

John Howarter
Director of Undergraduate Engineering Research
Associate Professor of Materials Engineering
Associate Professor of Environmental & Ecological Engineering

SURF Symposium Overview—August 1, 2019

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:	
	Biology……………………………………………	ARMS B071
	Biomedical & Biological Engineering………….	ARMS 1010
	Machine Learning……………………………….	ARMS 1021
	Materials…………………………………………	ARMS 1103
	Human Factors…………………………………	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:	
	Natural Science………………………………….	ARMS B061
	Environmental…………………………………....	ARMS B071
	Materials…………………………………………	ARMS 1021
	Aerospace………………………………………..	ARMS 1103
	Nanotechnology………………………………….	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

Biology

ARMS B071, 9:30 AM – 10:45 AM

Targeting Vre-31 for New Antibiotics Against Multi-drug Resistant Enterococci

Presentation ID:
MO-01

Room:
ARMS B071

Keywords:
Antibiotics, Drug Repurposing, Multi-drug Resistance, Bacteria, X-Ray Crystallography

Devon Amos, Karthik Srinivasan, Chad Hewitt, Mohamed Seleem, Daniel Flaherty, Nicholas Noinaj
Purdue University

The rapidly acquired antibiotic resistance by pathogenic bacteria has become a worldwide threat to modern medicine. Enterococci are a genus of bacteria that have resistance against many antibiotics. Vancomycin-resistant enterococci (VRE) are one example, where they are one of the main causes of increasing drug-resistant hospital-acquired infections. Since developing new antibiotics is not efficient, repurposing drugs that already have FDA-approval is a novel approach. Acetazolamide (AZM), is one such repurposed compound that can be used to combat multidrug resistance in VRE. Resistant isolates from VRE to AZM were curated and their genomes sequenced, identifying the target of AZM to be a previously uncharacterized protein, Vre-31. Designing a class of antibiotics against VRE by solving the 3D structure of Vre-31 with AZM bound is the goal. In doing so, Vre-31 has been expressed in a pHis2 expression vector and purified using an N-terminal 6X His-tag. Expression tests have shown that Vre-31 is more stable when expressed at lower temperatures after induction. Performing biophysical characterization of Vre-31's structure using size-exclusion chromatography (SEC), small-angle X-ray scattering (SAXS), and circular dichroism (CD) helped determine Vre-31's purity, stability, shape, and secondary structure composition. Crystallization screening of Vre-31 led to many lead crystals. Growing well-ordered crystals of Vre-31/AZM and performing X-ray crystallography may lead to deciphering the 3D structure. Lastly, characterizing the binding of AZM to Vre-31 using differential scanning fluorimetry (DSF) can determine the stability of Vre-31. Together, these studies will lead to combating multidrug resistance in VRE by targeting Vre-31 with new AZM-based antibiotics.

Characterization of Exosome-Like Extracellular Vesicles and Their Impacts on Lung Epithelial Cells

Presentation ID:
MO-02

Room:
ARMS B071

Keywords:
Exosomes, Lung Cancer, Extracellular Vesicles, Biology, Health

Anjali Byappanahalli, Zulaida Soto-Vargas, Humna Hasan, Ikjot Singh Sohal, and Andrea L. Kasinski
Purdue University

Non-small cell lung cancer (NSCLC) accounts for 85% of all lung cancer cases and is the leading cause of cancer-related deaths among both men and women. Moreover, as much as 90% of cancer-related deaths occur due to late-stage metastatic cancers. While treatments such as surgery, chemotherapy, and radiation are available, the associated complications and side effects the patient experiences are beyond measure, and they do not ensure permanent removal of the tumor. A specific type of extracellular vesicles secreted by cells, called exosomes, play an important role in cell-cell communication and cancer progression; understanding the nature of this communication between cells may enable us to understand how cancer spreads, metastasizes, and increases in oncogenic potency. Further understanding of the exosome-mediated communication process may enable early detection through non-invasive screenings, as well as the development of advanced, targeted therapies. To understand this, we isolated exosomes from various lung cancer cell lines and examined the type of morphological effects they induced in normal lung epithelial cell lines. Particularly, the study characterized the isolated exosomes and analyzed their impact on inducing invasion and migratory phenotypes in lung epithelial cells.

Quantification of KRAS Protein in Different Human Cell Types

Presentation ID:
MO-03

Room:
ARMS B071

Keywords:
Cancer, Biology, Immunology

Chin Fang Lin, Bingyu Yan, Majid Kazemian
Purdue University

The KRAS gene was found to be crucial for cell proliferation and growth. With further researches conducted, the KRAS was determined to also be oncogenic, which means it can cause cancer upon mutation. The mutation of KRAS gene is responsible for various cancers such as colorectal, pancreatic, and lung cancers. Many studies about cancer and KRAS have been done, but studies on the relationship between immune cells and KRAS are still scarce. Understanding KRAS related pathways can be helpful to develop treatments for immunity diseases and cancer in the future through immunotherapy different from traditional ways of chemotherapy, radiation, or surgery. In this project, the protein expressions of KRAS and other related genes in different cell types were observed and recorded through western blotting and flow cytometry. For western blotting and flow cytometry, different antibodies were used to optimize the detection of KRAS; also, concentrated protein level was used for more distinguishable and clear detection. KRAS protein is detectable by western blot in several cell types; and the method of immunoprecipitation would improve the expression of protein by boosting the signals. With a suitable and informative antibody combining with adequate techniques, the KRAS protein expression can also be analyzed along with other proteins in the related pathways.

A method to improve the heterogeneity of protein samples intended for high-resolution cryo-electron microscopy

Presentation ID:
MO-04

Room:
ARMS B071

Keywords:
Cryo-EM, near-atomic resolution, viral capsid protein, heterogeneity, norovirus

Hannah Pletcher, Frank Vago, and Wen Jiang
Purdue University

To determine the function and important characteristics of protein samples, the structure of the sample must be determined. Cryo-electron microscopy is a technique in which a frozen sample is imaged by an electron beam, producing many two-dimensional images that can be combined to result in a near-atomic level reconstruction of the sample. Although this method is becoming popular for imaging, reconstruction by this method is made more difficult when samples are heterogeneous, have preferred orientations, or are disrupted by the air-water interface. Heterogeneity, preferred orientations, and disruptions such as denaturation prevent the determination of a complete three-dimensional structure. This study suggests a method to lower the effects of these issues by using the human norovirus virus-like particle (VLP) as a shell around the sample. The target protein is fused to the viral capsid protein via molecular cloning and is then expressed in insect cell lines. The viral capsid protein of the human norovirus could encapsulate proteins to be imaged, allowing the protein to be more compact, ensuring a random distribution of orientations, and preventing contact of the sample with the air-water interface.

Purification and Characterization of Elastin-like Polypeptide Fusion Proteins for Non-muscle-invasive Bladder Cancer Imaging

Presentation ID:
MO-05

Room:
ARMS B071

Keywords:
Cancer, Bladder cancer, precision medicine, bladder cancer imaging, nanoparticle, Elastin-like polypeptide

Mollie Shinkle, Craig Sweet
Purdue University

Bladder cancer accounts for 5% of all diagnosed cancer and is associated with the highest lifetime treatment cost per patient. This is in part due to a lack of accurate imaging techniques, resulting in poor tumor detection and high rates of recurrence. While new imaging methods are available, they fail to accurately identify bladder tumors below 2 centimeters in diameter. They are also limited in their ability to differentiate cancerous cells from inflamed tissue. Thus, more robust methods of detection must be developed. A new type of imaging agent was synthesized using a biocompatible Elastin-like Polypeptide (ELP) as a protein carrier. The ELP was fused with various targeting ligands to form an ELP-growth factor fusion with increased targeting abilities. The proteins were purified and conjugated to a fluorescent dye to enable easy detection in cells. Concentration and purity were determined through western blotting and spectrophotometry; binding of the construct was studied in bladder cancer cells and quantified through flow cytometry. Early results indicate that the fluorescently-labeled ELP fusion particle had higher binding in bladder cancer cells as compared to untargeted constructs or free fluorescent dye. SDS PAGE showed the absence of contaminating proteins and western blotting confirmed the identity of the targeting ligand. This information suggests that the purified particle has very little contamination and possesses increased binding abilities in vitro. Future work will include the purification and fusion of this ELP to other targeting ligands, as well as incubating the current particle in mice to determine in vivo binding.

Biomedical and Biological Engineering

ARMS 1010, 9:30 AM – 10:45 AM

Set4 Expression in Candida glabrata and Saccharomyces cerevisiae under different drug conditions

Presentation ID:
MO-06

Room:
ARMS 1010

Livia-Maria Georgescu, Kortany M. Baker, Scott D. Briggs
Purdue University

Antifungal drug resistance is a growing problem that affects millions of people. Fungal infections can be superficial, such as ringworm and athlete's foot, or systemic, such as those that affect immunosuppressed patients. Systemic infections affect patients suffering from autoimmune diseases, HIV/AIDS, undergoing chemotherapy, or who had undergone an organ transplant. Human pathogens such as Candida glabrata opportunistically infect hosts with weakened immune systems and are naturally resistant to azole drug treatment. Azoles are a class of antifungal drugs that inhibit the biosynthesis of ergosterol, which is an integral part of fungal membrane fluidity and is equivalent to cholesterol in humans. Antifungal drug resistance can originate through various mechanisms, among them being altered gene expression or mutations in the genes that govern the ergosterol biosynthesis pathway or are involved in exporting xenobiotic drugs. Our approach is to identify genes that alter azole drug efficacy to find new pathways that could be targeted for antifungal drug development. Additionally, we are investigating compounds derived from plants that exhibit antifungal activity and work synergistically with fluconazole to inhibit fungal growth. Gene expression analysis has shown that such compounds induce the expression of a protein linked to sensitivity of fungal cells to azole treatment. Overall, these findings could lead to a greater understanding of drug resistance and improved therapeutics against fungal infections.

Keywords:
antifungal drug resistance, epigenetics, gene expression, ergosterol biosynthesis, SET-domain proteins

Characterizing Immunomodulatory Properties of Oligomer for Macrophages

Presentation ID:
MO-07

Room:
ARMS 1010

Parker van Emmerik, David O. Sohutskay, Rachel A. Morrison, and Sherry L. Voytik-Harbin
Purdue University

Biomaterials are an integral part of tissue engineering and regenerative medicine due to their ability to offer enhanced tissue regeneration and transplant protection. Current biomaterials present many issues for patients, such as tissue rejection, formation of fibrotic capsules, and degradation leading to cell necrosis. However, very little research has been conducted to characterize the interactions of these materials on the immune system. What little research that has been done has shown that many of the currently available biomaterials produce a persistent foreign body response, rather than promoting healing and providing protection. Previous studies conducted with Oligomer show potential suppression of pathological immune system activation. To further investigate this, RAW 264.7 macrophages were cultured on a variety of different biomaterials to evaluate the effects of Oligomer and fibril density on immunomodulation. Comparisons were made against a commercial collagen sponge, Integra, as well as a nature-derived polymer, alginate. These materials were then tested to determine the impact they have on macrophage activity. Cells were then stimulated with lipopolysaccharide, and inflammatory response was measured using a Griess assay to quantify nitric oxide production. Results show that in unstimulated groups, the commercial collagen, Integra, produced the greatest inflammatory response. In stimulated groups, oligomeric collagen groups showed the greatest suppression in macrophage activation. This feature also appears to be fibril density dependent as the oligomeric collagen and compressed oligomeric collagen groups produced statistically significant differences in their results. An unexpected chemical reaction occurring between the Griess reagent and alginate biological material prevented quantification. The results suggest that oligomeric collagen not only avoids invoking an inflammatory response but can also suppress immune cell activation in macrophages, in a fibral density dependent manner. These findings are in stark contrast to the commercial collagen and nature-derived polymers, which showed no ability to suppress immune cell activation. These results show promise of Oligomer providing unique immunomodulatory properties that can help prevent many of the current problems found with other biomaterials. To further investigate this problem, future studies using human primary cells will be conducted on other aspects of immune phenotype and function.

Keywords:
Immunomodulation, Collagen, Biomaterials, Macrophages

KRAS RNA Expression Level in Multiple Human Cell Types

Chao Fu, Majid Kazemian, Bingyu Yan
Purdue University

KRAS (Kirsten rat sarcoma 2 viral oncogene homolog) is a gene that controls cell proliferation and growth. In nearly 20% of all human cancers, the KRAS gene is found to be mutated and directly related to their pathogenesis. KRAS gene could also be amplified in cancer, which would directly affect its expression level. KRAS gene has two major isoforms and the expression level of these isoforms varies in different human cells. However, the relation between these two isoforms are less known. Here, we aim to measure the mRNA expression of these two major isoforms in 293T, A549, and Jurkat cell lines using quantitative real-time PCR. Our results show that the expression of KRAS was lower in A549 cells comparing to 293T and Jurkat and the expression of KRAS-4B isoform was higher than KRAS-4A in all three cell lines. The data indicated CD3 cell had the highest RNA expression level compare to other cell lines.

Presentation ID:
MO-08

Room:
ARMS 1010

Keywords:
KRAS, cancer cells, RNA expression level, mutant cells, KRAS isoforms

Force Transmission and Remodeling of Extracellular Matrix Induced by Actomyosin Contractility

Yihao Xie, Jing Li, Taeyoon Kim
Purdue University

Cell-induced forces generated from actomyosin contractility can be transmitted to a surrounding extracellular matrix (ECM). Understanding the process of force distribution and transmission in ECMs is important since it can help us better illuminate how cells interact with their surrounding ECM from a mechanical perspective. While the mechanism of force generation within cells is understood relatively well, it is unclear how cells remodel ECMs with various properties. Previous works focused on cell-ECM interactions considered ECM to be an elastic material by neglecting its time-dependent behaviors emerging from intrinsic viscoelasticity and viscoplasticity. To fill this gap, a comprehensive study accounting for complex rheological properties of ECMs will be useful for rigorous investigation of interactions between cells and ECMs. In this study, we employ a computational model for investigating cell-ECM interactions. We probed the cell-ECM interactions under various conditions, such as various cross-linking densities and nonlinear behaviors of matrix fibers. We found a significant correlation between ECM nonlinearity and local force diversity. For example, the spatial distribution of forces is strongly affected by the dynamic behaviors of cross-linkers. These results provide critical insights into understanding of force propagation and matrix remodeling induced by cells.

Presentation ID:
MO-09

Room:
ARMS 1010

Keywords:
Actomyosin Contractility, Extracellular Matrix Remodeling, Force Transmission, Nonlinearity of ECM

Non-invasive Characterization of Compositional and Structural Changes Following Myocardial Infarction

Alex Yeh, Arvin H. Soepriatna, Gurneet Sangha, Craig J. Goergen
Purdue University

Heart failure, a common and deadly sequela of myocardial infarction (MI), remains a prominent public health issue that affects more than 23 million individuals worldwide. In the United States alone, over $39 billion in health care costs are attributed to the treatment of patients suffering from heart failure. Thus, there is a need to improve current diagnostic methods for heart failure that focuses on both compositional and structural information to determine whether these changes can be used to predict the extent of damage following a heart attack. Here we characterized changes in oxygen and lipid accumulation in a surgical mouse model of MI. Specifically, we analyzed changes in cardiac structure and blood flow via 4D ultrasound (4DUS) and utilized multispectral vibrational photoacoustic tomography (VPAT) to quantify oxygen levels and lipid content. Through the implementation of a novel strain algorithm, we observed changes in strain that preceded anatomical changes. Mice that suffered from heart attacks portrayed a decrease in left ventricular contractility due to the presence of necrotic tissue and exhibited a decrease in strain profile. In addition, myocardial oxygen saturation level decreased significantly throughout disease progression. These novel techniques enabled the analyses of anatomical structure and blood flow, along with the quantification of oxygen content and lipid accumulation, that can be utilized to monitor the development of heart failure.

Presentation ID:
MO-10

Room:
ARMS 1010

Keywords:
Lipid, mouse, myocardial infarction, oxygen saturation, myocardial strain, photoacoustic, ultrasound

Machine Learning

ARMS 1021, 9:30 AM – 10:45 AM

Automatic Hyperparameter Optimization for Neural Networks

Presentation ID:
MO-11

Room:
ARMS 1021

Keywords:
neural networks, hyperparameters, classifiers, autoencoders, optimization algorithms, machine learning

Fernando Davis, Thilo Balke, Gregery T. Buzzard, Charles A. Bouman
University of Puerto Rico - Mayaguez and Purdue University

Deep neural networks (DNNs) have been applied successfully to a variety of tasks in machine learning. However, their success relies on a good set of hyperparameters, including learning rate, dropout values, number of layers, activation functions, etc. Hyperparameter optimization is the process of choosing values for hyperparameters with the goal of optimizing a metric, such as accuracy of classification, speed of learning, etc. A naïve approach is to hand tune values until the desired result is achieved, but this is time-consuming and error prone.
We describe a method for automating hyperparameter optimization using Tree-based Parzen Estimators (TPE) and software that can test hundreds of possible combinations of hyperparameters. We apply this approach to two types of networks: classifiers and autoencoders. We then tested with the datasets MNIST, CIFAR-10 and MNIST American Sign Language (ASL) to compare results with state-of-the-art architectures.
For CIFAR-10 we found architectures with 77% testing accuracy and fewer than 800,000 parameters, which ranks in the top scores for classification networks. The results suggest that automatic hyperparameter optimization meets and may exceed human expertise.

Improving Model Accuracy with Pseudo-Labeling

Presentation ID:
MO-12

Room:
ARMS 1021

Keywords:
Deep Learning, Data Labeling Cost, Active Learning, Dataset Bias, Unsupervised Learning, Transfer Learning, Domain Adaptation, Neural Network

Ashley Kim, Kirthi Sivamani, Fischer Bordwell, Shuhao Xing, Yung-Hsiang Lu, Abhinav Goel
Purdue University

Deep Convolutional Neural Networks have yielded the state of the art performance in various applications of image classification problems. In supervised learning, classification requires datasets that are general with sufficient amount of labels. However, there is an abundance of unlabeled data and scarcity of labeled data. In addition, training process heavily depends on the source domain because datasets used to train neural networks contain distinctive properties. In our paper, we propose to obtain the state of the art performance of Active Learning without any labels from the target domain. The first step utilizes the relationship between dataset distinctiveness and transferability. The higher the similarities between the datasets, the more features transferred. The second step pseudo-labels the images from the target domain with the confidence level. This allows images from the same domain to be used for both training and testing which can mitigate the impact of dataset distinctiveness. Our results outperform traditional Active Learning based methods by as high as 38% without querying labels while training. These results suggest that when the impact of dataset distinctiveness is mitigated, the accuracy and efficiency can be optimized without any additional labels.

Training an Object Recognition Neural Network Using Synthetic Data That Performs Well on Real Data

Presentation ID:
MO-13

Room:
ARMS 1021

Keywords:
Computer Vision, Neural Networks, Object Recognition

Steven Spencer, Jared Johansen, Thomas Ilyevsky, Jeffrey Mark Siskind
Purdue University

In the field of object recognition, convolutional neural networks (CNNs) are one of the state-of-the-art technologies. For these networks to perform well, they must be trained on many (1000+) samples of each object. However, acquiring enough examples can be a time-consuming task. If images could be generated by a 3D rendering software that were realistic enough to train a CNN for image detection, the hours spent on image collection could be spent elsewhere. Using a 3D graphics engine, we created over one million images to train a CNN to detect whether a car's doors were open or closed. These images included different vehicle types, camera angles, and lighting conditions. These images were then used to train a CNN used for image detection. Using this synthetically trained CNN to classify real images performed poorly. We were able to find success by training a generative adversarial network (GAN) to transform real images to synthetic images. We took our real images, applied various image processing techniques such as blur and grayscale filters, then transformed them into a synthetic-looking image. Early results indicate that this method is successful at domain adaptation. We present results that show a synthetically trained CNN obtaining nearly 100% accuracy on real images.

Training Data Set selection impact on the accuracy of Convolutional Neural Networks for Histopathology Image classification

Presentation ID:
MO-14

Room:
ARMS 1021

Keywords:
Training Data Set Selection, Convolutional Neural Networks, Classification Accuracy, Histopathology Image Classification

Valentina Buitrago, Monika Tomar, Mario Ventresca
Universidad de los Andes and Purdue University

Whole Slide Imaging (WSI) scans are able to translate glass slides into computerized images and with them Computerized Aided Diagnostics (CADx) are now a reality. Nonetheless, due to limited data availability and large dimensionality of the scans several problems in target goals related to image retrieval and classification arise. Especially, in this research we examine the problem of histopathology image classification given the medical data set Kimia Path24 that is comprised of 24 WSI scans of tissues having different colors and textures. From this data, we are interested in being able to effectively classify a given patch of a tissue to its corresponding scan using a Convolutional Neural Network (CNN).

WSI Scans have dimensions that range in the gigapixel scale and training CNNs with them is neither computationally efficient nor accurate. Because of this, our approach is to divide these scans into smaller patches to create a training data set and identify the impact it has on the accuracy results on two pre-designed CNNs. We determined new ways to select patches of the given medical scans that are later used for training the Convolutional Neural Networks. To solve the problem, empirical experimentation was conducted and by changing different factors such as size of the patch, data augmentation and selection criteria that include homogeneity threshold of patches for texture present in the image and gradient values indicating color change in the patch, we were able to design different training sets and with them we resolved that it is possible to improve classification accuracy.

Comparison of machine learning models for gesture recognition using a multimodal wrist orthosis for tetraplegics

Presentation ID:
MO-15

Room:
ARMS 1021

Keywords:
Spinal Cord Injury, Gesture Recognition, IMU, dynamic time warping, hidden Markov model

Charles A. Martin, Ting Zhang, Shruthi Suresh, Shanmugam M. Palaniappan, Brett English, Bradley S. Duerstock
Purdue University

Many tetraplegics are required to wear wrist braces to support paralyzed wrists and hands. However, current wrist orthoses have limited functionalities to assist a person's ability to perform typical activities of daily living other than a small pocket to hold eating utensils, pens, and toothbrushes. To enhance the functionality of wrist orthoses, gesture recognition technology can be applied to control mechatronic components on a wrist brace. While gesture recognition is a major area of study for human-computer interactions and has led to many advancements in touchless computer interfaces, its advancements have been underrepresented in people who have sustained cervical spinal cord injuries. In this study, three gesture recognition models were compared – two dynamic time warping models and a hidden Markov model – in terms of their classification accuracy of gestures from a tetraplegic specific gesture lexicon. Gesture data from participants with and without spinal cord injuries was collected using a prototype wrist orthosis. Leave-one-subject-out cross validation was used to develop a user independent gesture recognition library. The trained models were then loaded on a wrist orthosis and tested. The classification accuracy and classification time was computed and compared to determine the optimal gesture recognition model.

Materials

ARMS 1103, 9:30 AM – 10:45 AM

Bend Testing of Thermally Conductive Flexible Fabrics for Wearable Technology Applications

Presentation ID:
MO-16

Room:
ARMS 1103

Keywords:
Flexural rigidity, stiffness, thermal conductivity,Dyneema ® Ultra High Molecular Weight Polyethylene (UHMWPE), bend test

Jack Burke, Aaditya Candadai, Justin Weibel, Amy Marconnet
Purdue University

With advances in wearable device technology, thermal regulation will be important to ensure consumer comfort. Fabrics used in wearable electronics will need to feel comfortable to wear, while also efficiently spreading the heat generated to prevent overheating. Woven fabric materials having high thermal conductivity have not been extensively explored for such applications but appear to be a practical flexible heat spreading material. High thermal conductivity ultra-drawn ultra-high molecular weight polyethylene (UHMWPE) fibers are promising for development of fabrics. Thus, in this work, a woven fabric made entirely of UHMWPE fibers (Dyneema®) is constructed for testing. In parallel, we obtain commercial fabric materials that have atypical thermal properties (Arctic Cool, EeonTex, SheexÂ®, Performance Sleepwear, Tuff-n-LiteÂ®). The commercial materials either contain Dyneema®/UHMWPE fibers or have some cooling functionality (moisture wicking, breathability, etc.) that does not rely on heat conduction. Based on an ASTM standard approach, the bending stiffness of these materials is characterized. The bending stiffness of the custom-woven UHMWPE fabric proves to be the same order of magnitude as denim samples made with some lesser fraction of high conductivity UHMWPE. To further test the reliability of the custom-woven UHMWPE fabric, it is bent under different loads, based on an ASTM crease-test/folding standard. The impact of bending is studied through optical microscopy and in-plane thermal measurements with infrared microscopy to observe potential damage from bending. Preliminary results show that a single bending event has negligible impact on thermal transport. Therefore, this UHMWPE woven fabric is viable for further development and use as a heat spreader in wearables.

All Printed Low-Cost Dosimeter for Sterilization Monitoring Applications

Presentation ID:
MO-17

Room:
ARMS 1103

Keywords:
Sensing and measurement, Nanotechnology, Health, Gamma radiation monitoring, Conductive Polymers

Julia White, Sina X. Nejati, Rahim Rahimi
Purdue University

Gamma radiation of medical devices has been proven to successfully sterilize fully packaged materials without heat, moisture, or harmful chemicals due to its high energy and penetration. In this process, absorbed radiation must be carefully monitored to achieve sterilization at a standard dose of 25 kilograys (kGy) without exposing materials to excessive doses. As current radiation monitoring technology for high-dose applications relies on expensive equipment and expertise to determine the doses reached, this study aims to develop an all printed disposable sensor that exploits the change in the resistance of the conductive polymer poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) to monitor radiation dose. PEDOT:PSS with 0, 5, and 10wt% concentrations of polyvinyl alcohol (PVA), used as a thickening agent, was drop cast onto a printed electrode on a PET substrate, exposed to gamma radiation, and monitored through DC resistance measurements at set dose intervals of 5 kGy. The resistance of all sensors increased significantly with increased dosage of up to 40 kGy. Fourier transform infrared spectroscopy and Raman spectroscopy were used to verify that scission is the primary mechanism of degradation of PEDOT:PSS under radiation. These findings indicate that these materials and technology can be efficiently incorporated into medical device packaging to improve radiation sterilization monitoring.

Additive Manufacturing Applied to Reactive Materials in Solid Propellants

Presentation ID:
MO-18

Room:
ARMS 1103

Keywords:
additive manufacturing, 3D printing, solid propellant, nanoaluminum, energetics, solid fuel, reactive wires, ammonium perchlorate

Nicole H. Dorcy, Diane N. Collard, Steven F. Son
Purdue University

Additive manufacturing (AM) has proven to be a useful tool in producing intricate geometries in a range of materials, however, much development and characterization is still needed on the behavior of 3D printed energetic materials such as solid propellants so they can be applied to real world situations such as rocket propulsion. For example, more work is needed to investigate ways in which additive manufacturing can be utilized with printable energetics to modify the burning of solid propellant. In this work, a 3D printer was used to additively manufacture a reactive geometry of aluminum-fluorocarbon, then embedded in ammonium perchlorate/hydroxyl-terminated polybutadiene (AP/HTPB) using traditional mold casting to form solid propellant blocks. The quality of the filament feedstock and printed parts were assessed with micro-computed tomography (microCT) and also the burning rate of both the filament and printed parts were determined. Dynamic X-ray radiography was used to image the burning of the embedded printed part within the propellant. The results of these experiments proved there was a negligible difference in burning rates between extruded filament and printed lines. When cast into propellant stands, the geometry of the printed part has a distinct effect on the burning profile, changing the burning surface. These results establish the use of dynamic X-ray radiography in imaging burning as well as demonstrate a new way to manipulate the propellant burning surface pattern.

Investigation of incipient damage in continuous fiber reinforced composites through synchrotron radiation computed tomography

Presentation ID:
MO-19

Room:
ARMS 1103

Keywords:
Materials and Structures, Experimental Mechanics, Laminate Composite, In-situ Tomography

Jose Solano, Imad A. Hanhan, Ronald F. Agyei, Michael D. Sangid
University of Houston and Purdue University

Recently carbon fiber/epoxy laminates (CFLs) have seen increased use in aircraft load bearing structures due to their lightweight and high strength as compared to traditional engineering alloys. However, the way in which these composites sustain damage is different from alloys. Damage is comprised of an interaction between a combination of 4 main microstructural damage mechanisms: interlaminar matrix cracking (delamination), intralaminar matrix cracking, fiber breakage, and fiber-matrix debonding. An understanding of the interaction between these mechanisms in the initiation and propagation of damage through CFLs is necessary to produce efficient damage tolerant designs and a reliable prediction for the slow failure of structures. Although similar lay-ups of CFLs are used in current aircraft structures, the mechanisms in which damage initiates and propagates through these materials are still not completely understood, especially in [+45]n and [+45/-45/+45]s lay-ups, often resulting in overdesign of components. Therefore, in-situ synchrotron radiation computed tomography (SRCT) has been used to identify the mechanisms that initiate and propagate damage through the microstructure of [+45]6 and [+45/-45/+45]s lay-ups of the T650/5320 carbon fiber/epoxy composite when loaded via compact tension specimen. Although past studies have shown that CFLs with layups containing a [+45/-45] interface show delamination, it has yet to be proven that [+45/+45] interfaces show different behavior. This study aims to identify the potential disparate damage mechanisms in [+45]6 and [+45/-45/+45]s layups.

Characterization of Fabrication Capabilities with Two Photon Polymerization

Presentation ID: MO-20

Room: *ARMS 1103*

Keywords: *two photon polymerization, microrobots, micro-manufacturing*

Josiah Rudge, Georges Adam, David Cappelleri
Purdue University

Fabrication of complex structures and undercut features with resolution in the length scale of 1 to 100 um is desired for emerging biomedical uses such as microrobots and cell scaffolds. Traditionally, fabrication at this scale has been performed by photolithography, a planar process that requires multiple processing steps to produce simple structures. Two photon polymerization has emerged as a 3-dimensional process that can produce arbitrarily complex structures with resolution nearing 100 nm. Two photon polymerization is performed by passing a focused laser through a photo-curable resin to selectively harden a structure. Systems typically translate an 3D computer model of the desired structure into machine instructions for fabrication, known as 'slicing' the model, making this process especially useful for rapid prototyping. Fabrication tolerances are limited by the minimum feature size and resolution. These tolerances depend on the laser power, write speed, choice of resin, and development procedures. The fabrication capabilities of large structures may be compromised by internal collapse, macroscopic collapse of undercuts, and surface roughness. These capabilities depend on the slicing parameters, specifically, the spacing between polymerized lines. The width and height of a single polymerized line was measured to assess the minimum feature size at a range of laser powers and write speeds. Resolution was measured as the minimum distance between two adjacent yet separate structures. These measurements were used to infer settings for subsequent characterizations. Internal collapse was studied as a function of the fill density of a simple cube. Macroscopic collapse was observed for cantilevers of varying length extending from a base. Surface roughness was studied as a function of the line spacing parameters of the model slicing and assessed by qualitative observation of slants, steps, and spheres. The limits of the system were investigated in order to improve the accuracy of fabricating complex structures, such as helical microrobots. Qualitative observation confirms that the system is capable of printing complex structures with undercuts at sub-micron resolution.

Human Factors

ARMS 1109, 9:30 AM – 10:45 AM

Uncover Developer's Habits with Open Source Repositories: An Analysis of Git Commit Logs

Presentation ID: MO-21

Room: *ARMS 1109*

Keywords: *developer, habits, commit logs, open source*

Kaiyang Zhao, Liwei Guo, Professor Felix Lin
Purdue University

The habits of software engineers are key to the productivity and effective management of software engineering teams. The advent and prosperity of open source software provide massive amounts of publicly available logs of programmer's work (commit logs), from which objective measures of their habits and behaviors can be taken. Our goal is to understand the common working hours of developers, the stress level of their work, and variations in their behaviors with regard to holidays, weekends, and regions. We obtained the code repositories of three popular open-source projects, each of which has more than a thousand contributors representing a plethora of nationalities, affiliations and professional backgrounds. Commit logs were then exported containing the names and emails of the developers, the changes made, and the local time of the commit. We subsequently used Pandas and NumPy to analyze various characteristics of developers and produced graphs. We found that we could infer the geographical compositions of a project's developers by looking at their time zones. We also found that most developers spend two to four hours per week on a project, and tend to work late hours on weekends. We confirmed that projects oftentimes have spikes in their activities, possibly correlated to deadlines or release cycles. It is also worth noting that developers on different continents may exhibit different ranges of usual working hours, and that most developers do not work on holidays. We hope that our findings have shed light on software Developer's habits, and are useful to further studies of human factors in the technology industry.

Reducing Potentially Avoidable Hospital Readmissions for Long-Term Care

Presentation ID:
MO-22

Room:
ARMS 1109

Keywords:
Long-term care, potentially avoidable hospitalizations, nursing homes, hospital readmissions

Emily Garcia, Paul Griffin, Ph.D, Ping H. Huang, Ph.D, Jennifer M. Reagin, and Zachary Hass, Ph.D
University of California, Berkeley and Purdue University

According to the 2017 Long-Term Services and Supports Scorecard Overall Ranking, Indiana ranks the worst statewide in terms of long-term care (LTC) quality. Hospital readmissions originating from LTC facilities, while decreasing in recent years, continue to remain a problem both in Indiana and nationwide. To improve Indiana's LTC outcomes and potentially further reduce hospital readmissions nationwide, we investigated the risk factors associated with hospital readmissions from skilled nursing facilities (SNFs) and developed a prediction risk model. We used the 2018 Indiana Minimum Data Set (MDS) to build the prediction risk model and characterized the factors of SNF discharges to a hospital occurring within 30-days of a SNF admission versus discharges occurring longer than 30 days or to other LTC facilities including the community. Risk factor candidates included patient's age, race/ethnicity, sex, marital status, medications, and health conditions, such as those defined to be associated with potentially avoidable hospitalizations (PAHs). A total of 128,184 MDS assessments resulted in a SNF discharge to a hospital and out of these, 33% were within 30-days. Out of all the SNF patients, 42% were discharged to a hospital and 56% within 30-days. Using a logistic regression, 27 risk factors were identified to be associated with hospital readmissions and used in the prediction risk model. Although PAHs are defined by specific health conditions, our identified risk factors did not include all of them, providing some evidence that readmission characteristics have changed. Hospital readmissions continue to prevail at high rates demonstrating the need to improve LTC.

Resonant Human Body Communication

Presentation ID:
MO-23

Room:
ARMS 1109

Keywords:
Human Body Communication (HBC), Wireless Body Area Network, Capacitive Return Path, Inductive Cancellation, Channel Capacity, Narrowband HBC

Chun Tao, Shovan Maity, Shreyas Sen
Purdue University

Human Body Communication (HBC) utilizes the electrical conductivity property of the human body to communicate among devices around the body. The low-loss communication channel provided by the human body enables energy efficient and secure communication compared to radio wave based communication typically used in traditional Wireless Body Area Network. Capacitive Human Body Communication is the popular method of HBC, whose loss is limited by the parasitic return path capacitance between the transmitter and receiver devices. We explore excitation/termination methodology at the transmitter and receiver end respectively, which can enable low loss HBC communication by canceling the effect of the return path capacitance. We utilize inductors at the transmitter and receiver end to cancel the impedance provided by the return path capacitance and to enable low-loss HBC. Simulations are carried out on the Bio-Physical model of the human body, showing the possibility of low-loss HBC. Experimental results show achievable narrowband loss around the resonant frequency in the range of -10dB. This shows the possibilty of high SNR, and high channel capacity narrowband HBC, which can open up new application scenarios such as multi channel neural recording, AR/VR scenarios, etc.

FloARPlan: Using augmented reality to create walkable maps of indoor spaces

Presentation ID:
MO-24

Room:
ARMS 1109

Keywords:
Indoor navigation, Indoor mapping, Human-computer interaction, SLAM

Andrew Violette, Karthik Ramani
Purdue University

Google Maps cleanly solves the problem of navigating from building to building, but people still get lost inside buildings. Existing indoor navigation solutions rely on users to manually construct floor plans for other users to navigate on. We present FloARPlan, a tool for indoor mapping and navigation that automatically constructs floor plans based on where users walk. The device tracks the location of the user and visual markers based on Simultaneous Localization and Mapping (SLAM), a technique that blends vision and acceleration information from the smartphone's sensors. The user locations recorded during mapping are then linked across time and space to create a floor plan of walkable paths. Based on the floor plan, users are guided along the shortest path from their current location to a desired location using augmented reality cues. We ran a technical evaluation of the system on static markers to verify registration accuracy. FloARPlan was able to determine marker locations within 0.1m and the location of arbitrary points within 1m at room scale. This enables users to automatically perform indoor navigation tasks.

Prediction of Injuries in an Airline Maintenance Environment Using Ergonomic Assessment Tools

Zairelys Reyes-Rivera, Hamed Asadi, John H. Mott, Denny Yu
University of Puerto Rico at Mayaguez and Purdue University

Ergonomics literature has identified key workplace risk factors that are associated with worker discomfort and injuries in the workplace. Still, workplace injuries are commonplace and continue to impact worker health and safety. One area that has historically shown a high level of injuries is the airline maintenance environment. In 2017, our project assessed musculoskeletal disorder risks across all jobs performed by aircraft mechanics and avionics equipment technicians. The historical injury data was also obtained for observed areas and jobs for seven years. This project aims to model historical data vs observed data in an effort to a) compare the results from each assessment tool and the reported injuries, b) perform statistical analysis using tools, injuries, tasks, risk levels and job titles. Through iterative consultations with aviation and ergonomics domain experts, datasets from 2017 project were analyzed to standardize terminology for work five areas, fourteen tasks, and six job titles. Descriptive statistics were used to better understand the patterns of the results in datasets but specific statistical analyses were performed to associate injuries with risk assessment scores. Regarding the fourteen tasks, average results of the assessment tools classified all tasks as medium risk using REBA scores while thirteen indicated a risk based on the NIOSH Lifting Index. Others preliminary results show Lifting, Assembling/Disassembling, and Pulling/Pushing as the task with more injuries. Findings suggest a general relationship but specific results are expected after modeling data sets and performing statistical analysis.

Presentation ID:
MO-25

Room:
ARMS 1109

Keywords:
Ergonomics, Assessment tools, Injury-Risk Models, Airline Maintenance

MORNING POSTER PRESENTATIONS

MP

Biology

ARMS Atrium, 11:00 AM – 12:15 PM

Understanding Epigenetics: Developmental Requirements of ARID2, a Chromatin Remodeling Protein, in Early Porcine Embryo Development

Presentation ID:
MP-01

Room:
ARMS Atrium

Keywords:
Epigenetics, chromatin remodeling, embryogenesis, SWI/SNF, ARID2

Jillian Bouck, Jennifer Crodian, Yu-Chun Tseng, Ryan Cabot
Purdue University

In vitro production of animal and human embryos is an important practice utilized to address fertility in human clinical settings and production agriculture. Unfortunately, these in vitro produced embryos are often plagued by developmental disorders at a higher rate than organisms produced in vivo. Aberrant gene expression is a major factor underlying this developmental difference, often caused by irregularities in epigenetic modification. The process of chromatin remodeling is one way that cells epigenetically modify DNA expression and is especially important during early embryo development. Deviation of ATP-dependent complexes, which remodel chromatin during early embryonic development, is hypothesized to be one of the causes of an increase in epigenetic insults leading to disorder or developmental arrest in in vitro embryos. The SWI/SNF (Switch/Sucrose Non-Fermentable) chromatin remodeling complex is comprised of several unique proteins that aid in regulation of DNA transcription. In these studies, we aim to characterize function of ARID2, a key component of SWI/SNF complexes, in preimplantation porcine embryos. ARID2 is believed to play an important role in cell lineage differentiation, suggesting it may have functional importance during the zygotic genome activation (ZGA) stage. We evaluate the gene's role by microinjection of an interfering RNA to silence ARID2 expression, then analyzing developmental competency throughout various stages of development. Ultimately, a better understanding of events underlying chromatin remodeling in embryo development will help find solutions to develop new approaches to improve the quality and viability of in vitro produced embryos.

A Novel CTR1-Interating Protein at the Endoplasmic Reticulum

Presentation ID:
MP-02

Room:
ARMS Atrium

Keywords:
Ethylene, Phosphorylation, CTR1, ER, Botany, Biology

Katelin Burow, Chanung Park and Gyeong Mee Yoon
Purdue University

Phosphorylation is the most well-known post-translational modification that controls a wide range of cellular dynamics by controlling the subcellular localization, stability, and activity of cellular proteins. The signaling pathway for the plant hormone ethylene is also under the tight control of phosphorylation events. In an early stage of the ethylene signaling pathway, an ER-localized Raf-like protein kinase Constitutive Triple Response 1 (CTR1) negatively regulates the ethylene signaling pathway by direct phosphorylation of Ethylene-Insensitive 2 (EIN2), a positive regulator of ethylene signaling. Recent phosphoproteomic studies using ctr1 mutant have identified multiple target proteins of CTR1 other than EIN2 whose in vivo phosphorylation status is dependent on CTR1. A putative Calcium Binding Protein (CBP) is one such protein. CBP is known to be involved in plant stress responses such as drought tolerance. However, the roles of CBP, as well as calcium itself in ethylene signaling remains elusive. In this study, we investigated a direct interaction between CTR1 and CBP using Biomolecular Fluorescence Complementation. Using transient assay systems, we found that CTR1 and CBP directly interacted in unknown cytoplasmic puncta. Through further studies using subcellular organelle markers, we observed that the interaction may occur at the ER and an unknown nodule alongside of the ER. Further studies on the functional role of CTR1-CBP interaction at the ER will bring new insight into the roles of calcium in ethylene signaling.

Resolving Structural Variations in the Arabidopsis thaliana Genome Using Third-Generation Sequencing

Huijia Gong, Robert Auber, Jennifer Wisecaver
Purdue University

As a well-studied model organism, Arabidopsis thaliana is an ideal choice to investigate the association between genome variation and the diversification of metabolic pathways. For example, loci involved in glucosinolate (GSL) biosynthesis vary across different A. thaliana ecotypes, allowing theses ecotypes to produce ecologically advantageous GSLs. However, this variation is difficult to resolve using only Illumina short reads, which prevents more in-depth investigations. In the project, we evaluated the effectiveness of using Oxford Nanopore Technology (ONT), a third-generation genome sequencing technique that provides long reads, to resolve two GSL variable loci (MAM and AOP) in two A. thaliana ecotypes (Cvi and Ler). We sequenced DNA on an ONT MinION R9.4.1 flow cell and assembled sequence reads with miniasm. We then compared the MAM and AOP regions in the assemblies to the published descriptions of each locus and visualized the results using Integrative Genomics Viewer (IGV). In our assemblies, the MAM locus was well recovered, matching the expected numbers and positions for both Cvi and Ler ecotypes. However, the AOP locus was fragmented across multiple contigs, suggesting insufficient read length and yield. ONT may have the potential to be applied to study the evolution of variable loci, but our results were inconclusive. Future work will determine if longer reads or higher coverage results in a better recovery of AOP.

Presentation ID:
MP-03

Room:
ARMS Atrium

Keywords:
Oxford Nanopore Technology (ONT), glucosinolate biosynthesis, specialized metabolism, AOP locus, MAM locus

Characterization of Drosophila eye-specific GeneSwitch GAL4 Drivers

Aashka Shah, Spencer Escobedo, Dr. Vikki M. Weake
Purdue University

The classic GAL4 system is a genetic method used to study protein expression in Drosophila. Even though it allows spatial (tissue-specific) control over protein expression, it fails to provide temporal (time-specific) control. To combat this problem, a modified version of this system called the GeneSwitch GAL4 system is used. It is made up of two components: an RU488-dependent GAL4 driver (GeneSwitch) and an Upstream Activation Sequence (UAS). In the presence of RU486, the GeneSwitch GAL4 driver allows spatiotemporal control over protein expression. However, the problem with using this system in neuronal tissue (photoreceptor) studies is that no photoreceptor-specific G.SGAL4 driver has been characterized before. This creates a gap in the use of these drivers for photoreceptor-specific expression. So, my project aims to fill this gap by characterizing different photoreceptor-specific Rh1G.SGAL4 drivers and comparing them to an already published GMRG.SGAL4. It uses two main methods- luciferase assays (a measure of expression level) and microscopy (a measure of tissue specificity)- to do so. Results from these experiments will indicate which Rh1G.SGAL4 drivers are more suitable for photoreceptor-specific studies.

Presentation ID:
MP-04

Room:
ARMS Atrium

Keywords:
Photoreceptor cells, Rh1GSGAL4, RU486, Luciferase Assays

The Role of Mouse Rostrolateral Area in Motion Perception

Renee Towers, Yu Tang, Alexander A. Chubykin
Purdue University

Ischemic injury to the dorsal stream of the visual cortex can produce significant impairments in global motion perception in humans. Few treatments for such injuries are effective, and self-recovery of the mammalian adult brain is unlikely due to low rates of neurogenesis. Previous studies have demonstrated primary cortical visual response recovery using a novel technology, in vivo direct reprogramming, but how this treatment would affect visual perceptual learning, such as motion discrimination, remains elusive. Here we have developed an operant conditioning paradigm to examine global motion discrimination in mouse models with ischemic injury in the rostrolateral visual cortex (RL), a brain area that contains neurons which selectively respond to global motion patterns, to test the contribution of RL in visual motion perceptual learning. This study investigates the effects of ischemic injury to RL on global motion discrimination, and provides a potential behavioral assay to test visual perception recovery following in vivo direct reprogramming.

Presentation ID:
MP-05

Room:
ARMS Atrium

Keywords:
global motion perception; operant conditioning; dorsal stream; rostrolateral area; ischemic injury; in vivo direct reprogramming global motion perception; operant conditioning; dorsal stream; rostrolateral area; ischemic injury; in vivo direct reprogramming

Structure-Function Relationships of Propionyl-CoA Carboxylase for Rational Drug Design

Presentation ID:
MP-06

Room:
ARMS Atrium

Keywords:
propionyl-CoA carboxylase, macromolecular structure, X-ray crystallography

Brendan Williams, Trevor Boram, Jeremy Lohman
Purdue University

Propionyl-CoA Carboxylase (PCC) is an enzyme in mitochondrial metabolism where over or under expression is pathological, making it a target for metabolic drug design. In addition, in Mycobacterium tuberculosis PCC is drug target as inhibition leads to growth defects. PCC is a biotin dependent enzyme that converts propionyl-CoA to methylmalonyl-CoA in a twostep process. First a biotin carboxylase generates carboxybiotin from bicarbonate and ATP. Second the carboxy group on the biotin is transferred onto propionyl-CoA, which occurs on the carboxylase beta subunit (PCCB). The active site of PCCB is currently known. However, how the substrate or product is oriented within the active site has not been accurately described, knowledge of which will provide new avenues for inhibition or activation for drug design. We cloned and expressed PCCB with a His tag to be purified by affinity chromatography. After removal of the His tag, PCCB was purified on a size exclusion column. The PCCB protein was then concentrated and co-crystallized with methylmalonyl-CoA analogs. We found conditions that resulted in 3-dimensional rectangular prisms. These crystals were looped, frozen, and taken to Argonne National Laboratory where x-ray diffraction patterns were collected. The crystal diffraction patterns revealed low resolution diffraction with reflection smearing. These issues could possibly be overcome by setting up similar crystallization conditions with a cryoprotecting agent, which are ongoing.

Physics

ARMS Atrium, 11:00 AM – 12:15 PM

Constraining the Progenitor Systems of Ca-rich Transients Using Advanced Stellar Inferencing of Their Host Galaxies

Presentation ID:
MP-07

Room:
ARMS Atrium

Keywords:
supernovae, techniques: photometric, galaxies: photometry, galaxies: stellar content

YuXin Dong, Dan Milisavljevic
Purdue University

Calcium-rich (Ca-rich) transients are a newly recognized class of supernovae (SNe) with peculiar characteristics. They have a defining feature of strong calcium line emissions thirty days after explosion, and may be a significant driver of chemical evolution in the intracluster medium. Presently, the progenitor systems of Ca-rich transients remain unclear. Their early and late time spectra are very similar to core-collapse (Type Ib/c) supernovae. However, because some events occur in the outskirts of their often elliptical host galaxies, it is widely believed that Ca-rich transients are connected to thermonuclear (Type Ia) SNe. The possibility of mixed populations, i.e. a combination of Type Ia and Type Ib/c SNe contained in the class, has not been ruled out. Here we present a detailed stellar population characterization of the host galaxies of all 17 known Ca-rich transients using broadband photometry from ultraviolet to infrared wavelengths. We compared the estimated properties of their host galaxies to those of Type Ia and Type Ib/c SNe to uncover potential correlations. Our analysis is done using Prospector, which specializes in stellar population inferences. We fitted the spectral energy distribution of each host galaxy and calculated physical parameters including stellar population mass, age, and metallicity. We found that the Ca-rich transients' host galaxies are characteristically diverse and resemble both the host galaxies of Type Ia and core-collapse. Future work that can reconstruct detailed star formation histories under non-parametric model assumptions is required to place tighter constraints on Ca-rich transient progenitor systems.

Natural Convection Pattern of Liquid Xenon Inside Dark Matter Detector

Presentation ID:
MP-08

Room:
ARMS Atrium

Keywords:
Liquid xenon, dark matter detector, natural convection, free convection

Juan Ramirez, Rafael Lang, Juehang Qin, Michael Clark
Purdue University

Liquid Xenon detectors have a wide variety of applications for conducting physics research. Liquid Xenon is very clean and a scintillator (it produces a signal when it interacts with a particle) so these detectors provide great sensitivity, which is useful in the search for rare events like dark matter interactions. However, the detector's tank contains small amounts of radioactive Uranium, which has a decay chain containing the noble element Radon-222 that mixes with the liquid Xenon. Radon then continues the decay chain and the beta decay from Lead to Bismuth produces a signal in the same energy range as a dark matter interaction, which is the leading source of background in the experiment. We can track individual isotopes in the decay chain to predict when and where the Lead to Bismuth decay will occur, but the flow inside the tank makes this difficult. Using ANSYS Fluent, I ran simulations of how liquid Xenon would flow given different temperature gradients within the walls of the tank. We found that temperature gradients of 0.5-1.5 K from one side of the Xenon volume to the other produce circular convection patterns similar to what is seen in the experimental data. We also found a relationship between the magnitude of the temperature gradient and velocity of the flow. This takes us a step closer to reducing background generated by Radon decay and, thus, increase the sensitivity of the experiment. Additionally, it suggests that by reducing the temperature gradient (or eliminating it) a much slower pattern will develop, making it easier to reduce this background.

Biomedical Engineering

ARMS Atrium, 11:00 AM – 12:15 PM

Proteomics of the extracellular matrix secreted by mouse embryonic fibroblasts in vitro

Presentation ID:
MP-09

Room:
ARMS Atrium

Keywords:
Extracellular matrix, ECM, fibroblasts, mouse embryonic fibroblasts, cell culture, ECM culture, proteomics, mass spectrometry

Emmarie Ballard, Kathryn Jacobson, Sarah Calve
Purdue University

The scaffolding that maintains the integrity of bodily tissues, otherwise known as the extracellular matrix (ECM), is an important regulator in cellular function and growth. The health of the ECM is critical for the correct development of complex tissues. Mouse embryonic fibroblasts (MEFs) are known to secrete tissue-specific ECM proteins and other molecules during development. The goal of this project was to establish primary MEF cultures in vitro and analyze the ECM protein composition using liquid chromatography tandem mass spectrometry (LC-MS/MS). To establish primary fibroblast cultures, cells were isolated from embryonic day (E)14.5 mouse embryos. Fibroblasts were cultured for 2-3 days, then were split equally into 4 plates. Once the cells covered the entire plate (100% confluency), they were given new media containing sodium ascorbate and left to secrete ECM for 2-3 days. The deposited ECM was decellularized with ammonium hydroxide, and prepared for LC-MS/MS. Raw files were analyzed using the MaxQuant proteomics software and identified protein intensities were used to determine the composition of ECM proteins. We were able to resolve differences between the cellular and ECM fractions, the percentage of total intensity that attributed to ECM proteins was 9.1% ± 0.8% and 20.0% ± 9.2%, respectively. Additionally, volcano plot analysis indicated that more cytosolic, nuclear, membrane, and cytoskeletal proteins were more abundant in the cellular fraction compared to the ECM fraction. ECM proteins associated with development, particularly fibronectin, collagen type alpha-2(V) and lysyl oxidase, were more abundant in the ECM fraction, suggesting successful incorporation into the MEF-deposited matrix. Collectively, this data indicates that we were able to analyze ECM proteins deposited from MEFs using primary cultures and LC-MS/MS. Future work will be to characterize ECM proteins secreted from other cells present during development, such as myoblasts in the musculoskeletal system. Knowledge obtained from these studies will better define matrix dynamics and ultimately enhance our understanding of complex tissue development.

Large-Scale Analysis of Electrophysiological Data

Presentation ID:
MP-10

Room:
ARMS Atrium

Keywords:
Electrophysiology, data analysis, local field potential, current source density, extracellular recordings

Lindsay Karaba, Shulan Xiao, Krishna Jayant
Purdue University

The recording of extracellular and intracellular neuronal signals gives researchers access to the inner mechanisms of communication within the brain. While various analysis methods for these types of signals have been developed, few have been made to handle immense quantities of data. With an increase in technological advances that allow for more large-scale recordings of the voltage makeup within the brain (caused by electrical activity and referred to as local field potential, or LFP), advances in data analysis techniques must keep pace. A standalone suite for efficiently and accurately processing LFP data and for further producing current source density (CSD) maps, a useful tool for analysing activity, was developed. The ability to process such a wide range of data using various techniques will allow for a clearer image of individual neuron and neuron population activity, as well as coupling between the two. The suite was used to analyze previously recorded LFP data in the mouse cortex. While higher sampling rates and more detailed data are needed in future analysis, there was a promising correlation between spike behavior and the resultant CSD maps, indicating successful analysis of the given data. This advance will ultimately change how researchers map and investigate the brain, allowing for a widened scope of deep analysis.

Testing the Efficacy of Targeted Anabolic Agents on Maxillofacial Defects in a Rodent Model

Presentation ID:
MP-11

Room:
ARMS Atrium

Keywords:
Drug delivery, Osteology, Maxillofacial surgery, Bone fracture, wound healing, rodent

Jonathan Hicks, Stewart Low, Vaidehi Apte, Philip Low
Purdue University

Maxillofacial Surgeries, where the mandible or maxilla are restructured, are often debilitating to a patient. These operations leave a patient unable to be independent and put a patient through incredible pain lasting two to four months. Clearly there is a need to accelerate healing, to allow them to continue with their lives, unhindered by the operations they undergo. A promising solution to this is targeted drug delivery. Targeted drugs have been engineered to have a high affinity towards diseased tissue, drastically improving accumulation in the targeted diseased tissue over healthy. This affinity allows for a drug to have an amplified effect, in tandem with a minimization of side-effects. Previously, our lab targeted and significantly improved fracture repair in long bones but had not examined flat bones, such as the mandible. In this study, mandibular surgeries were performed on rodents, which are then allowed to heal while being systemically administered either saline as a negative control, or a targeted anabolic drug After 3 weeks, data was collected and analyzed for healing of the wound via force analysis and gap measurement. The difference in groups force analysis showed a significant improvement in force after fracture ($p=0.046$) as well as a significant difference in gap distance at 3 weeks ($p = 0.009$). This data shows that the targeted drug significantly improved fracture repair, and the drug can potentially be used in a clinical setting to improve quality of life.

Computational Investigation of Collective Behaviors of Actin Filaments

Presentation ID:
MP-12

Room:
ARMS Atrium

Keywords:
Actin Cytoskelton, Myosin Motility Assay, Actin Filaments, Actin Cross-Linking Proteins, Computer Model

Luke Fillenwarth, Taeyoon Kim, Wonyeong Jung, Jing Li
Purdue University

Animal cells have scaffolding structures known as the actin cytoskeleton. The actin cytoskeleton is responsible for a number of cellular functions, including migration, division, and morphogenesis. The actin cytoskeleton consists of actin filaments, actin cross-linking proteins (ACPs), molecular motors, and many other regulatory proteins. Because the actin cytoskeleton is crucial to cell functions, numerous studies have been conducted during the past decades to better understand these complicated intracellular structures, using both experiments and computer models. One of the most popular experiments is a myosin motility assay. In this experiment, actin filaments glide along a surface due to forces generated by molecular motors attached on the surface. Behaviors and movements of actin filaments depend on conditions of the experiment. Several studies have reported a noticeable difference in gliding behaviors of actin filaments depending on density of actin filaments and the existence of ACPs. However, there are limitations that experiments cannot overcome, which prevents full understanding of origins of intriguing behaviors of actin filaments. Computational models are able to overcome these experimental limits and can provide insights that are not able to be obtained through experiments alone. In this study, a well-established computational model is used to study the collective behaviors previously observed in motility assay experiments. With a wide range of parametrization that experiments cannot do, we observed various behaviors of actin filaments and analyzed data in order to better understand the complex mechanisms that drive these collective behaviors.

Spike Inference from Large-field Calcium Imaging

Alyssa Ignaco, Shulan Xiao, Krishna Jayant
Purdue University

Calcium imaging is a standard technique in neuroscience due to its ability to record the activity of large populations of neurons and other neural components, such as dendrites. As image resolution and size of imaging data increase, the need for faster, reproducible imaging analysis pipelines that require little human intervention continues to grow. This investigation identified an analysis pipeline that can efficiently analyze calcium imaging data from behaving animals. The research began with a review of methods used to detect neurons from imaging videos and estimate their underlying calcium dynamics. Based on these existing approaches, the investigation proceeded with the modification and testing of an analysis pipeline with the use of provided calcium imaging datasets. The pipeline accurately identified neural components from imaging data and estimated their neural activity based on their fluorescence traces. For future experiments, the study aims to utilize the pipeline to analyze in vivo calcium imaging data from awake head-fixed mice.

Presentation ID:
MP-13

Room:
ARMS Atrium

Keywords:
Two-photon imaging, calcium imaging analysis, spike inference, source extraction, motion correction

Stabilization of Large Proteins in In Situ Forming Implants Through the Addition of Basic Salts

Elizabeth Wakelin, Kelsey A. Hopkins, Luis Solorio
Purdue University

In situ forming implants (ISFIs) are a type of non-oral drug delivery system that have gained popularity in recent years due to the increase in drugs that cannot be administered by mouth, such as proteins and peptides. ISFIs form a solid drug-eluting implant after injection into the body and provide extended drug release. However, they must be optimized for macromolecular drug and protein release. The encapsulation of basic additives has shown promise in reversing the acidic microclimate that can form within ISFIs and cause protein instability. The current study examined the effects that three basic salts (MgCO3, Mg(OH)2, and MnCl2) have on the release and stability of bovine serum albumin (BSA), a model protein, from phase-inverting ISFIs. Implants were formed by combining BSA with the polymer, an organic solvent, and one of the three salts. The salts were added at either 1%, 3%, or 5%, with one implant containing no salt as a control. This solution was then dropped into phosphate buffered saline (PBS) to form the implants, and samples of the PBS were taken at different time points to measure BSA release. The addition of the salts resulted in an average total BSA release of 60.5% Â±15.5% compared to 36.9% Â±15.4% released with no salt present. However, the difference was not significant, and more tests will be done to confirm. This analysis of BSA with a variety of salts and concentrations will help in the optimization of other protein and drug release from ISFIs to increase their clinical usage.

Presentation ID:
MP-14

Room:
ARMS Atrium

Keywords:
Controlled Release, In Situ Forming Implants, Stabilization, Protein Release, PLGA, Additives

Chemistry and Chemical Engineering

ARMS Atrium, 11:00 AM – 12:15 PM

Using Vesicular Dispersions of a Cationic Surfactant for Stabilizing Suspensions of Dense Particles Against Sedimentation

Jordan M. Kruse, An-Hsuan Hsieh, Jaeyub Chung, David S. Corti, Elias I. Franses
Purdue University

Colloidal dispersions are used in many applications such as pharmaceuticals, soaps, and paints. For these dispersions to remain stable, the particles must remain suspended. However, many of these colloidal particles have large densities compared to their suspending medium. This leads to sedimentation even in the absence of agglomeration. In this project, the use of certain close-packed vesicular dispersions to prevent sedimentation is examined using the double-tailed cationic surfactant dimethyldidodecylammonium bromide (DDAB). The DDAB dispersions were prepared by three different methods (S, SS, and SE) to examine how the preparation procedure effects the properties of the formed vesicles. These dispersions were first stirred for 2 h (S procedure), followed by some samples undergoing either sonication (SS procedure) or extrusion (SE procedure). Separately, aqueous silica dispersions (d = 750 nm) were stirred for 30 min and then sonicated for 3 h. These two dispersions were then mixed, and the sedimentation rate of the silica particles was compared to a control of a 1.0 wt% aqueous silica dispersion. It was found that 2.0 wt% DDAB prepared by S and SS procedures was the most effective in decreasing the sedimentation velocity, as the mixture showed no sign of sedimentation up to four weeks. It was also found that SE DDAB dispersions produced a faster sedimentation velocity, while the S and SS dispersions produced slower velocities. Thus, the SE procedure produces smaller and less tightly packed vesicular dispersions. Overall, these results demonstrate that DDAB could be effective in preventing sedimentation.

Presentation ID:
MP-15

Room:
ARMS Atrium

Keywords:
Vesicular Dispersion, Particle Suspension, Particle Sedimentation, Surfactant

The Effect of Silver Ion Adducts on the Ionization Efficiency of Lipids

Presentation ID:
MP-16

Room:
ARMS Atrium

Keywords:
Mass Spectrometry, Electrospray Ionization, Lipids

Ryan Lagecy, Daniela Mesa Sanchez, Julia Laskin
Purdue University

Mass spectrometry (MS) is an important analytical technique utilized to determine the elemental composition of complex molecules based on their mass-to-charge ratio. Mass spectrometry imaging (MSI) is a related technique that uses spatially-localized MS analysis to create 2D images depicting the location of molecules in the sample. In biological samples, lipids can be difficult to detect using MSI as some do not readily ionize and might be present in very low concentrations. This project seeks to better understand and improve the ionization efficiency of lipids such as these. There have been many studies focused on increasing the ionization efficiency of lipids using metal adducts; notably, silver ions have been used to increase the ionization efficiency of endogenous prostaglandins due to their affinity to double bonds. This project is concerned with understanding previously unexplored silver ion complexation with other lipid classes.

Analysis of Pt Nanoparticle Size in Pt/SiO2 and PtNb/SiO2 Catalysts and Its Effect on Selectivity in Propane Dehydrogenation

Presentation ID:
MP-17

Room:
ARMS Atrium

Keywords:
Catalyst, shale gas, propane dehydrogenation, energy, nanoparticles, selectivity

Paige Probus, Johnny Zhuchen, Jeffrey T. Miller
Purdue University

The continual depletion of oil reserves has created a greater need for alternative fuels with a lower environmental effect. Shale gas fracking has increased the availability of natural gas and valuable light alkanes like ethane and propane. Ethane and propane can be converted to ethylene and propylene. These olefins will then be converted into transportation fuels in a second catalytic step. This study investigates the effect of Nb oxide on metallic Pt nanoparticles for propane dehydrogenation. Catalysts of different Nb promoter compositions were synthesized and the selectivity (to propylene) for propane dehydrogenation was determined. In situ X-ray Absorption Spectroscopy was used to estimate the Pt nanoparticle size. The results from the experiments allow us to compare Pt/SiO2 catalysts and a variety of PtNb/SiO2 catalysts. For both catalysts, selectivity decreases as the conversion temperature increases; however, the PtNb/SiO2 catalysts show significant in the propylene selectivity compared to Pt/SiO2. EXAFS data shows that Pt is present in both catalysts and that Nb inhibits Pt nanoparticle growth at higher temperatures. These results have led to the conclusion that Nb partially covers the Pt particles to improve selectivity and can be used to hinder Pt nanoparticle growth at higher temperatures.

Discovery and analysis of membrane-associated legionella pneumophilia deubiquitinase LPG0227

Presentation ID:
MP-18

Room:
ARMS Atrium

Keywords:
Ceg7, deubiquitinase, lipid-binding, LPG0227, ubiquitin, diubiquitin, assay, membrane association, diubiquitin cleavage, fluorescence, insoluble

Rachel Hohe, Kedar Puvar, Chittaranjan Das
Purdue University

Legionella pneumophila is a bacterial vector that thrives in freshwater environments and poses a deadly risk to humans with rising case numbers. During infection, L.pneumophila injects proteins called effectors into the host cell to hijack and disrupt cellular defense processes and allow for undisturbed bacterial growth. These effectors may serve as new drug targets, however many of them remain unstudied. Bioinformatic analysis predicted the uncharacterized effector LPG0227 to possess a deubiquitinase (DUB) activity, sharing some sequence similarity to known human and bacterial DUBs. To study this protein, it was cloned, expressed in bacteria, and subjected to analysis with a DUB-specific probe as well as ubiquitin chains of various linkages. This work revealed that LPG0227 is a DUB and possesses a substrate preference differing from other known bacterial DUBs. The key catalytic cysteine for this enzyme was also identified and confirmed via mutagenesis. Intriguingly, despite observable activity when expressed recombinantly, LPG0227 is not found in soluble fractions, suggesting it also possesses a lipophilic domain which may be important for targeting activity. Protein localization was determined by tagging the dub with GFP and inspecting the cell distribution using confocal microscope imagery. A better understanding of this enzyme and bacterial effectors in general is pertinent to understanding and eventually inhibiting disease development.

Evaluation of the Dynamics of Epigenetic Memory

Presentation ID:
MP-19

Room:
ARMS Atrium

Keywords:
Biology, Chemical Engineering, Biotechnology

Matt Zelinski, Kyle Wettschurack, Chongli Yuan
Purdue University

The goal of this experimentation is to analyze and understand the effects that chromatin regulating proteins have on gene expression. Understanding how chromatin regulators affect our expression patterns can help lead us to better understanding how the human body operates to change its gene expression when exposed to certain toxic chemicals. We use a CRISPR based binding system, when induced by 488nm light, chromatin regulating protein gains access to bind to DNA which allows for analysis on the expression dynamics of a specific gene after modification has occurred. The proteins used in this experiment methylate the DNA when bound which causes changes on the gene expression. These modifications are then evaluated under a microscope over a 5-day period of time, allowing us to study the dynamics of specific protein modifications to genes.

Influence of pore solution ion concentration and temperature on the poly(acrylic acid-co-acrylamide) hydrogel swelling in high-performance concrete

Presentation ID:
MP-20

Room:
ARMS Atrium

Keywords:
hydrogel, swelling capacity, temperature, ion concentration, high-performance concrete

Xunkai Chen, Jessica Sargent, Baishakhi Bose and Kendra Erk
University of California, Berkeley and Purdue University

High-performance concrete (HPC), because of its dense microstructures, has higher strength and durability compared to ordinary concrete. However, its low water to cement ratio causes volumetric shrinkage over time, which essentially leads to microcracks and a decrease in strength. The specific type of hydrogel has been integrated into HPC to solve this problem. In construction, the temperature of the concrete may vary locally because of the sunlight and the heat releases by cement curing reaction. Besides, certain ion concentrations will also increase as cement cures. Therefore, it is crucial to understand how the temperature and ion concentrations will affect the swelling behavior of the hydrogel. The percent change of swelling capacity for the hydrogels was determined using the gravimetric method under various temperatures and salt solution concentrations, and the compressive strengths of cement pastes with hydrogels were tested. Finally, a thermocouple was used to monitor the temperature fluctuations of the hydrogel in the cement paste during curing. It has been found that increasing salt concentration and temperature both decrease the swelling capacity of the hydrogels by up to 93% and 34% respectively. Hydrogel with a higher acrylic acid composition is more responsive to both changes in temperature and salt concentration. Besides, those in higher salt concentrations are less prone to be influenced by the temperature change. The compressive strength tests suggest that higher temperature curing could compromise the strength of concrete. This study has the potential to shed light on the deswelling behavior of the hydrogels in cement paste environment as curing proceeds. Hence, actions can be taken to maximize the performance of hydrogel as an internal curing agent in HPC.

Fabrication of Non-Spherical Microparticles for Particle Focusing Studies

Presentation ID:
MP-21

Room:
ARMS Atrium

Keywords:
polymeric materials, polystyrene microparticles, morphology, non-spherical, particle focusing, biaxial stretching, uniaxial stretching, uniaxial compression

Kwesi Kakraba-Ampeh, Audrey Britton, Cheng-Wei Tai, Vivek Narsimhan
Purdue University

In real-world viscoelastic fluid systems such as blood and other bodily fluids, studies have shown that solid particles tend to migrate laterally to form a specific pattern in the channel in which they flow. This phenomenon is known as particle focusing and occurs because of factors such as the fluid rheology, particle shape and channel geometry. Most experimental studies of this field have mainly focused on the effects that fluid rheology and channel geometry have on the particle focusing properties. As such, there is limited information about the role that particle shape has on focusing properties even though in most applications, the particles are non-spherical and somewhat deformable. A crucial step towards generating understanding in this field is the development of consistent and repeatable methods for the uniform fabrication of non-spherical micro-particles of different geometries, and in large enough quantities to support such investigations. In this study, non-spherical micro-particles are fabricated by suspending polystyrene micro-particles in thin polyvinyl acetate films, heating these films up in a silicone oil bath and either compressing or stretching them in one or two directions. These methods result oblate particles, prolate particles and other particles of more complex geometries respectively. They also offer independent control over different characteristics such as size and aspect ratio and will contribute to ongoing research about the effect of particle shape on particle focusing in viscoelastic fluid systems.

Developing a Method to Measure Nitrate N and O Isotopes

Presentation ID:
MP-22

Room:
ARMS Atrium

Keywords:
Nitrate, Stable Isotopes, Method Development

Jacob Brejcha, Jianghanyang Li, Greg Michalski
Purdue University

One particularly important mechanism of the nitrogen cycle, the collection of processes involving conversions among nitrogen-containing compounds, is denitrification. In denitrification, nitrate (NO3-), a chemical with both environmental and human health effects, is converted to N2 through many intermediate steps. To analyze the N and O stable isotopes of NO3-, it must be converted to an NxOy compound in the gas phase for measurement by an isotope ratio mass spectrometer (IRMS). Established methods involve conversion of NO3- to nitrous oxide (N2O), an intermediate in the process of denitrification. A recently-disseminated process uses titanium (III) chloride (TiCl3) to reduce NO3- to N2O, but the yield of this reaction is significantly lower than 100%, resulting in uncertainty in isotopic analysis. We aim to improve N2O yield of this reaction and isotopic results by 1) flushing capped 12-mL vials with He; 2) controlling pH; 3) adding dilute TiCl3 and a nitrate-containing standard and allowing the reaction to occur overnight; and 4) sampling the headspace of the vial using a needle connected to an IRMS. Using lower concentrations and controlling pH, we have improved the analysis of N and O stable isotopes. The highest N2O yield and most consistent N and O stable isotope values were found using pH 0-2 and a TiCl3 dilution of approximately 50 times, which also reduced the dependence of N stable isotope values on concentration. Through our improvements, we provide the enhancements to the titanium method needed for reliable determination of nitrate sources and formation.

Characterizing the Epigenetic Differences in Enzalutamide Resistant Prostate Cancer Cell Lines

Presentation ID:
MP-23

Room:
ARMS Atrium

Keywords:
Epigentics, Prostate, Cancer, Enzalutamide, Drug, Resistance

Harvey Holman, Kyle Wettschurack, Chongli Yuan
Purdue University

According to the center for disease and control in 2016 over 190,000 people were diagnosed with prostate cancer. Many of these cases will encounter some form of drug resistance during their treatment, making it difficult to treat and contain the cancer. Currently little is known about what factors drive the formation of this drug resistance. One potential driver of drug resistance formation is epigenetics, which are plastic modifications on your DNA and Histones that drive gene expression. To better understand what role epigenetics plays in the formation of drug resistance we characterize two Enzalutamide (MVD3100) resistant cell lines and their respective non-resistant versions. In our characterization we specifically focused on H3K4me, H3K27me, DNA 5mC methylation and H3K27ac due to their known role in prostate cancer. During the study we will utilize phenotypical assays, immunostaining assays, fluorescent live cell probes, and single cell tracking assays to characterize the cells with a focus on the above mentioned epigenetic features. Currently our analysis is still underway, and thus at this time we do not have any meaningful results to report.

Aerospace

ARMS Atrium, 11:00 AM – 12:15 PM

Control of Slender Body Wake Flow using Plasma Actuators

Presentation ID:
MP-24
Room:
ARMS Atrium

Keywords:
Aerodynamics, Computational Fluid Dynamics, Plasma Actuator, Wake, Separation

Raghav Chari, Devon Fano, Jonathan Poggie
Purdue University

Plasma actuators are an area of interest for high speed aerodynamics, with potential applications in the control and performance of hypersonic vehicles. Plasma actuators use a high-voltage AC current between two electrodes to accelerate the flow between the electrodes locally to provide energy through heat addition and momentum through an applied force, to affect the flow pattern and reduce drag. In the present work possible applications of plasma actuators were explored to reduce the separation layer in the wake of slender aerodynamic bodies. Computations were performed to simulate localized heating and radially inward actuation forces of various intensity at the sharp trailing edge of the slender body, and the resulting flow patterns and drag are examined. 2D axisymmetric viscous computations were performed to model the chosen configuration: 15 degree 0.459m length cone with a 3.5mm radius rounded nose and a 1m length cylindrical afterbody. A noticeable change in the flow field was observed with sufficient heating and force added, resulting in reduced separation and recirculation in the wake region. Varying amounts of heating and force were modeled, to represent potentially varying intensity of the AC current applied to the plasma actuator, and the energy cost of operation of the plasma actuator setup should be considered for any potential applications
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Improved Thrust Stand Design for Indirect Thrust Measurements from the KDC-40 Gridded Ion Source

Sanjana Singh, Glynn Smith, Yunping Zhang, Alexey Shashurin
Purdue University

Presentation ID:
MP-25

Room:
ARMS Atrium

Keywords:
KDC-40, Ion Thruster, thrust stand

The KDC-40 gridded ion source is a ground-based analog of an ion thruster that can produce thrust on the order of several millinewtons by accelerating noble gas ions such as Argon ions through electrode grids. The ejected ion flux is neutralized by electrons just outside the device and forms a well-collimated plasma plume with the designed ion optics configuration. One way to calibrate the small order of thrust is by using direct methods, which can be complex to design and inconvenient to implement. In this research, we have proposed an indirect method to measure thrust which unlike the direct methods does not require that the system be mounted on the thrust stand for measurements. The thrust stand presented here is a compound pendulum. It is used to calibrate thrust values of the KDC-40 gridded ion source based on the deflections of the pendulum when the plasma plume is directed towards the pendulum. The stand has a sensitivity of 1.66 mN /deg and can measure thrust in the range of 2 mN -100 mN, enabling it to cover the thrust level of the KDC-40 ion source and potentially the T-100-3 Hall Thruster. Preliminary experiments with the compound pendulum thrust stand and KDC-40 gridded ion source installed inside a vacuum chamber at Applied Plasma Science Lab show that the thrust stand is a feasible gauge for measuring the thrust for KDC-40 and the thrust was estimated at 8mN.

Improved Ignition of HCPEE 375 for use on T-100 Hall Thruster

Peter Waller, Yunping Zhang, Glynn Smith, Alexey Shashurin
Purdue University

Presentation ID:
MP-26
Room:
ARMS Atrium

Keywords:
Hollow Cathode Neutralizer, Hall Thruster, Electric Propulsion, Propulsion

Electric propulsion is a technology that has a growing use due to an increase in satellites that need an efficient system for orbital adjustments. Hall thrusters are a form of electric propulsion that have a relatively high thrust compared to other forms of electric propulsion at the sacrifice of efficiency and specific impulse, though they still have much higher values than chemical propulsion alternatives. In conjunction with the operation of the Hall Thruster a hollow cathode neutralizer is used. The hollow cathode is necessary as an electron source to initiate and maintain discharge in the Hall Thruster. This work focused on improving the ignition method of the 375 Series Hollow Cathode Plasma Electron Emitter (HCPEE 375) used to operate a T-100 Hall Thruster. Ideally the HCPEE 375 was designed to ignite with a heater voltage and current of about 4 V and 36 A and a keeper voltage of 52 V. This was no longer sufficient to ignite the HCPEE 375 being worked with so experimentation with keeper voltage was done to find that the HCPEE 375 could ignite once the keeper voltage was raised over 600 V. To streamline the ignition process we designed a circuit to provide a high voltage pulse. Several different variations of diodes and capacitors were compared and utilized in the circuit to find a most effective configuration for ignition of the HCPEE 375. After the inclusion of the high voltage pulse circuit the process of igniting the HCPEE 375 is quicker and more reliable than before. With the HCPEE 375 able to ignite again the T-100 thruster can now be operated.

Crater Formation and Transition of Gas Breakdown Mechanism at Nanoscale

Weihang Li, Russell S. Brayfield, Allen L. Garner
Purdue University

Presentation ID:
MP-27
Room:
ARMS Atrium

Keywords:
Electrical breakdown, Field emission, Paschen's Law, submicron gap, space-charge limit.

Gas breakdown is a common phenomenon in electronics devices and in plasma formation for multiple applications. Increasing device miniaturization motivates better characterization of this behavior to ensure device reliability. Gas breakdown is either driven by avalanche or, as device sizes are reduced to microscale, field emission, which depends strongly upon the electrode surface roughness and sharpness. However, repeated breakdown events or further reductions in gap size may further alter the breakdown mechanism. For instance, submicroscale gaps may cause the dominant electron emission mechanism to transition from field emission to space-charge limited emission. Repeated breakdown mechanisms can change the effective gap distance, electrode surface roughness, or gap distance. This study aims to characterize this behavior. We first measure current under different applied voltages to examine atmospheric gas breakdown for gap distance between 60 nm to 500 nm for cathodes with different aspect ratios. Second, we assess crater formation using a pin anode and plate cathode with gap distances at 1±0.5 μm and 5±0.5μm for multiple breakdown events on different areas of the plate using dcanning electron microscopy (SEM). Field emission generally occurs at higher electric fields for smaller gap distances and larger aspect ratios. The current vs. voltage curve shows a general pattern of a rapid rise in current followed by a plateau. This result contributes to better understanding on the transition between gas breakdown and electron emission mechanism at microscale and smaller gaps to ensure reliability of microelectromechanical systems (MEMS) and nanoelectromechanical systems (NEMS).

Thermal Remote Sensing on Unmanned Aircraft System Calibrations Comparison

Qijue Chen, Yan Zhu, Keith Cherkauer
Purdue University

Presentation ID: MP-28

Room: *ARMS Atrium*

Keywords: *Thermal remote sensing, UAS, MODTRAN, water target, atmospheric calibration*

Thermal remote sensing from unmanned aircraft systems (UAS) has great potential as a tool to improve agriculture practice for its nondestructive, low-cost and efficient characterizations. Due to its high susceptibility to environmental influences, the temperature data embedded in thermal images may not represent the objects' temperature directly. Therefore, multiple calibration approaches are established to improve the accuracy of all results. In recent years, calibration software using algorithms integrated with weather database are widely used during application, but there hasn't been any literature comparing them to field based calibration instruments. The objective of this research is to compare the accuracy of two atmospheric calibration methods. One utilizes a field-based device called water target and the other involves an atmospheric correction software Moderate Resolution Atmospheric Transmission (MODTRAN). Water targets are a relatively cheap system but require significant manpower to operate correctly for each flight, while MODTRAN is a relatively expensive software package used to generate atmospheric correction parameters but requires minimal effort on data collection during flight operations. This research would compare the calibrated results between MODTRAN and water target for thermal imagery in the 7.5–13-μm region over Purdue agricultural field. Results show accuracy of water target and MODTRAN on calibrating the raw thermal imagery, which will provide insight into the best methods to use in future thermal sensing applications based on effort, expense and accuracy.

Conceptual Design of a 10-passenger Thin-haul Electric AircraftBased Transcriptional Regulators

Boning Yang, Fangyuan Lou, Nicole Key
Rose-Hulman Institute of Technology and Purdue University

Presentation ID: MP-29

Room: *ARMS Atrium*

Keywords: *Aviation, Electrical Aircraft, Future Transportation, Electric Propulsion, Joint Wing*

With the development of battery technology, all-electric airplanes for thin-haul application is becoming a reality in the foreseeable future in the 2020s. Comparing to the traditional fossil-fuel-dependent airplanes, the electric-powered airplane offers lower cost in term of operation and maintenance, and also generates less greenhouse gas footprint. The present study shows the effort in the conceptual design of a 10-passenger aircraft for thin-haul application. The airplane falls in the category of general aviation, according to the Federal Aviation Administration (FAA) regulations. The target range of the aircraft is 500nm with a capacity is ten passengers. The airplane features a joint-wing design for better aerodynamic performance and is powered by two newly designed duct fans. The maximum takeoff weight (MTOW) of the airplane is 15813 lbs, and the cruise speed of the airplane is 245 Knots at an altitude of 30000 ft. The takeoff and landing distances are 2900 ft and 2000 ft, respectively. To achieve the range requirement, the battery weight is approximately 51.3% of MTOW for the existing design while using a pack level battery density of 300kg/kWh, which excepted to be available in the 2022-2025 timeframe. Achieving design with lower pack level battery density is possible; however, it will increase the challenges in the structural design to increase the battery weight percentage or sacrifice the mission performance and passengers comfortableness. Though the battery technology mostly limits the range of the all-electric airplanes, it was optimistic that electric airplanes would be able to achieve similar mission performance in the 2030s with development in battery technology.

Experimental Investigation of Combustion Characteristics of Monopropellant Sprays

Sodiq Adeniji, R.R. Jagannath, P.B. Venkatesh, B.Singh, L. Rajendran, S.P. Bane
Purdue University

Presentation ID: MP-30

Room: *ARMS Atrium*

Keywords: *Fuel Droplets; Ignition Properties; Fuel Droplet Proximity; Combustion Properties; Greener Alternative Fuels*

Conventional rocket fuels, while having high performance values, tend to be toxic and difficult to store and handle. Greener and safer alternatives are being explored, and it is important to understand how these greener alternative fuels burn as droplets in sprays. Therefore, experimental investigations of the ignition and combustion characteristics of single fuel droplets and fuel droplets in close proximity to each other are needed. While, a limited number of single fuel droplet experiments have been done on the ignition and combustion properties of greener alternative fuels, this study looks to further those experiments by providing a review on the interactivity of two fuel droplets based on proximity. We experimentally study the ignition and combustion characteristics of two horizontally aligned fuel droplets, and the interference effects the droplets exert on each other based on their proximity. The droplets are suspended at one end of a silica fiber before being exposed to a well-controlled, high temperature oxidizing environment provided by a flat flame burner. The ignition and combustion phenomena are captured in high speed videos which are analyzed to calculate ignition delays and burning rates of the droplets. The influence of droplet spacing on the combustion characteristics is investigated, and the results for multiple droplets is compared with previous experimental results involving single, isolated droplets.

Industrial Engineering

ARMS Atrium, 11:00 AM – 12:15 PM

Predicting Fatigue: Sensing Upper Body Muscle Activity in Robotic Surgeons

Presentation ID: MP-31
Room: *ARMS Atrium*

Xiang Feng, Jackie S. Cha, Jay Sulek, Chandru Sundaram, Denny Yu
Purdue University

Keywords: *Robotic Surgery, Electromyography, Muscle Activity, Discrete Wavelet Transform*

The number of robotic surgery procedures have been increasing over the past decade. It is said that robotic surgery—where a surgeon operates on a console to manipulate robotic arms positioned at the patient bedside—is more ergonomic for the surgeon and safer for patients. However, surgeons still report work-related musculoskeletal symptoms (MS) such as neck pain. The purpose of this study was to objectively measure upper body muscle activity patterns of surgeons during live robotic surgery. Electromyography data of left and right neck, trapezius, bicep, and forearm from surgeons performing twenty-nine robotic procedures were obtained. Each procedure was segmented into beginning, middle, and end phases of the surgery, and metrics describing muscle fatigue (i.e., power) was calculated using the Discrete Wavelet Transform. It was found that surgeons experienced muscle fatigue on their non-dominant forearm throughout a surgical procedure and throughout the entire surgical day. Findings from this work can be used to provide insight on measuring and monitoring muscle fatigue of surgeons to further develop interventions to help minimize MS symptoms and increase career longevity and patient safety.

Augmented Reality in Semi-autonomous Driving: The Effect of Warning Signal Format and Perceived Urgency on Takeover Performance

Presentation ID: MP-32
Room: *ARMS Atrium*

Alec Gonzales, Gaojian Huang, Brandon Pitts
Texas A&M University Kingsville and Purdue University

Keywords: *Human Factors, Semi-autonomous Driving, Warning Signals, Augmented Reality, Perceived Urgency*

Fully autonomous vehicles are developing at a rapid rate and are expected to be in commercial operation as early as 2021. In the interim, however, the vast majority of vehicles will be semi-autonomous, which will require drivers to take over control from the vehicle during an emergency, or unanticipated, event. As a result, it will be critical to design warning systems that can properly (re)orient driver's attention. The goal of our study was to evaluate the effectiveness of an in-vehicle Heads-Up, visual augmented, Display (HUD) that presents warning signals in both dynamic and static formats and is synchronized with auditory and tactile alerts. In this experiment, participants rode in a simulated semi-autonomous vehicle and were presented with various combinations of visual, auditory, and tactile signals with a static and dynamic variation in the visual cue. Driving performance and subjective responses were collected to determine whether warning signal format affects takeover performance and perceived urgency. The findings from this research may help to inform the development of future adaptive and customizable in-vehicle alerting systems that improve driver and roadway safety.

Optimizing Reflected Brownian Motion

Presentation ID: MP-33
Room: *ARMS Atrium*

Xiaotian Wang, Zihe Zhou, Harsha Honnappa
Purdue University

Keywords: *Partial Differential equation, Reflected Brownian Motion, Optimization, Optimal Control, Simulation.*

Reflected Brownian motion (RBM) is a stochastic process that behaves like a standard Brownian motion in the positive quadrant, and is instantaneously reflected back into the quadrant when the process hits the level zero boundary. RBMs are used to model queueing systems that are experiencing heavy traffic, for inventory systems, as interest rate models in finance and economics and in mathematical biology. This project considers the question of how to solve an infinite dimensional stochastic optimization problem driven by an RBM. The goal is to minimize a cost function that involves a weighted linear function of an additive sum of the RBM process over a fixed time horizon and a terminal cost at the end of the horizon. We seek to solve this optimization problem by leveraging the fact that the problem is equivalent to an "open-loop" optimal control problem, thereby transforming it into one of solving a partial differential equation — specifically a Hamilton-Jacobi (H-J) equation. In general, solving this H-J equation analytically is incredibly hard. Therefore, we develop computer code to solve the H-J equation numerically using the finite element method. This project serves as part of a larger research plan in which the results from this project will be compared with a more efficient Monte Carlo method being developed for solving the H-J equation.

Sensors and Measurement

ARMS Atrium, 11:00 AM – 12:15 PM

Development of a low-cost electronic nose for food adulteration and bacteria detection

Presentation ID: MP-34

Room: *ARMS Atrium*

Yixu Huang, Euiwon Bae
Purdue University

Keywords: *Electronic Nose, Food Safety, Food Adulteration, Bacteria, Sensors, Machine Learning*

Many foods such as oils, wines, and fruits emit odors specific to each sample. This has the potential for food adulteration and safety applications including the identification of bacteria within foods. While there are numerous conventional methods ranging from human smell testing to gas chromatography-mass spectrometry, simple odor characterization can be quite helpful in rapid classification of samples. Lower cost metal oxide gas sensors have the potential to allow the same type of detection with less training required. In this study, an electronic nose with 10 metal oxide sensors is built and tested on various food products. Machine learning techniques are applied to the collected data to automatically classify the results. As a proof a concept, two different wine samples were measured. The coefficient of variation (standard deviation divided by mean) of 8 of the 10 sensors stayed below 10% for almost all fan speeds, indicating excellent repeatability of these sensors. The current setup is able to achieve 80% accuracy when classifying between two wines when using all 10 sensors. The results suggest that the metal oxide sensors are suitable for usage in food adulteration applications.

A parametric study of laser-driven projectiles

Presentation ID: MP-35

Room: *ARMS Atrium*

Nolan Lewis, Abhijeet Dhiman, Vikas Tomar
Purdue University

Keywords: *Laser-driven, hypervelocity impact, laser induced projectile impact test*

Laser Induced Projectile Impact Tests (LIPIT) have been extremely useful to test materials under extreme conditions like the hypervelocity impact of meteoroids or shock induced stress in hypersonic flight. It is also used to study drug delivery through ballistic microparticles and the study of energetic materials and structures. It can be used to better understand micromachining techniques like powder blasting or coating deposition methods like cold spraying. It is also an economical way to test materials that are only available in small amounts since a conventional ballistic test would not be financially viable. Compared to conventional high strain experiments on the macroscale using a gas gun or kolsky bar, LIPIT performs impacts on the microscale which allows the study of stress distribution at the microstructural level. Previous attempts have mainly studied the launch of flyers greater than 500 microns; however, there has not been a parametric study on the launch of particles greater than 10 microns and less than 500 microns. In the current study, research has been conducted on various test parameters such as the laser fluence, thickness of the glass substrate and the particle size to find the optimum combination for the maximum launch speed of the particle. Simulations were performed to characterize the mechanism of the launch and obtain the optimum solution.

Low-Cost device for Quantification of Color on Paper-based Biosensors

Presentation ID: MP-36

Room: *ARMS Atrium*

Sai Venkata Sravan Putikam, Suraj Mohan, Mohit S. Verma
Purdue University

Keywords: *Color Quantification, Colorimetry, Point-of-Care testing, Rapid diagnostics, Low-cost, Image processing Biosensors*

Nowadays, paper-based biosensors are being developed in order to provide rapid and low-cost diagnostics at the Point-of-Care (POC) to detect infectious diseases. Most of the detection happens through a color change or colorimetric output. However, current low-cost devices used for quantification of colorimetric output suffer from scalability and versatility as sensors used in them can only detect changes from few reaction zones in the paper. This study focuses on designing and validating the reliability of a low-cost device based on a low-cost camera for quantification of multiple colorimetric responses. The setup consists of a Raspberry Pi Camera V2.1, single-board computer Raspberry Pi Zero W, paper with triangular-shaped zones containing multiple replicates of different dye concentration, and an internal light source to illuminate the paper and reduce any ambient light if present. Calibration curves were plotted before and after color correction at various brightness levels of the light source and compared to the one from the flatbed scanner (standard reference). The results have shown that the trends between pixel intensities of images from Pi camera were very similar to the one from flatbed scanner especially at 75% brightness where slopes of all the three RGB channels match the scanner. Thus, such a device could be useful in providing a faster readout at the POC by testing for multiple replicates of samples at the same time and suggesting which antibiotics will likely be successful in curing a disease.

Evaluation of Effective Sensing Zone of Piezoelectric Sensors using Acoustic Wave Attenuation Method

Sai Sharan Sundar, Yen-Fang Su, Na (Luna) Lu
Purdue University

The piezoelectric materials based electromechanical impedance (EMI) method has been proved to be a promising sensor-based technology for structural health monitoring (SHM). The EMI technique is based on the piezoelectric material’s direct and indirect effects to generate and receive acoustic waves to monitor the internal change of concrete structures. However, the effective sensing range, which has not been explored yet, depends on the material properties of the host structure and sensor. Therefore, this study proposes utilizing acoustic wave propagation properties to understand the attenuation of the wave propagation and further evaluate the effective sensing zone of piezoelectric sensors. This investigation incorporated two heuristic methods to find the sensing zone. Firstly, a sensor was excited using a wave generator and a concrete sample block was scanned with a transducer to assess the level of attenuation in the block. Secondly, the same transducer was excited with higher frequencies to observe the behavior of the sample. This study compares the results obtained from both methods and concludes the estimated sensing range, leading to future improvements in EMI sensing technology.

Presentation ID:
MP-37

Room:
ARMS Atrium

Keywords:
Structural Health Monitoring, Acoustic Waves, Piezoelectric Sensors, Non-destructive Testing, Concrete

Low V-pi SOH Phase Modulator Based On Metamaterial Cladding

Nikolai Knight, Navin Lingaraju, Andrew M. Weiner
University of Arkansas at Pine Bluff and Purdue University

Ultra-compact, densely integrated optical components manufactured on a (Complementary metal-oxide-semiconductor (CMOS) foundry platform are attractive for optical communications and signal processing. The EO modulator is an essential element for these applications. Electro-optic (EO) modulators based on the linear electro-optic effect (Pockels effect) are efficient in producing high-speed phase modulation which can be used for optical data signaling. However, silicon does not exhibit the linear electro-optic effect. As a solution to this problem, Pockles-type EO materials have been introduced to silicon photonic configurations. As a polymer is embedded into a silicon photonic structure, such as a slot waveguide, the optical mode propagates through both silicon and the organic EO. Through modulating the refractive index of the organic EO, one can modulate the effective index of the optical mode. Current Silicon-Organic Hybrid (SOH) configurations are often inefficient because of propagation loss resulting from evanescent waves interacting with the electrodes of an EO modulator resulting in absorption loss. The decay length of these evanescent waves is a key factor in determining the amount of loss in EO modulators. Efficient EO modulators depend significantly on advanced materials that exhibit strong electro-optical activity and can produce large phase shifts for low operating voltages and small device lengths along with low insertion loss. Here, simulations are used to demonstrate a SOH configuration that introduces fin-like anisotropic materials that shorten the decay length of evanescent waves to reduce loss and allow for lower operating voltages. This assessment provides insight on the effectiveness of introducing SOH material into EO modulators to increase their efficiency.

Presentation ID:
MP-38
Room:
ARMS Atrium

AO

AFTERNOON ORAL PRESENTATIONS

Natural Science

ARMS B061, 1:30 PM – 2:45 PM

Structural Characterization of P-Rex1-DH-PH-DEP1 in Its Autoinhibited State

Madison Kane, Sandeep Ravala, John J.G. Tesmer
California State University Long Beach and Purdue University

Tumor development and metastasis is a primary concern for individuals diagnosed with cancer, as metastatic cancer is often fatal. Patients afflicted with some cancers are known to overexpress a specific enzyme, P-Rex1 which is involved in the migration of cancerous cells. Thus, deciphering how P-Rex1 is regulated may open doors to new therapeutic approaches. P-Rex1 is regulated via a number of ways, including via phosphorylation by protein kinase A (PKA) which leads to decreased activity. Our hypothesis is that phosphorylation of P-Rex1 leads to blockade of substrate binding. To test this, we are generating fragments of P-Rex1 in their unphosphorylated and phosphorylated states, assessing their activity, and attempting to determine their respective structures by X-ray crystallography. Preliminary results show 2-fold lower activity of the phosphorylated protein. Crystallization screens have been set. Future work will determine optimal conditions for the structure determination of phosphorylated and unphosphorylated P-Rex1 fragments by X-ray crystallography, which will help provide molecular information that can aid in the development of novel cancer therapeutics targeting metastasis.

Presentation ID:
AO-1
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ARMS B061

Keywords:
P-Rex1, cancer, metastasis, enzyme, phosphorylation, protein kinase A, crystallography

Characterizing Disease Progression for Night Blindness in the Zebrafish Model

Truc Kha, Logan Ganzen, Yuk Fai Leung
Purdue University

Vision loss impacts an individual's quality of life and can be caused by retinal degeneration diseases such as retinitis pigmentosa. Retinitis pigmentosa (RP), also known as night blindness, is a common and severe form of human retinal degeneration. RP affects 1 in 4,000 people across the world and has no cure. Current treatments, such as gene therapy, optogenetics, and cell transplants, are experimental and costly. A cost-effective treatment can be tested using a disease model, such as zebrafish. Zebrafish provides a good model to study human eye diseases due to their comparable physiology, high fecundity, and easy maintenance. Using transgenic zebrafish lines, we studied the disease progression of RP. We investigated rod loss progression in zebrafish lines with human RP rhodopsin mutations Q344X, P23H, and R135W to represent mutation classes I, II, and III. Each class exhibits different biochemical and cellular properties for an inclusive understanding of the disease progression. We visualized rod degeneration through a time series from 4 days post fertilization (dpf) to 7dpf in larval zebrafish using histological analysis and visual motor response (VMR) startle behavior. The Q344X and P23H lines begin to exhibit rod degeneration on 5dpf while R135W lacks phenotype. At 7dpf, Q344X and P23H exhibit visual deficit in the VMR assay while R135W does not. With a better understanding of the disease progression, these zebrafish models would be used as a primary drug screening tool to identify novel drugs. Novel drug discoveries would provide a cost-effective intervention to combat RP in patients.

Presentation ID:
AO-2

Room:
ARMS B061

Keywords:
Retinitis pigmentosa, retinal degeneration, zebrafish, disease model

Plaque formation and adhesion strength of M. Edulis mussels over intervals of time

Elizabeth Nichols, Samuel L. Huntington, Jonathan J. Wilker
Purdue University

Presentation ID:
AO-3

Room:
ARMS B061

Keywords:
Adhesion, Time, Biological adhesion, Marine, mussels, biological material

Marine mussels affix themselves to underwater surfaces via a self-produced adhesive capable of withstanding wet, turbulent environments. Mussel adhesion has been studied as a model system for marine adhesion and has been an inspiration for synthetic, water-resistant adhesives. Mussel foot proteins have been characterized and specific amino acids or motifs have been identified and incorporated into different technologies such as bio adhesives or, inspired antifouling substances. Mussels rely on more than protein interaction for their wet-setting adhesive. Recent studies have shown that both time-regulated secretion and controlled pH within and around the mussel foot are essential for underwater adhesion. This investigation aims to demonstrate the role of time in the adhesive curing process by studying mussel plaque formation and adhesion strength over time. The adhesion strength was determined by measuring the tensile strength of the plaques adhered to aluminum substrates over several hours to several days of plaque formation.

Amyloid beta-mediated Inflammatory Response in Microglia

Elizabeth Thayer, Priya Prakash, Gaurav Chopra
Purdue University

Presentation ID:
AO-4
Room:
ARMS B061

Keywords:
Microglia, amyloid beta, phagocytosis, chronic inflammation, priming, Alzheimer's disease

Microglia are the resident immune cells in the brain that remove misfolded protein aggregates and cell debris by the process of phagocytosis. In Alzheimer’s disease, microglia become dysfunctional and are unable to phagocytose the amyloid beta (Aβ) plaques thereby contributing towards their accumulation leading to disease progression. Previous models of bacterial lipopolysaccharide-induced inflammation have shown that “activated” microglia produce a heightened proinflammatory response; however, the effect of Aβ activation on microglial phagocytic and other effector functions like nitric oxide production have not been well characterized. In this study, we evaluated BV2 microglial cellular and molecular response to acute and chronic exposure to aggregated Aβ peptide. We show with live cell imaging and flow cytometry analysis that the majority of the BV2 microglia phagocytose Aβ at 500 nM at 1 hour acute treatment. Further, we have performed label-free quantitative proteomic profiling of these cells with this treatment condition to identify differentially regulated proteins with initial Aβ uptake. With chronically activated BV2 microglia for 96 hours, we show that priming with 100 and 200 nM recombinant Aβ does not significantly affect their phagocytic capacity compared to unprimed cells. Further investigation will include chronic Aβ exposure for a longer time period at different concentrations and determination of effector functions along with phagocytosis. The results from this study provide further characterization of BV2 microglia in acute and primed state when exposed to Aβ and contribute towards identifying new targets for phagocytosis.

High Temperature Alkene Oligomerization on Single Site Cobalt Catalyst

Aubrey Quigley, Nicole LiBretto, Laryssa Cesar, Ethan Edwards, Rhea Nargund, Guanghui Zhang, Jeffrey T. Miller
Purdue University

Presentation ID:
AO-5
Room:
ARMS B061

Keywords:
single site, oligomerization, catalyst design, high-temperature stability, shale gas conversion

Nonrenewable resources make up 80% of worldwide energy consumption and are being depleted faster than they can regenerate themselves. It is vital that new methods of energy retrieval are discovered to provide for society’s current and future needs. Shale gas, which contains short-length alkanes (methane, ethane, propane), has steadily become a more prominent resource over the past decade because of advancements in drilling technology. Ethane and propane can be catalytically converted into longer chains through a two-step process of dehydrogenation, to convert alkanes to olefins, followed by oligomerization, to convert olefins to higher molecular weight hydrocarbons that can be used in fuels, plastics, and a variety of household objects. While these processes are traditionally performed under different conditions, they share common intermediates. Here, we developed a high-temperature stable single-site cobalt catalyst (Co2+/SiO2) to perform high-temperature ethylene oligomerization. The Co2+ single site structure was confirmed using X-ray absorption spectroscopy (XAS) at the Advanced Photon Source (APS), Argonne National Laboratory. The C-H bond activation capability of Co2+/SiO2 was benchmarked against literature using propane dehydrogenation at 550Â°C and propylene hydrogenation at 200Â°C with conversions up to 25% and selectivities up to 99%. Ethylene oligomerization performed at atmospheric pressure and temperatures greater than 350Â°C resulted in a large selectivity (>50%) towards butenes as well as the formation of hexenes (>30% selectivity) and trace amounts of other higher molecular weight hydrocarbons. At higher pressures, these reactions are predicted to condense to liquid fuel products that are more compatible with the United States transportation methods.

Environmental

ARMS B071, 1:30 PM – 2:45 PM

Influence of confining pressure gradients in the process of seafloor spreading: Insights from analogue modelling

Presentation ID:
AO-6

Room:
ARMS B071

Juan D. Olivella, Christopher L. Andronicos
Universidad de los Ande and Purdue University

Keywords:
Confining pressure gradient, mechanical failure law, mid-ocean ridges, photoelasticity, scaled analogue models, seafloor spreading, structure from motion.

Currently, the scientific community focuses on explaining in detail the processes that govern the geological phenomena that take place on Earth such as volcanic activity, the formation of mountains, and the occurrence of earthquakes and tsunamis. These processes are generally associated with subduction; therefore, geological and geophysical research has focused on subduction zones. As a consequence, less research has focused on seafloor spreading and its influence on the geological phenomena mentioned above, in part because of the inaccessibility of mid-ocean ridges, where seafloor spreading occurs. This study is focused on understanding the influence of confining pressure gradients in the seafloor spreading processes based on the mechanical failure law which predicts the conditions under which a material fails under the action of external or internal loads. The project was tested by using scaled analogue models where a fluid such as water is injected into gelatin under varying confining pressures. Likewise, the velocity field of the intrusive liquid was reconstructed by using Particle Image Velocimetry (PIV), an optical method of flow visualization, and the stress field was determined by means of the photoelasticity technique. From the experiments conducted to date, we found that when fluid is injected with no pressure gradient present, it propagates into the gelatin producing a bowl-shaped, fluid-filled crack, or a tabular fluid-filled crack inclined from vertical. When a load is added to the gelatin with preexisting cracks, the fluid migrates through the preexisting cracks until the edge of the crack is reached, where tensile wing cracks form, most likely due to the shear stress generated by the load. Finally, with a pressure gradient within the gelatin, produced by solidifying the gelatin on an inclined plane, the injected fluid generates a sheet-shaped fracture that is inclined at a steeper angle than the gelatin's surface slope but dipping in the same direction as the surface slope. These cracks are geometrically similar to â€œseaward dipping reflectorsâ€• found at the transition from continents to oceans in many places around the world, indicating that the preliminary experiments may provide insight into the processes that lead to the initiation of seafloor spreading.

Analysis of quagga mussel effects in deep waters: Numerical methods for one-dimensional diffusion modeling in Lake Michigan

Presentation ID:
AO-7

Room:
ARMS Atrium

Nhu Pham, David Cannon, Cary Troy
Purdue University

Keywords:
Numerical Modeling, Quagga Mussels, Nutrient Cycling, Phytoplankton, Lake Michigan

Benthic filter-feeding quagga mussels are important nutrient recyclers in marine and freshwater systems; however, in-depth understanding of potential effects of quagga mussel in deep aquatic ecosystems remains limited. In Lake Michigan, scientists have connected recently accelerated delivery and recycling rate of phosphorus to direct effects of invasive quagga mussel grazing and filter-feeding. The research group hypothesizes that mussel clearance rates are correlated to water turbulence at boundary layers, and that weak hypolimnetic mixing can limit the effects of quagga mussels in deep lake regions. A one-dimensional diffusion-advection-grazing model (1-D NPD+M Model) that accounts for the coupling interdependence of nutrient (N), and detritus (D) under the influences of quagga mussels (M) is being used at a 55-m deep sample site in Lake Michigan to simulate the spatial and temporal distribution of phytoplankton (P) under realistic seasonal-varied conditions. When mixing is weak, temperature-dependent factor stabilize phytoplankton growth rates in the upper epilimnion. Quagga mussels can increase delivery timescale by regulating the hypolimnetic concentration gradient, especially when delivery is dominantly driven by such gradient as well as settling velocity. In the winter, mussels have access to phytoplankton throughout the water column due to stronger vertical mixing. In the summer, the model shows that quagga mussels cannot access particulate matters that are trapped above the thermocline; the observed behavior is not reflected in collected field data. The results contribute to the development of an analytical framework to analyze the effects of invasive mussels in deep lakes under various forcing mechanisms.

Changes in Flux of Polyamide-Based Reverse Osmosis Membrane During the Chloramination of Halide Containing Waters

Maria Ramirez, Holly Haflich, Amisha Shah, John Howarter
Purdue University

Presentation ID:
AO-8

Room:
ARMS B071

Keywords:
Environmental engineering, polyamide membrane, reverse osmosis, chloramines, halides, membrane degradation

Polyamide (PA) based reverse osmosis (RO) membranes are the industrial standard for desalination of seawater to produce drinking water. These membranes naturally undergo biofouling, performance loss due to biological growth. When a disinfectant (e.g. free chlorine or monochloramine) is added, it effectively stops biofouling. However, the disinfectant can react with the membrane but full understanding of reaction pathways remain unclear. This project aims to understand the impacts the chloramines in the presence of bromide at concentrations present in seawater on PA-RO SWC4-LD membranes. Membrane flux, or permeability, is a way to measure the performance of the membrane. Membrane flux was evaluated before and after the membrane was exposed monochloramine (NH2Cl), bromide (Br-), chloride (Cl-), free chlorine (HOCl/OCl-), or a combination of those. The results indicated at a low pH, the flux decreased and at a high pH, the flux increased, regardless of the concentration of the disinfectant and/or halide. At low pH, the decrease in flux is likely due to a halogenation, either chlorination or bromination. At high pH, the increase in flux is likely due to an increase in amide bond cleavage, which opened up that polyamide structure. Free chlorine was the most degrading disinfectant, then a combination of monochloramine and bromide, and monochloramine was the least degrading disinfectant. Results indicated that the addition of bromide exacerbates the damaging effects of monochloramine on the membrane, but free chlorine still causes the most severe damage.

NAPRA+: Development of an updated version of the National Agricultural Pesticide Risk Analysis (NAPRA) WWW system using Open Source Tools

Ian Zimmer, Benjamin Hancock, Dharmendra Saraswat
Purdue University

Presentation ID:
AO-9

Room:
ARMS B071

Keywords:
NAPRA, GLEAMS, Nonpoint source pollution, Nutrient, Pesticide, WWW, Decision support system

NAPRA WWW system was launched in 2003 as a spatial decision support system (SDSS) by incorporating field scale, groundwater loading effects of agricultural management systems (GLEAMS) model. It allowed users to assess effects of agricultural management practices on nutrient loss and pesticide runoff for the continental US. This web-based SDSS was used by numerous stakeholders such as researchers, consultants, and non-governmental organization (NGOs) since its inception. Due to advancement in web technologies and lack of maintenance, the SDSS became outdated and was taken off the internet in 2018. The goal of this project is to update NAPRA WWW system into NAPRA+ using open-source software and web framework. The basic algorithms and logic used in NAPRA WWW system remain intact, but the file structure, programming languages, and user interface have been updated. Backend executables have also been updated to their most recent versions such as CLIGEN ver. 5.3 and agGEM. Provisions have been made to update soils data to SSURGO version 2.3.2. The user interface of NAPRA+ has been rebuilt in JavaScript using a React client framework to be viewed across varying form factors. The Formik library has been used to increase form variable management and validation. The backend is a node.js server that utilizes express middleware to connect to soil data and executables. With this overhaul, NAPRA+ is expected to continue serving various stakeholders in evaluating effects of on-site management practices on non-point sources (NPS) and serve as a public communication tool for sharing the outcome of these practices.

Evaluation of machine learning models for classifying and detecting common weeds in corn and soybean crops

Aanis Ahmad, Aaron Etienne, Benjamin Hancock, Dharmendra Saraswat
Purdue University

Presentation ID:
AO-10

Room:
ARMS B071

Keywords:
Weed Detection, Precision Agriculture, Site Specific Weed Management, Machine Learning, Deep Learning, Transfer Learning, Supervised Learning, Smart Agriculture, Datasets

Early season site specific weed management (SSWM) is an important preventive strategy for checking the spread of weeds throughout a field before they negatively affect crop yield. Accurate identification of weeds is a prerequisite for developing an effective SSWM strategy. Though machine learning and computer vision are promising technologies for object detection, they rely on the availability of a large database of weeds for training various algorithms. This research aims to develop a well-organized and annotated weeds dataset common to corn and soybean production system in the Midwest USA. The database architecture is patterned after ImageNet and consist of 4 different weed species. It has been designed to be accessed without requiring any user account. In addition, users will have the ability to upload images and annotate it in order to expand the training dataset. Another motivation of this research is to compare 3 different pre-trained networks (VGG16, ResNet50, and InceptionV3). Within each network, transfer learning with feature extraction will be used to identify the presence of different weeds from a single image of the field acquired through the fusion of several single images. The images will be acquired using an unmanned aerial vehicle (UAV). The experimental outcomes will be measured using metrics such as accuracy, precision, recall, f1-score, and mean average precision (mAP). The expected advantage of the research is to provide support to stakeholders (researchers and farmers) through the information and knowledge generated by the pre-trained networks.

Materials

ARMS 1021, 1:30 PM – 2:45 PM

Experimental Validation of an Approach-to-Contact Method for Determining Hamaker Constants Using Atomic Force Microscopy

Presentation ID:
AO-11

Room:
ARMS 1021

Keywords:
Particle adhesion, surface roughness, Hamaker constant, atomic force microscopy (AFM), van der Waals (vdW) force

Wesley Oliver, Michael C. Stevenson, David S. Corti, Stephen P. Beaudoin
Purdue University

Understanding and controlling particle adhesion is important to a wide variety of applications including pharmaceutical tablet production and swab-based explosive detection in order to reduce production costs and increase detection accuracy. The van der Waals (vdW) force is among the intermolecular forces that comprise the overall force of adhesion. Because it is present in every physical interaction, a greater understanding of its contribution to adhesion forces is wanted. The Hamaker constant, *A*, provides a way to quantify the vdW force, and is unique to each interacting material. While a purely theoretical approach exists to determine *A*, its application is limited. Therefore, an easier experimental method is desired. This work aims to experimentally validate a novel surface force equation that improves upon the previously developed “approach-to-contact” method for determining *A* using atomic force microscopy (AFM). A new parameter, the deflection of an AFM cantilever at first contact with a substrate, d_c, is well-defined experimentally and can be used to determine *A* from an AFM force experiment. By generating a distribution of experimental d_c values and a corresponding theoretical distribution of d_c values predicted by the surface force equation, a comparison can be made between the two. Ultimately, a comparison of the means, spreads, and shapes of the theoretical and experimental distributions reveal that the new surface force model shows promise in its ability to predict the effects of nanoscale roughness. Additionally, further experiments will be conducted in order to address the disagreement observed between the predicted and experimental distributions.

Measuring Surface Roughness through Power Spectrum Analysis of Images

Presentation ID:
AO-12
Room:
ARMS 1021

Keywords:
Surface Metrology, Surface Roughness, Stereo-microscopy, Power Spectrum, Fourier Transform

Joshua Z. Stalbaum, Anirudh Udupa, Srinivasan Chandrase
Purdue University

The human eye can distinguish the roughness between various surfaces simply by looking at them without having to touch the surface. With this acknowledged, there is an opportunity to design an algorithm to be able to make a similar distinction with a computer program that our eyes can, if not better. Various surface topographies, consisting of machined and cast surfaces of different roughness, were initially characterized using the Zygo NewView White Light Interferometer. The surface topology was deconvoluted using the Fourier Transform to obtain power spectrum data as a function of the surface wavelength. A similar procedure was then performed on optical images of the surface, obtain using an Olympus SZX9 stereo microscope. The power spectrums obtained from the interferometer and from the optical images were then compared for the various surfaces. Initial results suggest that the power spectrums obtained by the two methods follow the same trend as one goes progressively from a rougher to a smoother surface. Implementation of this power spectrum method of image analysis can provide a way for roughness of surfaces to be compared with each other with enough accuracy to be applicable in many of the fields that comparators are useful.

Particle Detachment of Polymeric Substrates upon Mechanical Deformation

Presentation ID:
AO-13
Room:
ARMS 1021

Keywords:
Particle detachment, adhesion, mechanical deformation, contact area, polymers.

Elina Ghimire, Naomi Deneke, David Bahr, Chelsea Davis
The University of Southern Mississippi and Purdue University

The effect of mechanical force on particle detachment is crucial to understand because it plays an important role in characterizing the adhesion of particles in many applications such as printing, water filtration system, and pharmaceuticals. For example, an efficient and precise way to load and release the fine particles of drugs would be extremely helpful for transport purposes in the field of medicine. This project generates insight on the debonding mechanism of rigid microparticles adhered to thermoplastic and elastomeric substrates by studying the change in particle-substrate contact area upon mechanical deformation. Particularly, this article has presented the mechanism for the detachment of spherical glass beads from a poly(dimethyl siloxane) (PDMS) substrate under uniaxial tensile loading. An indentation experiment was performed utilizing a piezo-electric actuator and force sensor to determine the normal displacement and load, respectively, on the stretched PDMS. Experiments were conducted over a microscope to simultaneously observe the contact areas of the particle-substrate interface and JKR (Johnson, Kendell and Roberts) analysis was performed to calculate the work of adhesion. This study presents a comparison of the work of adhesion when PDMS is stretched to different strain values. Also, an analysis of the effects of the substrate modulus and particle size on adhesion is included.

Electrically Conductive Collagen Coatings for Implantable Electrodes

Noah Neidigh, Sarah Brookes, Sherry Voytik-Harbin
Purdue University

Presentation ID:
AO-14
Room:
ARMS 1021

Keywords:
Biomedical engineering, collagen, implants, electrodes, conductive, resistivity, impedance, resistance, cellular

The immune response associated with foreign materials in the body has long been a significant barrier to biomedical devices, especially those embedded within tissue. All implantable electrodes eventually fail after a build-up of scar tissue surrounds the electrode, caused by a defensive immune cell reaction. This is primarily due to a several mismatches between the tissue and the electrode material, including electrical conductivity, biocompatibility, and various mechanical properties. Despite various attempts at the formulation of a coating that will enable electrodes to remain functional over long periods of time in the tissue environment, no ideal coating has been discovered thus far. Type-1 self-polymerizing collagen, however, presents a promising opportunity in this area of research. Because it is native to the body, it has immunomodulatory properties and is mechanically similar to most tissues. Additionally, it can be cellularized to recreate natural tissue. Pure collagen was measured with an LCR meter to measure the impedance and resistance of the matrix in various conditions. Then, the collagen was cellularized with two different cell types: MPCs (muscle cells) and PC12s (neurons). The electrical properties of these constructs were then measured and compared to known resistivity values for similar tissues. Results from all three collagen constructs were analyzed and compared to both one another and values found in literature. Conclusions and recommendations about the feasibility of a collagen electrode coating are based off of an analysis of the properties of this type-1 self-polymerizing collagen.

Comparison of Titanium Nitride Microelectrode Designs for Neurostimulation Devices

Amanda Maples, Hyun Su Park, Hyowon Lee
Purdue University

Presentation ID:
AO-15

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Keywords:
Neurostimulation, Microelectrodes, Titanium Nitride, Geometry, Fractal, Serpentine, Circular, Cyclic Voltammetry, Electrochemical Impedance Spectroscopy, Voltage Transient

Neurostimulation devices have been used to help with Alzheimer's disease, migraines, Parkinson's disease, depression, and epilepsy. The corrosion of electrode materials leading to unreliability proves to be a major impediment in current neurostimulation devices. Novel metals such as gold, platinum, and iridium oxide have been used for neurostimulating electrodes, transfer electrons through faradaic charge-injection accompanied by electrochemical dissolution. Irreversible dissolution during neurostimulation can alter and corrode the electrode surface. Corrosion can produce cytotoxic, allergenic and carcinogenic byproducts, and harm the tissue. Due to this, nerve damage, neuritis, and or neuropathy can occur and cause severe injury or death. This paper suggests the use of capacitive charge-injection materials to enhance the electrochemical stability of neural interfaces for electrical stimulation due to their limited consumption and production of chemical species during a stimulation pulse. Titanium nitride (TiN) has widely been used in implantable electronics because of its chemical stability and biocompatibility, and TiN injects charge through the charging and discharging of the electrode-electrolyte double layer. Superior charge injection capability of platinum and gold result in favored use compared to TiN, however, charge injection performance of TiN may be improved with altered electrode geometry. Several tests were performed including cyclic voltammetry to find charge storage capacities, electrochemical impedance spectroscopy to display charge transfer impedance, and voltage transients to determine charge injection limits. The effect of electrode geometry in capacitive charge-injection material can be found from analyzing electrochemical characteristics of the TiN electrodes. Results indicate that charge injection capability of TiN microelectrodes may be adjusted by modifying electrode geometry.

Aerospace

ARMS 1103, 1:30 PM – 2:45 PM

Novel Catalysts for Enhancing the Burn Rate of HAN-Based Monopropellants

Michael Cooper, Li Qiao
Purdue University

Presentation ID:
AO-16

Room:
ARMS 1103

Keywords:
Propulsion, Monopropellants, Combustion

Monopropellants are chemicals typically used for spacecraft propulsion and maneuvering. Typical monopropellants are highly toxic and considered very dangerous to work with, resulting in increased spacecraft manufacturing costs. Improving the performance of safer “green” monopropellants could provide motivation for their use as spacecraft propellants, leading to safer and cheaper spacecraft manufacturing. HAN-based monopropellants are green monopropellants that have seen significant interest in the propulsion industry due to their low toxicity, safety, and high propulsive efficiency compared to other green monopropellants. Few studies have attempted to improve the performance of HAN-based propellants using solid metal powders, such as graphene. This study proposes a novel graphene powder catalyst for improving the performance of HAN-based propellants by increasing the burn rate. Aqueous HAN was used as a representative test propellant. Graphene nanopowders were dispersed into the HAN with varying concentrations. Thin strands of the prepared propellant were burned in a test stand under a high-speed camera measuring the linear burning rate of the propellant. A device for generating and burning small droplets of propellant at different temperatures was constructed to determine the ignition temperature of the propellant. This study compares the results of these experiments for the catalyzed propellant with the results for the unmodified propellant. These results enable conclusions on the effect of a graphene catalyst on the performance of HAN-based propellants.

Remote Sensing of Soil Moisture and Forest Biomass using I-Band Signals of Opportunity: Instrument Development

Eric Smith, James L. Garrison, Jared D. Covert
Purdue University

Presentation ID:
AO-17

Room:
ARMS 1103

Keywords:
Remote Sensing, Signals of Opportunity, Root Zone Soil Moisture, Forest Biomass, Unmanned Aerial Vehicle (UAV)

Soil moisture is an important variable in meteorology, hydrology, and agriculture. It can help predict precipitation or inform farmers about where to irrigate their fields. Similarly, biomass is an important measurement to quantify the large fraction of carbon stored in forest vegetation. Measuring soil moisture or forest biomass over a large area can be difficult. Remote sensing is a potential solution, however space-based remote sensing is limited is spatial resolution, while tower-based sensors are limited in coverage. Using signals of opportunity and an Uncrewed Aerial Vehicle (UAV), a remote sensing instrument can take soil moisture and forest biomass measurements over a large area. Satellite remote sensing to date has used L-band frequencies, with a wavelength of 19 cm. Penetration into dense vegetation requires lower frequencies. ORBCOMM communication satellites provide illumination in I-band (137 MHz) with wavelengths of two meters. A software defined radio receiver mounted to the UAV receives a signal from one of the satellites and records the signal after it has been reflected off of the ground. The two signals are later analyzed to find the reflectivity of the soil, which is related to the soil moisture. This research presents the design of a new remote sensing system for measuring soil moisture and forest biomass from a UAV using reflected signals from communication satellites.

Characterization and Mechanical Behavior of Additive Manufactured Materials

Nolan A. Miller, Kartik Kapoor, Priya Ravi, Michael D. Sangid
Purdue University

Presentation ID:
AO-18
Room:
ARMS 1103

Keywords:
Additive Manufacturing, Porosity, Surface Roughness, Crack, Topography, Titanium (Ti64)

Selective Laser Melting (SLM) is a type of additive manufacturing that utilizes a powder bed and a directed laser to fuse the metal particles together. This processing method is effective for producing geometrically complex parts, and since titanium alloys and nickel-based superalloys are widely used for aerospace applications, understanding how SLM effects the fatigue life is crucial for the use of those materials in application. AM often utilizes a layer-by-layer deposition methodology to create a three-dimensional design, which can often lead to surface roughness, porosity, and residual stresses that ultimately reduce the remaining life of the component. In this work, surface roughness was characterized using optical profilometry and the information about porosity was analyzed by post-processing data obtained from high energy X-ray microtomography using AvizoLite 3D visualization software. Using the characterization data, statistics (like size and sphericity) about the pores, their distribution within the sample were obtained relative to their effect on crack initiation. Using surface roughness data coupled with concepts of fracture mechanics, the effect of surface roughness on the life of the material was analyzed. By understanding how the degree and characteristics of porosity and surface roughness effect the mechanical properties of the tested material, the results provide the potential to improve the safety and reliability of additively manufactured components.

Meeting Tomorrow's Emission Requirements: Turbulent Hot-Jet Ignition for Gasoline Engines

Cole Replogle and Dong Eun Lee
Oklahoma State University and Purdue University

Presentation ID:
AO-19

Room:
ARMS 1103

Keywords:
Ignition, Combustion, Emissions, Internal Combustion Engines

Growing environmental concerns call for the reduction of emissions and fuel consumption of automobile engines. One method shown to positively affect emissions is the development of technologies capable of reliably igniting ultra-lean (more air than fuel) mixtures. Past studies have shown decreased emissions and augmented combustion performance through use of a pre-chamber to ignite the main chamber contents with a turbulent hot-jet. Several studies have characterized this hot-jet in natural gas engines, but further research is required to understand the fundamentals of a passive (no dedicated fuel injector) pre-chamber for gasoline engines. A General Motors 4-cylinder 2.0L LTG gasoline engine was chosen as the basis for the experiment. A test matrix was developed that consists of variations in main chamber pressure and temperature, engine rotational speed, and piston crank-angle. In order to collect data via OH* chemiluminescence, the engine was modified to provide optical access to a cylinder during combustion. The original engine block was not used and was instead replaced by a single, custom machined aluminum combustion chamber with four fused-quartz windows. Results from this study will show the effects of main chamber, and subsequently passive pre-chamber, conditions on combustion performance. An understanding of these effects will aid in optimizing designs using turbulent hot-jet ignition for the greatest reduction in emissions.

Characterizing a Fully Optically Accessible RDE: Analysis of Continuous Detonation Waves for Aerospace Applications and Design

Payton Miller, Zach Ayers, Venkat Athmanathan, Jordan Fisher, Guillermo Paniagua, Terrence Meyer
Purdue University

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AO-20

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ARMS 1103

Keywords:
RDE, combustor(s), detonation and deflagration wave(s), OH Chemiluminescence, planar laser-induced fluorescence, particle image velocimetry, Schlieren Imaging, aerospace design*

The Rotating Detonation Engine (RDE) is considered a new technology that could improve power production and propulsion systems because of its simple structure and higher fuel and thermal efficiency compared to traditional gas turbine and rocket combustors. Though RDEs may provide potentially significant improvements, there are a variety of factors that could determine the impact of RDEs on aerospace designs such as: the characterization and cause of the formation of the continuous detonation wave, the ideal reactant fuel mixtures, and the flow dynamics within the combustor. To further our understanding of RDE operation, this work presents experimental data collected from a novel RDE with unrestricted optical access to the air injection plenum, fuel mixing region, and combustion chamber. Several high-speed optical diagnostics are employed to characterize the RDE operation modes, reactant mixing properties, and detonation wave dynamics, including OH* Chemiluminescence, Planar Laser-Induced Fluorescence Imaging (PLIF), Particle Image Velocimetry (PIV), Schlieren Imaging and Shadowgraphy. For the first time, the reactant mixing process, wave structure and dynamics are simultaneously visualized in an annular RDE operating at steady state. The collected data are used to make conclusions about the effect of localized flow phenomena and chemical kinetics on the global performance characteristics of the system.

Nanotechnology

ARMS 1109, 1:30 PM – 2:45 PM

Introduction to Capacitance-Voltage Characterization for Metal-Oxide-Semiconductor Devices with High-K Materials

Siyun Qiao, Yuanqiu Tan, Theresia Knobloch, Peng Wu, Xiangkai Liu, Zhihong Chen, Joerg Appenzeller
Purdue University

Presentation ID:
AO-21

Room:
ARMS 1109

Keywords:
Semiconductor, Metal-oxide-semiconductor field-effect transistor, High-k materials, Capacitance-voltage characterization

Silicon dioxide (SiO_2) was traditionally adopted as the gate dielectric in metal-oxide-semiconductor field-effect transistors (MOSFETs). As the channel length scaling successfully followed Moore's law over the past decades, scaled transistors have continuously achieved higher drive currents and better device performance. To avoid undesired short channel effects, the thickness of the gate dielectric has to be scaled down with the channel length accordingly. However, significantly large leakage current appears when SiO_2 is scaled below 1 nm, leading to high power consumption and reduced device reliability. Replacing SiO_2 with high dielectric constant (high-k) materials allows a thicker gate dielectric layer to be implemented while maintaining the equivalent gate field control, which can effectively reduce the gate leakage currents. Examples of high-k materials are aluminum oxide (Al_2O_3) and hafnium dioxide (HfO_2). In this study, frequency dependent capacitance-voltage (CV) measurements are employed to explore effects of different annealing conditions on high-k materials by comparing CV characteristics of different devices, with one sample group without annealing treatment being the reference. Trap charge and defect mechanisms in high k dielectrics can be identified through our comparison and annealing conditions for gate stacks will be optimized to ultimately improve transistor device performance

Photonics in Photocatalytic Water Treatment Systems

Presentation ID:
AO-22
Room:
ARMS 1109

Xavier Morgan-Lange, Yuhang Fang, David Warsinger
University of Nevada, Las Vegas and Purdue University

Keywords:
photocatalysis, inverse opal, photonic crystal

With a growing global population and an increase in industrial activity, the demand for fresh water grows as supplies decrease to the detriment of the natural environment. Coupled with a need for alternative sources of energy, methods of sustainable water treatment are of great import to humanity. Photocatalytic degradation via photocatalysis offers an intriguing and potentially lucrative solution to this problem by introducing solar-powered semiconductors for water treatment. Furthermore, many photocatalytic materials are biocompatible and readily abundant in the Earth's crust. However, finding a photocatalyst that is both highly efficient and capable of being integrated into a water treatment system has yet to be accomplished. Consequently, research investigating techniques to enhance known photocatalysts such as TiO2 has garnered significant attention. Improvements in photocatalytic degradation are often obtained by increasing both the available surface area and light exposure. The morphology of an inverse opal photonic crystal maintains a high surface area and porosity, as well as the ability to achieve the â€œslow photon effect,â€• wherein light slows down within a compatible medium, thereby increasing light absorption. This study synthesizes an inverse opal TiO2 film using the solution-gel method to increase efficiency and produce membranes that are capable of being integrated into water treatment systems. The efficiency was measured by analyzing the concentration of a Methylene Blue solution over time when placed in placed in contact with the TiO2 film. This assessment provides insight into the benefits gained from an inverse opal morphology and establishes a direction for photocatalytic water treatment systems.

Optimizing Parameters of Sol-gel Co-assembly in Inverse Opal Fabrication

Presentation ID:
AO-23
Room:
ARMS 1109

Seunghyo Jeon, Yuhang Fang, David Warsinger
Purdue University

Keywords:
Inverse opal, sol-gel, co-assembly, nanofabrication

Whether on display at a museum or worn as jewelry, opal gemstone will grab the attention of passerby with its array of vibrant colors. Looking under a microscope, it reveals a nanoscale structure that allows the gemstone to change the behavior of light, giving it its beautiful colors. Similarly, inverse opal is a type of iso-porous nanostructure that can manipulate light. Its properties allow for applications in photonics, filtration, catalysis, and sensing. The structure is commonly assembled on a substrate by evaporating nanoparticle solution. However, cracks formed from the evaporation process can limit its application. Previous works on the topic have revealed that the use of sol-gel in the solution, which transitions from a solution to a gel, can reduce defects for certain pore sizes. However, the concentration change during the evaporation process makes it difficult to replicate, and it is not applicable for nanoparticles of different sizes. There lacks quantitative guidance on the recipe and fabricating condition to build defect-free inverse opals. In this study, we varied the initial concentration of nanoparticles and sol-gel as well as the orientation of the substrate in the solution to fabricate defect-free inverse opals of different pore size. Based on the characterization results of the inverse opals, an experimental function has been derived to predict the optimal concentration for the nanoparticle and sol-gel as well as the optimal substrate orientation.

Piezoelectric ultrasonic transducers in a Roll-to-Roll platform

Presentation ID:
AO-24
Room:
ARMS 1109

Vishal Meyyappan, Jesse C. Grant, Matthew Storey, Mukerrem Cakmak, Dana Weinstein
Purdue University

Keywords:
Piezoelectricity, Ultrasound, MEMS, Roll-to-Roll

Piezoelectric transduction continues to play a significant role in technological advancements in various scientific and engineering disciplines. This conversion of mechanical energy into electrical signals and vice versa has enabled the feasibility of devices such as lighters, sensors, relays, motors, generators, actuators etc. Ultrasound has driven the field into applications like medical imaging, sonar and wearable tech. This study aims to enhance the physical and mechanical properties of transparent piezoelectric transducers, to extend the frequency of operation to the ultrasonic regime. Using a network analyzer and landing DC probes on the electrodes on the device, power measurements are taken from device samples. Feeding the obtained values into the existing electromechanical circuit model created in the simulation tool, gives us the piezoelectric coefficient, acoustic propagation loss and electrical properties like dielectric loss and dielectric constant as the resulting parameters. This study analyzes these parameters of each sample to optimize the transducer for various ultrasound applications. Conclusions on the device performance are made based on the values of these resulting parameters.

Analysis of Rarefied Flow in FEMTA Microthruster

Daniel Mayper, Steven Pugia, Katherine Fowee, Anthony Cofer, Alina Alexeenko
Purdue University

Satellites with masses between 1 and 10 kg, called nanosatellites, are increasing in popularity due to their low launch costs and small volume. With a decrease in satellite size also comes the need for propulsion with lower power, lower mass, and more accurate spacecraft orientation control. Though micropropulsion solutions such as cold gas thrusters and ion engines exist, they require too much energy, have too much mass, or are not precise nor efficient enough for the minimalist structure of nanosatellites. Film-Evaporative Micro-Electrical Mechanical Systems (MEMS) Tunable Array (FEMTA) thrusters are a low mass, low power microthruster capable of providing effective and specific propulsion for nanosats through microcapillary evaporation. FEMTA operates on less than 1 W of power and with a total system mass as low as 1 g. Recent testing on a micro-newton thrust stand at Purdue's High Vacuum Lab showed icing in the micronozzle during operation, thus reducing the efficiency and reliability of the thruster. Direct simulation Monte Carlo (DSMC), a molecular simulation tool, was used to simulate the flow within the micronozzle to compute the temperature profile and total pressure loss for multiple nozzle fabrication recipes. Device efficiencies were calculated from the results to mitigate ice generation in future FEMTA design iterations.

Presentation ID:
AO-25
Room:
ARMS 1109

Keywords:
Nanotechnology, direct simulation Monte Carlo, DSMC, SPARTA, rarefied, micronozzle, nanosatellites

AFTERNOON POSTER PRESENTATIONS

AP

Agriculture and Food Science

ARMS Atrium, 3:00 PM – 4:15 PM

Smart glasses for fluorescence image-guided contaminant detection in food industry

Presentation ID:
AP-01

Room:
ARMS Atrium

Keywords:
Smart glasses, portable device, head-up display, fluorescent detection, food contaminant, food quality, electronic control, optics

Hanlu li, Euiwon Bae
Purdue University

With the rapid development of technology, every industry is interested in seeking more convenient, accurate, and cheaper devices to improve their product quality. So it also inspires research community to employ the technology that is used in research and scientific area to design some innovative devices which are beneficial to industry. Considering of smart glasses is one of the promising platforms for the group of people who conducts on-site detection and inspection in food processing product line, this project is aimed to develop a low-cost, portable, field-deployable device for food industry. Raspberry Pi is used in conjunction with a fluorescence filter and principle of head-up display for this hands-free device. Most food components are usually non-fluorescent, however, some products of food oxidation or deterioration exhibit fluorescence. Additionally, some food contaminants such as myco- and aflatoxins equally exhibit fluorescence. Therefore, fluorescence can be used to analyze all of these aspects of food quality. Thus, this design shows the feasibility of smart glass application in fluorescence detection by allowing the users to have access to augmented reality which one eye can see the regular image and the other eye can the fluorescent image. It is helpful for inspectors to identify contaminants and no-conformance product quickly and accurately.

Fabrication of Antimicrobial Electrospun Kafirin Fibers through Essential Oil Encapsulation for Sustainable Food Packaging

Presentation ID:
AP-02

Room:
ARMS Atrium

Keywords:
Kafirin, electrospinning, nanofibers, antimicrobial food packaging, thymol, carvacrol.

Yumi Higashiyama, Hazal Turasan, Geraldine M. Tembo, Jozef Kokini
Purdue University

Synthetic materials including plastics are still the most commonly used ingredients for food packaging. Despite advantages such as lightness, low cost and desirable mechanical strength, the use of synthetic materials leads to an accumulation of non-biodegradable waste at an alarming rate and poses detrimental effects on the environment. To slow the rate of harm, the fabrication of an environmentally friendly food packaging material comprised of under-investigated kafirin protein was explored. In this study, a hydrophobic kafirin protein was first extracted from commercial sorghum flour. After purification, kafirin was solubilized in acetic acid, encapsulated with phenolic compounds carvacrol and thymol, and electrospun with different parameters. The nanofiber mats were then evaluated with optical microscopy, SEM, tensiometer and FTIR spectroscopy for their physical properties, chemical properties, surface properties, and encapsulation efficiency. Experimental results have shown that 50 (w/v)% kafirin-acetic acid had the highest yield in nanofibers and possessed the most homogenous appearance in comparison with fibers made of 51% and 52% formulations. Encapsulation of thymol at 5% revealed a decrease in diameters of fibers and increased numbers of cracks to fibers. Whereas, encapsulation of carvacrol at 5% did not have morphological nor chemical changes to nanofibers. This suggests larger concentration of carvacrol is required for better encapsulation compared to thymol. Encapsulation of phenolic compounds have decreased initial contact angles but prevented instant adsorption of the droplet by the fiber mat. Although homogenous nanofiber mats were fabricated successfully, further work needs to be done for future sustainable and antimicrobial food packaging application.

Nuclear Engineering

ARMS Atrium, 3:00 PM – 4:15 PM

Detection of Neutrons from Pu-Be and Cf-252 Isotope Sources using Acoustically Tensioned Metastable Fluid Detectors

Stepan Ozerov, Nathan Boyle, Catalin Harabagiu, Rusi Taleyarkhan
Purdue University

Neutrons, being neutral, can be highly penetrating and interact in a multitude of reaction pathways when interacting with matter. They form the bedrock of nuclear energy science; thus, an ability to reliably detect them at high efficiencies and with low cost is of great importance, e.g., to minimize health risks and identify materials (radioactive and non-radioactive). This study used the novel Acoustically Tensioned Metastable Fluid Detector (ATMFD) sensor technology to induce resonance mode fluctuating negative pressures (i.e., tensioned below vacuum pressure states) in a fluid which allows for cavitation and macroscopic bubble growth when a femto-scale neutron deposits its energy when striking at the nucleus of target atoms. A resonant frequency must be determined to induce negative pressure states and become sensitive to incident neutrons. A resonance controller was deployed to dynamically track the resonance states vs. temperature to reestablish resonance state variations. ATMFD transient bubble cavitation rates were determined for two radically different neutron energy spectrum emitting sources of known intensity: Cf-252 and Pu-Be; these were placed at various distances from the ATMFD for specified combinations of reflector spacing, sensing fluid, and average drive power settings. An MCNP nuclear particle transport code based theoretical simulation of the experiment was also performed to compare the theoretical vs. experimentally observed neutron detector efficiency for the specified fluid, reflector, and source type used for this study.

Presentation ID:
AP-03

Room:
ARMS Atrium

Keywords:
Neutron, radiation, metastability, acoustic waves, negative pressure, detector, Special Nuclear Materials, neutron spectra

Detection of neutrons from PuBe, AmBe, and Cf-252 isotope sources using Centrifugally-Tensioned Metastable Fluid Detector

Catalin Harabagiu, Stepan Ozerov, Nathan Boyle, Mitchell Hemesath, Rusi P. Taleyarkhan
Purdue University

Although not well-known, fluids like solids can be stretched and placed in tensioned (yes – sub vacuum pressure) states. Placing fluids in tensioned (negative) metastable pressure states offers unique benefits in nuclear physics; particularly for: neutron detection with spectroscopy and directionality while remaining blind to background gamma-beta radiation. The Centrifugally Tensioned Metastable Fluid Detector (CTMFD) establishes a region of negative pressure (below vacuum) in the detector by centrifugally tensioning the fluid. A basic question then arises of how efficiently can the CTMFD detect neutrons from a wide array of source types and as to how this compares with state-of-art detectors. For this 2019 SURF study we placed three different neutron sources (PuBe, AmBe, and Cf-252) of known intensity at varying distances from the detector to assess detection efficiencies at various distances. A sweep of negative pressures was then performed and a count-rate curve was produced. The experimental data were combined with simulations of the experiments using the MCNP nuclear particle transport code in order to assess for measured versus theoretical predictions.

Presentation ID:
AP-04

Room:
ARMS Atrium

Keywords:
Neutron detection, neutron energy spectrum, detector efficiency

Environmental

ARMS Atrium, 3:00 PM – 4:15 PM

The influence of building environment conditions on indoor oxidative chemistry and aerosol production

Nhi Khuu, Jinglin Jiang, Brandon E. Boor
Purdue University

The chemistry of indoor air has a major impact on our health, given that we spend an average of 90% of our time indoors. While the chemistry of certain compounds and oxidants are well-studied in the outdoor environment, the chemistry that occurs indoors is not nearly as well understood. A one-month field campaign was conducted at Indiana University at Bloomington, in collaboration with an atmospheric chemistry group, to explore indoor oxidative chemistry. State-of-the-art air quality instrumentation was used to measure time-resolved concentrations of the hydroxyl radical (OH), peroxyl radicals (HO2 and RO2), ozone (O3), nitrogen oxides (NOx), nitrous acid (HONO), volatile organic compounds (VOCs), and nano-sized aerosols. The primary factors that were examined are the effects of natural and artificial lighting, ventilation mode, and HONO/VOC concentrations. Preliminary results from the measurement campaign suggest that radicals can be formed indoors under certain lighting conditions and the oxidation of indoor VOCs can form nano-sized aerosols. These results will advance our understanding of indoor chemistry and support future research in the field.

Presentation ID:
AP-05

Room:
ARMS Atrium

Keywords:
Indoor Chemistry, Indoor Air Quality, Oxidative Chemistry, Ozone, Hydroxyl Radicals, Nitrogen Oxides, Nitrous Acid, VOCs, Nano-Sized Particles, Particulate Matter

Impact of Surfactant Concentration and Type on the Stability of Bilge Water Emulsions During Static and Dynamic Ageing

Presentation ID:
AP-06

Room:
ARMS Atrium

Keywords:
Emulsion Stability, Surface Excess Concentration, Ageing, Bilge Water

Rina Sabatello, Cole Davis, Kendra Erk, John Howarter, Carlos Martinez
Purdue University

Oil-in-water (O/W) emulsions present in the bilge of ocean vessels are inefficiently filtered, causing oil to be discharged which increases oil pollution. Separation of the oily wastewater is difficult due to the presence of surfactants that stabilize oil droplets in water. Bilge water contains two types of surfactants: anionic and nonionic, with concentrations ranging from 10-2500 ppm. The behavior and stability of emulsions drastically changes over these surfactant concentrations. This study investigates model bilge water emulsions by measuring the volume mean diameter (D(4,3)) of the oil droplets as a function of time and surfactant concentration during static and dynamic ageing. Interfacial tension measurements of nonionic (Triton X-100) and anionic sodium lauryl ether sulfate (SLES) in mineral oil were used to determine their surface excess concentration, which 61 A^2/molecule and 67 A^2/molecule respectively. These values gave underestimated minimum drop diameters formed at 10 ppm surfactant and 5000 ppm mineral oil. A decrease in D(4,3) with increasing surfactant concentration was observed during both static and dynamic ageing. However, dynamic ageing caused Triton X-100 to coalesce more quickly than static ageing at concentrations of 100 to 500 ppm. High concentrations of Triton X-100 (>1000ppm) do not significantly change mineral oil drop size during static ageing and low concentrations (10 ppm) do not change after 5 days of static ageing. Concentrations greater than 10ppm SLES do not change mineral oil drop size over time for statically aged emulsions while dynamic ageing showed higher drop sizes for 10 and 100 ppm due to coalescence. Overall, the behavior of droplet size in bilge water emulsions over time is dependent on surfactant concentration and ageing conditions.

The Effect of Nanoparticles in the Stability of Salty Shipboard Emulsions

Presentation ID:
AP-07

Room:
ARMS Atrium

Keywords:
Bilge water, Pickering emulsions, emulsion stability, nanoparticles, surfactants, environment

Hosea A. Santiago, Cole Davis, Carlos Martinez, John Howarter, Kendra Erk
University of Puerto Rico and Purdue University

Bilge water emulsions are composed of different types of oils, surfactants, and solid particles. These systems are harmful to the environment if not properly processed and separated before discharging to the ocean. Although many separation techniques exist and are implemented in marine vessels, there is a lack of fundamental understanding on how these shipboard emulsions form. Because both nanoparticles and surfactants are known to be components in bilge water, Pickering emulsions, emulsions stabilized by solid particles, could form in these systems. Previous studies have shown that Pickering emulsions can be more difficult to separate than traditional surfactant stabilized emulsions because the particles offer a steric boundary at the oil-water interface. The aim of this study is to investigate the formation of Pickering emulsion under similar conditions present in bilge water. Three types of nanoparticles were tested: Alumina coated Silica, Iron Oxide, and Zinc Oxide; in the presence of ionic (SLES) and nonionic (Triton X-100) surfactants. Stability was studied at different salt and surfactant concentrations by measuring the creaming and coalescence of mineral oil in water emulsions. Stability was also evaluated by measuring the emulsion droplets using DLS and optical microscopy. Emulsions with SLES in the presence of silica nanoparticles have, on average, smaller droplet diameters, however they seem the be more unstable than SLES stabilized emulsions alone. At high surfactant concentration, nanoparticles have little or no effect on emulsion stability. Silica nanoparticles also act as a coagulant evidenced by flocculated droplet sedimentation at low surfactant concentration (100ppm SLES) and either very high or very low salt concentration (420mM, 50mM, and 0mM). For metal oxide particles (ZnO and Fe_3O_4), emulsions tend to be more stable in the presence of these NPs at relatively low concentrations of SLES(0.35mM). These particles were also observed to stabilize small oil droplets without SLES at low concentration or no salt. So far, Pickering emulsions are capable of existing in conditions similar to those in bilge water however, their stability is not significantly different to the stability offered by surfactant alone at the low concentrations of NPs (0.01wt%).

Spatial Life Cycle Assessment of Indiana Soybean to Biodiesel

Presentation ID:
AP-08

Room:
ARMS Atrium

Keywords:
life cycle assessment, soybean, biodiesel, spatial, modeling, emissions

Esai Lopez, Shweta Singh, Gargeya Vunnava
New Mexico State University and Purdue University

National interest in energy security and sustainability has led to an increase in the production of biodiesel. Soybeans, are one of the most common feedstock converted to biodiesel and are the second most abundant crop in Indiana. Life cycle analysis (LCA), measure societal, economic, and or environmental impacts associated with a product's production. Current life cycle analysis, for soybean-based biodiesel, look at the national production. National assessments fail to account for spatial differences in the production process and use broad regional averages and generalizations. To date no assessments have been conducted to assess the production of biodiesel from soybeans in Indiana. Using Indiana specific farm practices, process modeling, and emissions assessments a spatial life cycle analysis was preformed to quantify the environmental impact of soybean-based biodiesel in Indiana. The production of soybean-based biodiesel was be aggregated into three stages, soybean production, soybean oil production, and biodiesel production. Indiana farm practice data, for the soybean production stage were collected form the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS). Inputs and output amounts during the soybean oil and biodiesel production stages were calculated based on ASPEN plant simulation models. Using LCA software, SimaPro, the inputs and outputs of each stage were used to assess the environmental impact of soybean-based biodiesel in Indiana.

Decentralized Distributed IoT Home Monitoring System

Presentation ID:
AP-09

Room:
ARMS Atrium

Keywords:
IoT, DC, nanogrid

Joshua Mason, Jon Ore, Eckhard Groll
Prairie View A&M University and Purdue University

The aging of the US electrical grid and its inability to sustain the modernization and growth of industrial and consumer demands has motivated the need to investigate alternative and efficient mitigation of energy consumption. One strategy is the implementation of renewable energy paired with an intelligent in-home monitoring system capable of responding to fluctuations in load demand, power generation, weather conditions, and occupant comfortability. In this environment, networked sensors embedded in strategic locations of buildings make it possible to gather rich information about the natural environment and its impact on human activity. Sensors installed in a room under study measure variables such as temperature, humidity, proximity, illuminance, etc., and transfer this data to a distributed network of IoT devices. These devices then process the data, and enable specific control mechanisms of appliances and other internal instruments (e.g. dimming lights based on exterior luminance, or regulating the HVAC system to offset heat produced by cooking appliances). This research demonstrates two important concepts: (1) The opportunity to examine in-home improvements that yield the most optimal energy savings, and (2) the ability for the networked sensors to effectively lower power consumption, improve thermal comfortability, and provide real-time monitoring to a decentralized IoT system. These measurements contribute to the ongoing research of an all-DC nanogrid home, seeking the most energy efficient, environmentally-friendly, and cost-effective outcomes undergirding a data-driven architecture for modern residential infrastructure.

Modeling Impact of Engineering Undergraduate Experiences on Student's Conception of Climate Change and Sustainability

Presentation ID:
AP-10

Room:
ARMS Atrium

Keywords:
Engineering Education, Climate Change, Data Analysis, Sustainability

Jared France, Allison Godwin, Tripp Shealy
Purdue University

While a consensus has been reached about climate change in the scientific community, there is limited research about undergraduate engineering students' beliefs. There is also little known about the effect of undergraduate education on students' development of these beliefs. Climate change presents a number of challenges for current and future engineers, across disciplines. The U.S. can gain a strategic advantage across sectors, when compared to other countries who have not implemented similar measures, by ensuring that engineering students are prepared to confront problems related to a dynamic climate in their career. Using two surveys that capture beliefs and experiences of engineering first-year (Sustainability and Gender in Engineering [SaGE], n = 7709) and senior (Student Survey about Career Goals, College Experiences, [CLIMATE], n = 4605) students, we compared these groups using pairwise testing and multiple regression. The results indicate significant differences in engineering students' beliefs about climate change, sustainability, and engineering, as well their implications for career motivations and outcomes. This work is a first step towards understanding how undergraduate experiences impact engineering students' beliefs about climate change and sustainability. Findings from this work will help educators discern what interventions are necessary to address the apparent gaps between students' climate beliefs and their motivations to make change through engineering.

Nanotechnology and Nanomaterial

ARMS Atrium, 3:00 PM – 4:15 PM

Relationship between Photoluminescence and Surface Potential in 2D Materials

Presentation ID:
AP-11

Room:
ARMS Atrium

Keywords:
Nano materials, 2D Materials, TMDCs, Photoluminescence

Mathew Heighway, Jaehoon Ji, Jong Hyun Choi
Purdue University

As silicon-based technology approaches its mechanical limits, 2-Dimensional nanomaterials are exciting new candidates that have unique electronic and optical properties that make them suitable to next generation electronics. 2D Transition metal dichalcogenides or TMDCs such as MoS2 and WSe2 are the focus of much of this research as they are easy to create, stable in ambient conditions and have a direct band gap in thin layers which allows them to emit a bright photoluminescence (PL) which is promising for optoelectronic applications. PL is dominated by the formation and recombination of exciton which is a bound state of an electron and hole. However, we do not fully understand how the number of electrons on TMDC flakes relates to the photoluminescent response for MoS2. In this paper, the relationship between the number of electrons and PL is studied by investigating the light-emitting response and surface potential of MoS2 after various manipulations including thermal-annealing, solvent treatment, and organic-functionalization, since the surface potential which is governed by the concentration of electrons informs us how many electrons are extracted and donated by the modifications. We find that there is an optimal amount of charges for MoS2 to achieve highest photoluminescence and anything lower or higher will result in a lesser response. The finding allows us to get a better understanding on the physics of 2D materials and tune the properties of them in order to get a maximum PL for future optoelectronics.

Two-photon polymerization towards rapid 3D projection printing

Presentation ID:
AP-12

Room:
ARMS Atrium

Keywords:
Two-photon polymerization, Nanotechnology, 3D printing, Projection lithography

Yining Wang, Paul Somers, Xianfan Xu
Purdue University

With the ability to create desired nano-scale three-dimensional (3D) structures, 3D nano-printing triggered by the two-photon absorption of femtosecond laser pulses has shown significant potential in several fields, such as optical data storage, photonic crystals, microfluidic devices, smart materials, and tissue scaffolds. However, the current printing technique lacks strong capability for high-throughput of printed structures. A study on incorporating STimulated Emission Depletion (STED), an idea of applying a second laser that locally disables the polymerization so that the polymerization can be constrained to a refined region, and projection printing with the two-photon technique will likely enhance the printing performance. A fully automated printing platform is built including an 800 nm writing laser, a 532 nm depletion laser, square apertures to project an image on the printing surface, and multiple lenses, all of which is managed using a LabVIEW control system. This study reveals the underlying mechanisms for projection printing using two-photon polymerization as well as provides insight into the applicability of STED in this printing technique. STED lithography is tested at low writing speed simulating the actual STED working conditions in projection printing. With the help of this discovery, STED lithography is shown to have the possibility of being incorporated into projection printing, which will be a promising method of high-throughput nano-scale printing.

Anion Diffusion in 2D Lead Halide Perovskite Vertical Heterojunctions

Presentation ID:
AP-13

Room:
ARMS Atrium

Keywords:
Halide perovskite, photovoltaic, heterostructure, anion diffusion, photoluminescence.

Cindy Atencio, Akriti, Letian Dou
Universidad de los Andes and Purdue University

Perovskites are crystalline semiconductor materials that have emerged rapidly in the last few years in the field of optoelectronic devices such as solar cells, LEDs and transistors, due to their excellent optical and electronic properties and ease of synthesis. The most commonly used hybrid perovskites are formed by one halide anion and two cations—one of them an organic molecule and the other one a metal. These constituent anions and cations offer flexibility to form varied structures with desired optical and electronic properties. However, perovskites degrade when exposed to moisture and light, influenced largely by the anion diffusion within the perovskite material. In order to study the anion diffusion and enhance the utility of perovskite based devices, vertical junctions were made from two perovskites with same cations (phenylethylamine and lead) but different halides (bromine and iodide). The evolution of their optical properties was measured using photoluminescence spectrum after heating them for 100Â°C and 125Â°C during different time durations. The collected data has been processed to qualitatively study the influence of temperature and inorganic layer thickness on anion diffusion. Understanding the anion diffusion in a perovskite heterostructure is an important part of exploring new chemistries to crystalize and grow high quality nanocrystal halide perovskite semiconductor materials with better performance and higher efficiency.

Macromolecular Design of Radical Polymers for Electronic Applications

Presentation ID: AP-14

Room: *ARMS Atrium*

Keywords: *Materials Science, Chemical Engineering, Nanotechnology, Device Design*

John Vergados, Siddhartha Akkiraju, Bryan Boudour
Purdue University

Typical modern electronic processes utilize inorganic materials to fabricate the devices used today, but with new demands seeking devices that are flexible, lightweight, and fast-charging, current materials are becoming inadequate. A possible solution is to implement organic (i.e., carbon-based) materials in electronic devices because they are flexible and environmentally benign in nature. Initial research in organic electronics relied on polymers with conjugated backbones, however, this research has encountered complications with doping and stability. Since then, a new class of conductive polymers- radical polymers- has surfaced, displaying strong promise due to their flexibility, transparency, and electrical conductivity values, but while radical polymers possess desirable qualities, they still lack in certain areas namely conduction length, conductivity, and stability. In this study, one previously known conducting radical polymer was copolymerized with a secondary polymer in an effort to create a cross-linked copolymer that could conduct over longer lengths, maintain greater stability in electronic applications, and achieve enhanced mechanical robustness. While maintaining the concentration of the secondary polymer, the conductivity of the copolymer was examined by through-plane conductivity and preliminary mechanical tests were performed to observe the flexibility and stretchiness. Comparing the obtained values with the original polymer, it was found that this copolymer does maintain a considerably higher stability and improved mechanical robustness, but at the cost of a large drop in conductivity. While this copolymer did not improve every property of the original polymer, it can be said that adding a cross-linking secondary polymer to an existing conductive polymer reveals new opportunities for organic electronics.

Highly Flexible and Transparent Conductor for Solar Cells

Presentation ID: AP-15

Room: *ARMS Atrium*

Keywords: *Solar cell, transparent electrode, flexible, polymer, silver nanowire, solution process*

Thao Nguyen, Blake Finkenauer, Letian Dou
Purdue University

Flexible and wearable electronic technology has recently gained a significant amount of attention because of its potential application in life improvement. Application of nouveau devices, such as electronic skin, human-machine interfaces, and health monitoring sensors, etc., can aid human and enhanced their comfort and convenience. Because the most commonly used transparent conducting material in photovoltaic devices, which is indium tin oxide (ITO), is rigid and brittle, it cannot be used in flexible devices. Given that, as the wearable electronic and optoelectrical technology grows, the demand for a highly flexible electrode to accommodate human body movement like folding limbs or stretching and shifting muscles for such devices emerges. In this paper, a flexible electrode comprising of fused silver nanowires (Ag NWs) and a conductive polymer blend has been developed having proficient conductivity, high optical transparency. The fabricated electrode can be made at low temperature and at low cost, making it efficient for mass production. After multiple bending and twisting cycles, the flexible electrode film still has a sheet resistance of less than 22 ohm/sq. and average optical transmittance of 85%. The developed transparent electrode shows proficient flexibility and competent optoelectrical performance compared to commercial ITO, making it a promising candidate for flexible, transparent conductive layer in the solar cell.

Energy

ARMS Atrium, 3:00 PM – 4:15 PM

Effects of Varying Electrolyte Concentration on Lithium Metal Anode

Presentation ID: AP-16

Room: *ARMS Atrium*

Keywords: *Li-ion batteries, Li-plating, Dendritic Growth, Electrolyte Concentration*

Samruddha Gujrathi, Yuvraj Singh, Sobana P. Rangarajan, Partha P. Mukherjee
Purdue University

Lithium ion batteries (LiBs) are more prevalent than ever, uses ranging from smart watches, smart phones, and laptops to electric vehicles like the Tesla. Cell engineering used to increase the volumetric energy density of LiB has reached its peak, but the idea of affordable and market competitive electric vehicles will require new battery strategies. Rechargeable batteries capable of 30,000 safe charge/discharge have been made, but the current challenge is to combine this life cycle and safety into an affordable and high energy density battery. One of the major roadblocks in using high energy density lithium metal anode is inhomogeneous lithium plating leading to dendritic short circuit of the cell. This inhomogeneous lithium plating further reduces the cell capacity and Coulombic efficiency, and causes irreversible loss of active lithium, which lead to premature cell aging and safety hazards. The ionic conductivity of the cell is varied by varying the concentration of the electrolyte at different temperatures to observe its influence on lithium deposition qualitatively and quantitatively. The electrodes were imaged optically for surface and topographical qualitative analysis and the cycling data was analyzed for quantitative trends. The interface characteristics are studied as a function of ionic transport in the electrolyte at different operating conditions to find the optimal combination for homogeneous lithium plating.

Influence of electrolyte starvation on lithium plating at different operational conditions

Presentation ID:
AP-17

Room:
ARMS Atrium

Keywords:
Li-ion Batteries, Lithium plating phenomenon, Electrolyte volume

Yuvraj Signh, Samruddha Gujrathi, Sobana P. Rangarajan, Partha P.Mukherjee
Purdue University

The world is becoming highly dependent on Li-ion batteries and their demand is growing steeply. One limitation faced by these batteries is the lithium plating phenomenon that reduces Coulombic efficiency and capacity of the cell especially during fast charging and extreme conditions such as low temperature and high C-rate. As the cell is cycled, the electrolyte begins drying up over time and this changes the lithium plating characteristics. We explored lithium plating's relationship with electrolyte loading at different operating temperatures and charge rates and formulated a trend between these factors as the cell dries up. We fabricated half cells and added different amounts of electrolyte to them to simulate conditions of flooding to starvation. They are discharged at various temperatures and rates to induce lithium plating. Plating is characterized through Electrochemical Impedance Spectroscopy (EIS), cell postmortem and surface morphology. The study concluded that as the cell starves, the tendency for plating increases. This plating becomes more in-homogeneous and encourages electrolyte degradation. These characteristics are further amplified by the reduction in temperature and increase in C-rate.

Analysis of Reactor Systems for Ethane Dehydrogenation

Presentation ID:
AP-18

Room:
ARMS Atrium

Keywords:
Catalytic dehydrogenation, shale gas transformation, process design, ethane dehydrogenation, NGL conversion, ethylene production

Prerena Prahlad, Peter Oladipupo, Rakesh Agrawal
Purdue University

The last 10 years have witnessed an unprecedented revolution in the domestic supply of shale hydrocarbon reserves in the potential to lower cost U.S.'s electricity, power, chemicals, and fuels for the next 100 years. If new technologies can be developed, energy experts project the U.S. will transition from a net importer to net exporter of energy resources by 2030. In addition, substitution of natural gas for coal for electrical power generation has, and will continue, to be a major contributor to the reduction in U.S. greenhouse gas until economic, renewable energy future can be developed. In the meantime, energy technologies have to be in place to bridge the gap between complete fossil fuel dependence and renewable energy. This effort includes exploring opportunities that can function in remote areas to produce liquid fuels and chemicals from shale resources. The most widely used industrial process for producing ethylene from ethane is steam ethane cracking. While steam ethane cracking is an efficient process for the conversion of ethane, it results in the production of side products necessitating expensive separation technologies to recover ethylene from the cracked gas. In order to mitigate the production of side products in the ethane-conversion process, a catalytic route for ethane dehydrogenation is necessary to improve the selectivity of the process towards ethylene, while also increasing yield. In view of this, different reactor configurations for the process are conceptualized and analyzed for a target conversion of at least 50% of pure ethane feed and a selectivity of 100% towards ethylene. Due to the high temperature requirement of ethane dehydrogenation, a major concern in designing a catalytic process is how to effectively supply heat to the system without promoting thermal cracking and/or side reactions, which could occur prior to feed to the catalyst bed in the reactor(s). Therefore, amongst different reactor configurations that have been analyzed, a furnace-fired catalytic reactor is considered as a possible solution for catalytic ethane dehydrogenation.

Nexus of Thermionic, Field, and Space-charge Limited Emission

Presentation ID:
AP-19

Room:
ARMS Atrium

Keywords:
Nexus Point, Thermionic Emission, Field Emission, Space Charged Limited Emission, Richardson-Laue-Dushman, Child-Langmuir, Fowler-Nordheim

Caleb Darr, Adam M. Darr, Sarah A. Lang, Allen L. Garner
Purdue University

Electron device design for directed energy and high power microwaves requires detailed understanding of the physics of electron emission from the cathode; however, the transition between the mechanisms remains incompletely understood despite over a century of experimental and theoretical studies. This presentation outlines the steps for unifying thermionic emission with electron emission and field emission, which have all been studied piecemeal, but not as a whole. We start by considering the force on a single emitted electron in the presence of an applied electric field and consider the electron current density as a combination of thermionic and field emission. This permits theoretical demonstration of the transition between these three electron emission regimes using the resulting asymptotic solutions under appropriate limits of applied voltage and cathode temperature and the definition of a nexus when all three asymptotes intersect. The transitions between these mechanisms is fundamental to the comprehensive understanding of electron emission in cathode physics, particularly for the design of microscale and nanoscale emitters for high power radars and directed energy devices.

Investigations on Thermoelectric Properties of CuAl1-xFexO2 material

Presentation ID:
AP-20

Room:
ARMS Atrium

Keywords:
Metal Oxide materials, Solid-state reaction, Thermoelectric Properties, Nano bulk materials

Jin Hong Joo, Yining Feng and Na (Luna) Lu
Purdue University

Thermoelectric technology has been studied widely as it allows energy harvesting from wasted thermal energy. Thermoelectric devices have been potentially used in automobile, HVAC, electronics, and many other industries. However, current commercially available thermoelectric materials are toxic, or rare, or highly unstable at a higher temperature. To resolve these problems, it has come to attention in using oxide materials for thermoelectric applications. In this work, Fe-doped CuAlO2 has been thoroughly studied as it is relatively easy to prepare with common raw materials and display potentially promising thermoelectric properties. To prepare Fe-doped CuAlO2, three raw materials of Fe2O3, CuO, and Al2O3 were mixed through the solid-state method using ball milling, hydraulic pressing, and annealing at different temperature ranges in air. The prepared materials were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), Hall effect measurement, the Seebeck coefficient measurement, and thermal conductivity measurement. The study has compared the thermoelectric properties of the product acquired from various compositions of raw materials and processed with high temperature annealing. Also, these properties have been compared to the literature values of Fe-doped CuAlO2 that prepared using various methods. The study may provide potential solutions for fabricating non-toxic thermoelectric materials with high performance.

Cooling Spacer for Thermal Management on Li-Ion Batteries

Presentation ID:
AP-21

Room:
ARMS Atrium

Keywords:
Thermal management, Electric Vehicles, Lithium-Ion Batteries, Spacers, Battery-Packaging

Odette Kuehn, Thanh Nguyen, Thomas Siegmund
Purdue University

Nearly thirty percent of US petroleum is used for transportation. Electric Vehicles (EVs) could significantly reduce consumption, however; thermo-mechanical management systems for the batteries are often expensive and ineffective. In order to create the optimal solution for use in EVs, each component of the system should be contributing in some way to the overall performance and cooling efficiency. Typical EV battery packs consist of Lithium-Ion cells connected in parallel with their largest faces adjacent to one another. They are separated by 2-millimeter-thick plastic spacers and held together by metal end pieces. The behavior of different materials and manufacturing methods in the configuration of a spacer is investigated to determine the effects on temperature gradient and average temperature of the surface of the cell. Materials of varying thermal conductivities are used in a spacer with the most contact between cell and spacer. The spacer is attached to a battery cell package loaded with a 5 Watt heating pad. Under natural and forced convection, the cell is allowed to reach steady state before thermal images are taken and compared. The experiment is intended to produce results that can designate the ideal material to create the most even temperature distribution. This optimization could increase safety and longevity of lithium-ion batteries in electric vehicle applications.

Computer Science

ARMS Atrium, 3:00 PM – 4:15 PM

iFly: Forensic Data Collecting iOS Application

Presentation ID:
AP-22

Room:
ARMS Atrium

Keywords:
iOS, Application, Development, Software, Swift, Objective-C, Entomology, Forensics, data

Mauneel M. Amin, Trevor I. Stamper
Purdue University

In forensic science, data accuracy and collection can be very important when it comes to solving cases. We are developing a prototype entomological data-collection application called "iFly," which runs on a field-capable iPad device in order to capture the details present on site. This app works on iOS platform and we have used SQLite3 database in Apple's XCode Integrated Development Environment (IDE) which works in SWIFT. Using simple coding structures like MVC (Model View Controller) and integrating it with complex SDK and APIs will help to make this application fully-functional and ideal for user experience. Altogether, this app will have various features and functionality like 3-D scanning, case data insertion, audio / visual note-taking capability, weather data extraction, etc. In order to successfully launch the iFly application into the commercial market, we have decided to move out the iFly prototype in the physical world for testing with the help of numerous students and professors from different universities throughout the country. This application will test iPad data gathering capacity and will help make data gathering a lot easier in the field of Forensic Science.

Dynamic Aggregation Network for 3D Semantic Scene Segmentation

Presentation ID:
AP-23

Room:
ARMS Atrium

Zongyue Zhao, Min Liu, Karthik Ramani
Purdue University

Keywords:
Point Cloud, Semantic Segmentation, Dynamic Aggregation, Deep Learning, Computer Vision

Deep learning algorithms, e.g., convolutional neural networks, have shown great success in 2D image segmentation. However, vanilla 2D networks cannot be directly applied on point clouds that represent 3D data in an unstructured manner. Although multiple architectures have been proposed to extract pointwise/local features or to globally integrate them, they often use static, rigid aggregation operations which fail to adapt the individual structure of the scene. In this paper, we propose a novel network that dynamically aggregates information in both local and global scales while considering individual scene complexity. The network is trained and tested on the S3DIS dataset that contains more than 300 large-scale indoor scenes. Our network structure gives out segmentations results with a 58.8% mean intersection over union value and a 68.4% mean accuracy value, showing a 6.0% and 6.2% improvement compared to the state-of-the-art architecture. The results indicate the advantage of using dynamic aggregation methods for large-scale semantic scene segmentation tasks.

Geolocation Prediction with Near Real-Time learning

Presentation ID:
AP-24

Room:
ARMS Atrium

Ray Chen, Luke S. Snyder, Morteza Karimzadeh, David S. Ebert
Purdue University

Keywords:
Geolocation Inference, Deep Learning, Twitter, Situational Awareness, Web Development, First Responders

Twitter has become one of the most popular social media services over the years, and tweets have since become an established source of information for many research fields. Geotagged tweets, or tweets with attached locations, are valuable to researchers and groups such as first responders by providing the geographical context of a tweet’s content. However, tweets are not geotagged by default, and only about 0.9% of all tweets are geotagged and available for researchers to perform spatial analysis. We address this limitation by first filtering the tweet data stream with certain restrictions, and then feed the non-geotagged tweets to the adapted state-of-the-art machine learning models to perform geolocation prediction. The machine learning models are trained with historical and real-time geotagged tweets to improve the model’s performance. The machine learning models analyze the metadata of each individual tweet, such as text and creation time, and output an estimated location at the city level. We integrated the model with the Social Media Analytics and Reporting Toolkit (SMART), a visual analytics web application that provides interactive visualization of geotagged social media data, and have increased the number of the real-time tweets streamed to the application by up to 60%. SMART can now provide more effective visual analyses for its end users than before.

Human Like approach to M2M

Presentation ID:
AP-25

Room:
ARMS Atrium

Vignesh Ramachandran, Baibhab Chaterjee, Shreyas Sen
Purdue University

Keywords:
IoT, Energy, M2M, Bluetooth, Ultrasound

It is predicted that by 2020 there will be over 30 billion connected IoT devices and each of these devices will be communicating more than 30 Exabytes (one million gigabytes) of data per month. The amount of data transfer is so massive and with current wireless communication protocols there are no foreseeable issues, however the power consumed in communicating all this data has a very significant value. Humans and animals have always been very efficient in the way they communicate with each other in all aspects. This paper aims to propose a new way of machine to machine communication that is inspired by the methodologies and modalities that humans and/or animals have been using. To implement such communication protocols, we have worked with multiple raspberry pi that have peripheral devices (camera, microphone, speaker and LED sequence) to mimic the basic external organs of humans. The protocol involves sending low frequency signals (compared to RF signals) with the different configurations of the LED sequence to convey different meanings. Alternatives to Bluetooth are currently being looked into with the help of Shannon Entropy and an attenuation analysis between Bluetooth and low frequency signals such as ultrasound. With such a communication protocol at lower frequencies the amount of power dissipation will be significantly reduced and will allow opportunity for more context-based communication between machines.

Morteza Karimzadeh, David S. Ebert

Presentation ID:
AP-26

Room:
ARMS Atrium

Keywords:
Automated Landform Inference Mapping, Soil-mapping, Visual Analytics, Clustering

Bryan Jimenez, Morteza Karimzadeh, David S. Ebert
Purdue University

Automated landform inference mapping (ALIM) is a knowledge-based soil-mapping method used for optimal crop management practices. Unlike conventional soil-mapping methods, ALIM uses terrain attributes and small amounts of soil sampling to create visual model representations of the distribution of soil properties (e.g. PH, CO2). However, even though ALIM has an advantage over other soil-mapping methods due to its ability to produce accurate soil maps with small amounts of soil samples, the current visual analytics application makes it inconvenient for the user to access the end results of the computation and is therefore less effective than it could be. In this project, we will be focusing on improving the functionality of the current ALIM-based visual analytics application. As a result, users will be able to seamlessly perform both clustering and membership assignment from the same interface. In the future, we hope to use this platform to analyze vineyards in the Arequipa region of Peru and utilize the information derived from the soil maps to make Arequipa a relevant player in premium wine production once again.

Application of Traffic Signal Probability for Green Light Optimized Speed Advisory

Presentation ID:
AP-27

Room:
ARMS Atrium

Keywords:
Traffic Signal Probability, GLOSA, Dilemma Zone, Fuel Consumption, Travel Time, g-force

Enrique Saldivar-Carranza, Woosung Kim, Howell Li, Darcy Bullock
Purdue University

Green Light Optimized Speed Advisory (GLOSA) systems have the objective of providing a recommended speed to arrive at a traffic signal during the green phase of the cycle. GLOSA has been proven to decrease travel time, fuel consumption, carbon emissions, and exposure to the dilemma zone. However, many of these systems rely on real-time communication between the vehicle to the infrastructure, or V2I. Data loss presents a major concern to GLOSA's performance; nevertheless, few studies have been conducted using historical cycle-by-cycle phase probabilities to provide speed advisory for all kinds (fixed-time, semi-actuated, and fully-actuated) of traffic signal operation. In this study, a GLOSA system based on phase probability, obtained from traffic signal controller high-resolution event data, is proposed. This probability is calculated from the data prior to each trip based on the same time-of-day and day-of-week timing plan. The selection of an effective threshold value acquired from traffic patterns is utilized. Proof of concept is carried out by virtually driving, utilizing historical high-resolution traffic signal data, through the test-route. Results obtained from the use of the proposed system are compared to those acquired from unadvised trips. Reductions of 6.7% in the amount of stops, 87.4% in the number of hard braking (0.39 g to 0.58 g), and 82.1% in crossings through red light were accomplished with the proposed system. This data suggests the viability of utilizing traffic signal phase probabilities with GLOSA purposes.

Organic Electronics in the Axon-Hillock Circuit

Presentation ID:
AP-28

Room:
ARMS Atrium

Keywords:
Analog electronics, neuromorphic systems, axon-hillock circuit, simulation, organic electronics

Dakota Warren, M.J. Mirshojaeian Hosseini, Robert A. Nawrocki
Purdue University

Neuromorphic engineering, coined by Carver Mead, is used to describe electrical systems inspired by biological information processing systems, including silicon retinas, brain-machine interfaces, and neuromorphic processors. A handful demonstrations of neuromorphic systems using organic electronics, electronics based on organic materials, have shown success due to the tenability of individual materials, simple fabrication, physical flexibility, and biological compatibility. However, the axon-hillock circuit, the basic building block of a spiking neural network, has yet to be implemented in organic neuromorphic engineering. The main difference between organic and inorganic electronics is their parameters, which can cause a significant difference in circuit behavior, and present challenges for replicating the spiking behavior of the axon-hillock. The idea of an organic axon-hillock circuit was investigated through SPICE simulations with custom organic transistors and parameters. A model based on these simulations was also fabricated for physical measurements. Simulations were performed in NI Multisim and Cadence's Spectre and comparisons were made. The axon-hillock circuit was modified to use Pseudo-CMOS architecture because the organic transistors were only p-type. Values of the injection current and VDD were also modified due to the characteristics of the organic transistors. The circuit was modified to include a voltage divider to mitigate the high ON resistance of an organic transistor, as well as an additional inverter to account for the use of a p-type reset transistor. Results from both simulations showed a behavior similar to the expected behavior of the circuit. The results were also compared to the implementation of the organic axon-hillock circuit.

Mechanical Engineering

ARMS Atrium, 3:00 PM – 4:15 PM

Yamalis Lopez Massa, Murali K. Maruthamuthu, Mohit Verma, Mahdi Hosseini and Arezoo Ardekani
University of Puerto Rico, Mayagüez and Purdue University

Room:
ARMS Atrium

Keywords:
Microfluidic Device, Bacteria, Acoustic Waves, Continuous Flow, Separation.

Microfluidic devices provide the ability to study and analyze micro-scale particles and cells for biomedical applications. The study of the behavior of biological entities is highly important for developing new technologies that represent innovative approaches to current emerging problems. Our research is mainly focused on the fabrication and testing of a microfluidic device which supports acoustic waves in order to concentrate bacteria in a continuous flow. A microfluidic device was designed using soft lithography procedures in a LiNiO3 128Â° Y-cut wafer. A stream of a continuous flow of E. Coli bacteria was input and various frequencies were applied to generate the acoustic wave. Imaging of the acoustic wave nodes was taken in real-time to observe the bacteria concentration. This study analyses the efficiency of the microfluidic device design and provides conclusions based on its capability to concentrate bacteria in a continuous flow.

Deformation- Driven Particle Debonding

Presentation ID:
AP-30
Room:
ARMS Atrium

Keywords:
Debonding, particle adhesion, elastomeric materials, poly(dimethyl siloxane) (PDMS)

Valeria Tellez, Naomi Denek, Chelsea Davis, Kimberly Stevens, and Ivan Christov
Texas A&M University – Kingsville and Purdue University

There are many instances in industry where it is necessary to be able to move around or manipulate the position of particulate matter. These industries might include energetic materials, pharmaceuticals, or particle release on filtration membranes. There is great potential in the use of mechanical deformation of soft substrates in order to control particle adhesion for positioning and maneuvering. This project focused on the detachment or debonding of spherical silica particles from the surface of an elastomeric substrate of poly(dimethyl siloxane) (PDMS), as uniaxial tensile deformation is applied to the substrate. Spherical silica particles with diameters ranging from 0.5 to 1mm and PDMS moduli ranging from 0.2MPa to 2MPa were used. We observed a change in size and shape of contact between the substrate and the silica particles. Often detachment was not observed prior to macroscopic substrate fracture. Understanding the interfacial behavior of these silica particles while undergoing a tensile test has provided key insights towards controlling particle adhesion for positioning and maneuvering.

Oil Return and Retention in Unitary Split System Gas Lines with HFC and HFO Refrigerants

Presentation ID:
AP-31

Room:
ARMS Atrium

Keywords:
HVAC, Oil Retention, Compressor Design

Meghavin Bhatasana, Vatsal Shah, Eckhard Groll
Purdue University

Oil plays an important role in compressors of vapor compression systems by lubricating its moving components, acting as a sealant to reduce leakage losses from its chambers, and as a heat sink. Inadvertently, some of the oil escapes the compressor along with refrigerant, travels through various components of the vapor compression cycle, retains within the system components, and thereby decreases system efficiency. Current studies investigate the oil retention phenomenon but the HVAC industry lacks design guidelines that take this occurrence into account. This research aims to provide additional design parameters to help determine appropriate line size and give values for oil retention in interconnecting gas lines of vapor compression systems. Suction and discharge conditions for a vapor compression system compressor were emulated with various refrigerant-oil mixtures, different refrigerant mass flow rates and oil injection rates, and two different line orientations. Early results showed a significant increase in oil retention within the horizontal section and churn flow within the vertical section at low refrigerant mass flow rates and high oil injection rates. The increased oil retention in the connecting lines indicates a strong susceptibility for compressor failure due to oil starvation.

Development of Teleoperation System with Haptic Device and ROS Framework

Iveindigo Djianto, Huitaek Yun, Martin B.G. Jun
Purdue University

Presentation ID:
AP-32

Room:
ARMS Atrium

Keywords:
Robotics, Teleoperation, Haptic, ROS, Framework

Currently, the development of teleoperation in the field of robotics has been limited. While there are some researches done to develop a platform that supports simple communication between one or more input haptic device (master) and a robot (slave), most require a significant amount of effort (difficult to program, requires multiple external hardware, etc.) to implement new master and slaves into the platform. In order to solve this problem, this paper proposes a new platform for teleoperation utilizing ROS (Robot Operating System). ROS is itself a new platform that is used by engineers to allow different devices to communicate, one that performs the control algorithm, making it significantly easier for the end-user. The project uses a haptic device as the input device and aims to control a 6 DOF (Degrees of Freedom) collaborative robot. Both these devices are selected primarily due to their compatibility with ROS. Another additional 6 DOF robot is also added to proof the versatility of the platform. The results showed that the platform allows for a much simpler method of communication between haptic devices and robots, making it easier to add new devices and control multiple devices. With the proposed framework, the development of human and robot interaction through haptic interfaces can be more efficient.

1D models for particle-laden flows in tight geometries

Masashi Nishiguchi, Daihui Lu, Ivan Christov
University of Mount Union and Purdue University

Presentation ID:
AP-33
Room:
ARMS Atrium

Keywords:
gravity currents, Hele-Shaw flows, suspension

Investigating the motion of suspensions of particles in a fluid in channel with complex and variable geometry is a problem that arises in many geophysical situations. A model of the behavior of such a gravity-driven suspension current has not been derived or analyzed before, yet it is needed to capture the physics of the phenomenon. The motion of gravity currents of clear fluids (no suspended particles) in a channel with simple geometry, including rectangular and V-shaped cross-sections, has been studied; however, the spreading of a suspension of particles in a channel with thickness variation described by a power-law function, called a Hele-Shaw cell, has not yet been investigated. In this study, the partial differential equation governing the spreading of a suspension gravity current spreading through a variable Hele-Shaw cell was derived and a similarity solution to the equation was obtained numerically via finite-difference methods. similarity solution has fewer number of variables than a direct solution due to dimensionless analysis, and allows us to represent the motion of a gravity current with a single “universal” curve (profile). As a result, the similarity solution and its graph describing the motion of suspension in Hele-Shaw cell are going to be provided, corresponding to various flow situations in a Hele-Shaw cell. Then, conclusions will be drawn based on these similarity solutions, with implications for the geophysical problems in which gravity-driven spreading of suspensions is observed.

On the Finite Element Method for Solving the Poisson Equation: The Accuracy of the C0-P2 Scheme with Numerical Integration

Logan Cross, Xiangxiong Zhang
Purdue University

Presentation ID:
AP-34

Room:
ARMS Atrium

Keywords:
Poisson equation, finite element method, numerical integration, quadrature

Many physical phenomena such as fluid dynamics and heat transfer are characterized by complex differential equations (e.g., the Poisson equation) with no closed form solution. In order to better understand and model these systems through simulation, numerical methods for solving these equations are critical. The finite element method creates a mesh of elements that are uniform in shape, and solves a system of equations to find the numerical solution. The finite element method produces numerous high accuracy schemes, but it is typically computationally expensive to compute the resulting integrals produced by this method. Recent research has shown that for one finite element scheme (C0-Q2), numerical integration can be used to approximate the integrals without sacrificing overall accuracy of the scheme. This results in a high accuracy solution that is more efficient to compute. By testing the scheme implementation on equations with known solutions, the research presented shows that the high accuracy of a different finite element scheme (C0-P2) is preserved while using numerical integration. The result is a better understanding of how to utilize these high accuracy schemes in efficient ways for simulation of complex systems.

Machine Learning-based Determination of Particle Sizes for the Ideal Passive Radiative Cooler

Carmela Mohan, Joseph Peoples, Xiulin Ruan
Purdue University

Presentation ID:
AP-35

Room:
ARMS Atrium

Keywords:
Passive radiative cooling, nanoparticles, nanoparticle size, genetic algorithm, photon transport, Monte Carlo simulations, Mie theory, Mie scattering

Much of the world's energy is spent keeping buildings and places cool; in the United States alone, homeowners spend billions of dollars each year to cool their houses. A new way to reduce this can be found in passive radiative coolers comprised of nanoparticle-polymer composites; these are high-performing and low-cost methods where no energy is expended in the cooling process. The purpose of this study is to use a genetic algorithm to determine the best particle size distribution for the ideal passive radiative cooler. To do this, it was important to understand and accurately model photon transport in a wide variety of media. Mie theory was used to determine the scattering and absorption coefficients to that end. A Monte Carlo simulation tailored for photons was then created to predict a specific photon packet's journey through layers of media and obtain the needed reflective and absorption quantities. A genetic algorithm was then written to test various ranges of particle sizes using the two previous programs and determine which range of particle sizes produced the optimal passive radiative cooler that would have the highest emissivity in the range of wavelengths known as sky window and highest reflectance in the solar region. These results will give a range of particle sizes for a theoretically ideal passive radiative cooler; this can later be tested experimentally. These results will provide guidance for future experiments to verify and validate the simulated results and illustrate the optimal characteristics for efficient passive radiative coolers.

Robustness of Leading Edge Vortex to Turbulence

Yun-Jui Tu, Jesse Roll, Xinyan Deng
Purdue University

Presentation ID:
AP-36
Room:
ARMS Atrium

Keywords:
Aerodynamics, Flapping Wing Flight, Leading Edge Vortex

The presence of a stably attached leading edge vortex (LEV) on an insect's wings is attributed to the aerodynamic performance they exhibit during hovering flight. Although LEV has been visualized on real insects and demonstrated by robotic analogs and through computational fluid models, the physical mechanisms are poorly understood. Prior studies have demonstrated that the stability of the LEV is sensitive to the local Rossby number, a dimensionless number associating the wing's distance from its axis of rotation, with transitions to periodic shedding occurring at a critical point. Therefore, the researchers hypothesize that, with the addition of external flow disturbances in the form of turbulence, LEV instability will occur prior to the critical Rossby number, allowing for the systematic study of this transition region. To first verify and then investigate this phenomenon, aerodynamic force measurements obtained from dynamically scaled tank experiments will be paired with a flow quantification technique known as particle image velocimetry (PIV), providing new insights into the transition between region stability. The hypothesis that turbulence does not affect the transition in LEV instability which occurs under laminar flow conditions will be discussed based on the results. The results of the study would either verify the robustness of the mechanism(s) resulting LEV stability or provide an avenue for further investigation if an effect is observed.

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