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**FITCH H. BEACH NOMINEE POSTERS**

**Poster Number:** FB-01  
**Authors:** Gautham Dharuman; Liam G. Stanton; James N. Glosli; Michael S. Murillo  
**Title:** Molecular Dynamics Studies of Correlated Charged Particle Systems: Predictions for a New Paradigm in Non-Ideal Plasma Science  
**Abstract:** Charged particle systems are ubiquitous in nature. Making them strongly coupled in a controlled laboratory environment would enable experiments to validate different models on their ionization properties, transport, and equation of state. Available avenues are dusty plasmas, ultracold neutral plasmas, and warm dense matter. But, they have their limitations in terms of coupling strengths possible, ease of creation and diagnosis, or their dimensionality. Using a suite of molecular dynamics (MD) simulations we have proposed a solution with a new paradigm: creation of non-ideal plasmas by photoionizing compressed gases. The idea is centered on conversion of pressure induced correlation in the neutral state to correlation between charged particles. Choosing xenon as the candidate neutral gas, we simulated the neutral-neutral correlation with exponential-6 potential, followed by plasma evolution that was simulated with screened Coulomb interactions. The equilibrium state was simulated with explicit electrons (in addition to ions) using quantum statistical potentials, to compute the contribution of correlated electrons to the equation of state. Our results indicate that the paradigm is a promising alternative offering the desired controllability over a wide range of properties, possibly opening a sub-field in laboratory physics of charged particle systems. Further, owing to the widespread occurrence of medium-range interactions in correlated charged particle systems, it becomes essential to accelerate MD simulations that are being widely employed to study the system properties. There are efficient methods for short- and long-range interactions, but for medium-range interactions an optimal method hasn't been established. We generalized the Ewald decomposition and adapted the particle-particle particle-mesh algorithm for a class of screened Coulomb interactions that are medium-range. In the low screening limit, we achieved about $10^{-100}$ times faster force calculation with the adapted algorithm compared to a neighbor-list algorithm. Through extensive computational studies powered by efficient methods, we have identified a new paradigm for non-ideal plasma science which would have been impossible or prohibitively expensive for experimentalists to otherwise identify.

**Poster Number:** FB-02  
**Authors:** Hassene Hasni; Nizar Lajnef  
**Title:** Damage Progression Quantification Using Self-Powered Wireless Sensors Networks  
**Abstract:** This research proposes a novel damage progression quantification system for structural health monitoring (SHM) using a new class of self-powered piezo-floating-gate (PFG) sensor. This SHM system relies on harvesting the mechanical energy from structures through the direct effect of piezoelectricity. The operating power of the smart sensor and the data used for damage identification is harvested directly from the sensing signal induced by a piezoelectric transducer under dynamic loading. The developed models integrate structural simulations using finite element method (FEM) techniques, experimental studies, statistical and artificial intelligence (AI) methods. In this work, the performance of the sensor in identifying damage is investigated for various damage scenarios based on numerical and experimental studies. Both steel and pavement structures are studied. Sensor fusion models are developed to improve the damage detection accuracy.

This work is supported in part by the FHWA grants DTFH61-13-C-00015 and DTFH61-13-H-00009.
**Poster Number:** FB-03  
**Authors:** Matthew R. Herman; A. Pouyan Nejadhashemi; Fariborz Daneshvar; Mohammad Abouali; Dennis M. Ross; Sean A. Woznicki; Zhen Zhang  
**Title:** Reshaping the American Bioenergy Landscape to Address the Food, Water, and Energy Paradigm

**Abstract:** As we approach the middle of the 21st century, the demands for food, energy, and water (FEW) continue to climb, straining the natural systems that provide these resources. In order to ensure that current and future needs for FEW are met, the sustainability of natural systems that produce FEW has become a major global research focus. However, the interconnected nature of the FEW sectors makes sustainability achievable if only all three sectors are addressed together. Therefore, this study introduces a novel approach for redesigning agricultural landscapes to increase energy and food production while minimizing the impacts to water resources. To do this, stream health models based on the Index of Biological Integrity were developed for the first time by coupling the Soil and Water Assessment Tool, Hydrologic Integrity Tool, and Adaptive Neuro Fuzzy Inference System. These models served as criteria for an evolutionary algorithm that evaluated bioenergy landscapes for the Flint River Watershed in Michigan. Thirteen different bioenergy managements were considered for this study. After over two thousand simulations an optimal bioenergy landscape was identified that increased the bioenergy and food productions in the region while significantly improving the region’s stream health. In the final landscape the most commonly implemented management was (27.07%), followed by corn-soybean-rye (19.00%), corn stover-soybean (18.09%), and corn-soybean (16.43%). The success of this technique shows that it is possible to address social and natural system demands under the lens of FEW.

*This work was supported in part by USDA.*

**Poster Number:** FB-04  
**Authors:** Christine James; Yue Qi  
**Title:** Computational Study of the Interaction Between Cathode and Electrolyte Components in Li-Ion Batteries

**Abstract:** While Li-ion batteries are a promising means of energy storage they still can be improved in areas such as capacity, cycle life and safety. In terms of capacity, the cathode is the limiting component. While anodes such as graphite with a capacity of >300 mAh/g exist, common cathode materials have a much smaller capacity. Some of these common cathode materials are layered materials such as LiCoO2 (160mAh/g), spinel materials such as LiMn2O4 (130mAh/g) and phosphates such as LiFePO4 (160mAh/g). A higher capacity cathode material (>200mAh/g) that has recently been studied intensely are Li2MnO3 stabilized layered materials of the form xLi2MnO3-(1-x)LiMO2, where M is commonly a transition metal or combination of transition metals. It is commonly accepted that the Li2MnO3 component undergoes an “activation” process during the first cycle of charging which includes the removal of oxygen from the material. This is known as an “activation” process because it allows the material to have a higher capacity. Previous studies have shown that the oxygen vacancies created in the material affect properties such as Li diffusion and Li vacancy formation. This work aims to focus on the interaction of an electrolyte component, ethylene carbonate (EC), and the Li2MnO3 surface. Specifically, the adsorption/degradation of the EC on the Li2MnO3 and the role of surface vacancies in Li2MnO3 are explored.

*This work was supported in part by DOE Office of Science and National Science Foundation*
Poster Number: FB-05
Authors: Aryan Mehboudi; Junghoon Yeom
Title: Deformable Shallow Microfluidics: Physics of the Fluid Flow and Novel Particle Manipulation Platform for Filtration, Isolation, and Controlled Release

Abstract: Over the past decade, several pneumatically-tunable deformable microfluidic devices have been demonstrated for the cell/particle trapping purpose. In addition to the difficulties associated with the fabrication, integration, and operation of these devices, keeping the trapped species stationary necessitates the continuous actuation of the membrane, which makes the devices cumbersome for prolonged analysis on isolated cells/particles. The objective of this work is to alleviate the aforementioned difficulties through developing a new deformable microfluidic platform that does not require separate pneumatic actuation. The central idea is to leverage deformable shallow microchannels with ultra-low height-to-width-ratio, where the original channel height is smaller than the target particle size and the channel is sufficiently wide for the deformable wall to deflect simply by a pressure drop across the channel. The particle trajectory and potential trapping sites depend on the particle size, channel geometry, membrane properties, and applied pressure. The theoretical, computational, and experimental tools are employed to provide a deep insight into the underlying coupled fluid-solid mechanics, making the proposed platform more versatile and predictable. It is shown the ultra-low height-to-width-ratio (O(0.001)) deformable microchannel permits a few-order-of-magnitude higher volumetric flow rates for the same applied pressure compared to the rigid counterpart. Moreover, our investigations on nozzle-diffuser deformable shallow microchannels reveal previously-unexplored characteristics, demonstrating a sizable flow rectification behavior under the Stokes flow regime. Finally, this unique platform allows us to regulate the deformation of the flexible ceiling and consequently the channel opening size, selectively filtering larger particles and trapping/releasing them at/from the desired locations.

Poster Number: FB-06
Authors: Jinshui Miao; Suoming Zhang; Haochuan Wan; Yiheng Zhang; Chuan Wang
Title: 3D Integrated Electronic Devices Using Layered 2D Materials

Abstract: Two-dimensional materials have been actively explored for electronic device applications because of their ability to form van der Waals heterostructures. Here, we report the 3D integration of multi-heterostructures of layered materials for the fabrication of a new generation of 3D logic transistors, diodes, and complementary inverters. The logic transistors show high room-temperature on-off ratio and current density. We also leverage the band-structure alignment properties of small-bandgap black phosphorus and large-bandgap MoS2 to realize heterojunction diodes with gate tunable rectification ratios. Finally, we demonstrate a complementary inverter by vertically stacking graphene, black phosphorus (p-channel) and MoS2 (n-channel). This is a major breakthrough result which opens up the possibility of highly-integrated 3D electronic device applications.

Poster Number: FB-07
Authors: Xi Yin; Xiang Yu; Kihyuk Sohn; Xiaoming Liu; Manmohan Chandraker
Title: Feature Transfer Learning for Deep Face Recognition with Long-Tail Data

Abstract: Real-world face recognition datasets exhibit long-tail characteristics, which results in biased classifiers in conventionally-trained deep neural networks, or insufficient data when long-tail classes are ignored. In this paper, we propose to handle long-tail classes in the training of a face recognition engine by augmenting their feature space under a center-based feature transfer framework. A Gaussian prior is assumed across all the head (regular) classes and the variance from regular classes are transferred to the long-tail class representation. This encourages the long-tail distribution to be similar to the regular distribution, while enriching and balancing the limited training data. Further, an alternating training regimen is proposed to simultaneously achieve less biased decision boundaries and a more discriminative representation. We conduct empirical studies that mimic long-tail datasets by limiting the number of samples and the proportion of long-tail classes on the MS-Celeb-1M dataset. We compare our method with baselines not designed to handle long-tail classes and also with state-of-the-art methods on the general face recognition benchmarks. Results on LFW, IJB-A and MS-Celeb-1M datasets demonstrate the effectiveness of our feature transfer approach and training strategy.

This work was supported in part by NEC Labs America.
BIOMEDICAL ENGINEERING

Poster Number: BME-01
Authors: David Filipovic; Sudin Bhattacharya
Title: PyPK: An Open-Source Cross-Platform Program for Physiologically-Based Pharmacokinetic (PBPK) Modeling

Abstract: Physiologically-based pharmacokinetic (PBPK) modeling is a mathematical modeling technique for investigating the disposition of chemical agents within the body. Over the last three decades PBPK modeling has emerged as a vital quantitative tool complementing in-vivo and in-vitro research studies in pharmacology and toxicology. It has been widely used for both basic research and regulatory purposes, especially within the field of risk assessment. However, the field of PBPK modeling still lacks a freely available cross-platform model construction and simulation program that can be used by educators, modelers and model evaluators alike without the need for specialized coding skills in a particular programming language. To address this gap, we have developed PyPK, a Python-based PBPK modeling program with an intuitive graphical user interface that allows ordinary differential equation-based model coding, simulation and output visualization, with additional modules for parameter sensitivity and uncertainty analysis, and population variability modeling. The program is freely available as a Python package that runs on Windows, macOS and Linux platforms to ensure usability and easy model exchange among academic and industrial scientists as well as regulators. It is also open-source and built to be extensible in order to support community-driven development. We expect that the extensibility and ease of use of PyPK will result in increased adoption of PBPK modeling. To illustrate the capabilities of PyPK, we have developed a PBPK model for 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) uptake in the mouse, and accumulation in the liver and fat compartments using this modeling tool.

This work was supported in part by MSU Superfund Grant  http://cit.msu.edu/superfund/

Poster Number: BME-02
Authors: Wenjie Qi; Sudin Bhattacharya
Title: Predictive Models of Aryl Hydrocarbon Receptor - DNA Binding

Abstract: The Aryl Hydrocarbon Receptor (AHR) is a ligand-inducible transcription factor that regulates genes involved in a variety of physiological functions. The AHR, together with the aryl hydrocarbon nuclear translocator (ARNT) protein, binds to specific DNA sequences called dioxin response elements (DRE) containing the core 5-nucleotide motif 5'-GCGTG-3' after being activated by the environmental pollutant 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) or other ligands. Because the flanking sequences adjacent to the core motif also play a role in binding activity, the AHR does not bind to every core DRE motif in the genome. Knowing the identity of valid AHR binding sites is necessary for assembling AHR-mediated transcriptional regulatory circuits. In this work, we predict valid AHR binding sites in B cells and hepatocytes via application of classification algorithms to the core and flanking sequences. First, a list of 19-bp sequences that contain both the DRE and its 7-bp upstream and downstream flanking nucleotides is generated, with known AHR binding sites treated as positives, and DRE motifs with random flanking sequences treated as negatives. We applied k-nearest neighbor (k-NN) classification to the sequences, obtaining 80% accuracy on the training data and 70% accuracy on the test data. In continuing work, we will apply more sophisticated classification models including boosted trees, support vector machines and neural networks for more precise prediction of AHR binding sites in B cells and hepatocytes, and test our predictions against AHR ChIP-seq data. Predicted AHR binding sites will then be used to assemble AHR transcriptional networks in both cell types.

Poster Number: BME-03
Authors: Joseph Salatino; Arya Kale; Stefanos Palestis; Matthew Drazin; Erin Purcell
Title: Alterations in Ion Channel Expression Surrounding Brain Implants

Abstract: Implanted devices capable of “reading-out” and “writing-in” brain signaling have created a renaissance in the study and treatment of neurological injuries and diseases. These technologies are becoming increasingly multi-functional and sophisticated, including electrical, chemical, and optical modes of interfacing with improved spatiotemporal resolution. However, poor biological integration remains a significant barrier to the longevity and stability of sensors and stimulators implanted in the brain. Recently, our laboratory showed that the expression of glutamatergic and GABAergic synaptic transporters are altered locally to the implanted interface, suggesting that changes in excitatory/inhibitory tone occur surrounding implants over time (Salatino 2017). Here, we report that shifts in voltage-gated sodium and potassium ion channel expression parallel our previous results, supporting the hypothesis that changes in local intrinsic excitability accompany chronic devices. Sixteen-channel microelectrode arrays (Neuronexus) were bilaterally implanted in M1 of adult male Sprague-Dawley rats for pre-determined time points (1d, 1wk, 6wks) with bi-weekly recording sessions. At terminal endpoints, subjects were sacrificed and brains were processed for immunohistochemistry, imaged, and analyzed as previously described (Salatino 2017). Results show a progressive elevation in potassium channel expression coupled with a reduction in sodium channel...
expression surrounding devices. These changes accompany loss of signal over the observed time course. Our results suggest an initial period of hyperexcitability surrounding devices followed by hypoexcitability at chronic time points. The findings reveal a novel mechanism underlying the instability and signal loss which typically occur with chronically implanted recording arrays, as well as a previously-unreported form of plasticity associated with brain implants.

This work was supported in part by National Institute of Neurological Disorders and Stroke (1R21NS094900 grant)

**Poster Number:** BME-04  
**Authors:** Monica Setien; Nathan Blanke; Kylie Smith; Cort Thompson; Wasif Afsari; Wen Li; Steve Suhr; Erin Purcell  
**Title:** Characterization of Light-Driven Reporter Genes for Spatial Patterning of Neuronal Circuitry

**Abstract:** Understanding brain function remains a grand challenge of our time. Likewise, when neurodegeneration occurs, repair efforts are limited due to the highly heterogeneous and interconnected nature of the cerebral cortex. Optogenetics, which was introduced in the past decade, allows cells to become light responsive by delivering photosensitive genes from other organisms. The use of light enables high spatial resolution of gene expression while allowing for multimodal control of expression. Here, we are exploring the use of a bacterial transcription factor (EL222) that allows for blue light-dependent transcriptional activation. In this study, we validated the use of EL222 for spatial patterning of fluorescent reporter genes (dsRED, YFP) in HEK293 cells. We assessed the spatiotemporal capabilities of the system in relation to blue light intensity and duration of exposure. Further, we coupled the EL222 system to proneural genes (NeuroD, Neurog) and observed successful light-induced expression. The data illustrate our progress towards the long-term goal of developing approaches for light-driven regeneration of neural circuitry.

This work was supported in part by We would like to thank the National Institutes of Health for providing funding for this research project (R03 NS095202-01).

**Poster Number:** BME-05  
**Authors:** Victoria Toomajian; Masamitsu Kanada; Christopher H. Contag  
**Title:** Artificially Derived Exosomes for Targeted Gene Delivery to Myocardial Infarcts

**Abstract:** Of the one million people who have myocardial infarctions (MI) each year in the United States, there is a 10% mortality rate, and those who survive may have substantial heart damage. MI treatment is time-critical and often cannot be delivered rapidly enough to prevent tissue damage, making treatments that repair damaged myocardium critical for full recovery. For this purpose, we investigated cell-derived nanovesicles (CDNs) as exosome mimics as a potential delivery tools for tissue repair strategies. Like exosomes, CDNs are naturally biocompatible and have natural targeting abilities, while having a greatly increased yield, making them scalable as a delivery tool. Others have shown that CDNs created from monocytes (mCDNs) target areas of inflammation. Post-MI, the heart is heavily inflamed, so mCDNs could act as a natural delivery vehicle for nucleic acid-based therapeutics post-MI. To investigate the potential of mCDNs for DNA delivery, monocytes were transfected with minicircles encoding firefly luciferase and tandem tomato fluorescent protein (fluc-TdT), mCDNs were created from these transfected monocytes by scraping cells off the substrate, which served to both increase mCDN yield and decrease the production time relative to exosome production. To test if mCDNs can functionally deliver minicircles, we will add the engineered mCDNs to target cells and demonstrate the expression of luciferase in the target cells by bioluminescence imaging. Efficient functional transfer of minicircle-fluc-TdT to target cells would suggest that mCDNs may be able to deliver therapeutic genes to target cells in vivo, making mCDNs a delivery vehicle with potential relevance to treat MI.
Poster Number: BME-06  
Authors: Bailey Winter; Joseph Salatino; Steve Suhr; Erin Purcell  
Title: Optimization of the Direct Conversion of Astrocytes into Functional Neurons using Ascl1 and Dlx2  

Abstract: Implanted microelectrode arrays have shown great promise as tools to study neural activity and as a treatment for neurodegenerative diseases; however, the long term efficacy of these devices is impeded by the reactive tissue response. Glial encapsulation and neuronal loss around the device are accompanied by reduced signal quality and inconsistent stimulation thresholds. Increasing the neuronal population at the interfacial region could restore device performance, improving device lifetime. Here, rat primary cortical astrocytes were infected in vitro with varied concentrations of either Ascl1, Dlx2, or a combination of both transcription factors in two distinct media formulations (N2 and Neurobasal). Whole-cell patch clamp recordings and immunocytochemistry were performed six to twenty-five days post-infection to assess the electrical activity and morphological identity of the infected cells. Antibodies for glial fibrillary acidic protein and beta 3 tubulin were chosen to identify astrocytes and induced neurons respectively. In parallel we have been developing methods to implement cellular conversion in vivo. Ultimately, we aim to assess the effects of transcription factor concentration and combination, as well as culture conditions on conversion efficacy for future in vivo use.

This work was supported in part by Department of Biomedical Engineering and Department of Electrical Engineering
**Title:** A Systematic Approach in Feedstock Development for Anaerobic Co-digestion

**Abstract:** Anaerobic digestion of biosolids is a widely used process for waste stabilization and biogas production that can be used for energy recovery. Digesting biosolids alone results in a stable process but does not produce biogas at the level supported by the available nutrients and buffering capacity. Co-digestion of biosolids with food waste or food processing wastewater, when correctly selected, has the potential to substantially increase energy production. Selecting the substrates for co-digestion involves identifying the waste biomass sources, quantifying the energy potential, and studying their synergistic or inhibitory effect during co-digestion. This study presents a systematic approach that combined two decision making tools with laboratory studies to select waste biomass sources for co-digestion. Specifically, this case study was conducted at the Detroit Water Resource Recovery Facility (WRRF), managed by the Great Lakes Water Authority. First, the Michigan Waste Biomass Inventory (MI BioMass) was used to identify potential waste biomass sources around the WRRF. Next, the Anaerobic Digestion Development Iterative Tool (ADDIT) was used to pre-screen the sources. Based on the results from applying ADDIT, samples were collected from the waste biomass sources that showed the greatest potential and analyzed for basic characteristics such as pH, alkalinity, total solids, volatile solids, nitrogen, phosphorus, chemical oxygen demand, and total ammonia. These values were entered into the ADDIT tool for further screening. Finally, a biochemical methane potential (BMP) assay was conducted by blending biosolids with selected waste biomass at different proportions to identify the best blend for anaerobic digestion. The process described above can be applied as a systematic approach for anaerobic digestion feedstock development for enhanced biogas production.

*This work was supported in part by Great Lakes Water Authority*

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**Title:** Estimating Salmonella Inactivation Kinetics for High Temperature, Short-Time Experiments that do not Reach Isothermal Temperatures

**Abstract:** Isothermal experiments are commonly used to estimate Salmonella inactivation kinetics in foods. In these experiments, time required for samples to reach the processing temperature is often relatively short as compared to the time of the experiment. Temperatures used in the experiments usually fall below those of a typical processing environment, and therefore, extrapolation of the inactivation kinetics must be used to estimate inactivation in a commercial process. A more accurate method could be to use the actual, higher processing temperature in laboratory-scale experiments. However, Salmonella may be rapidly inactivated, even in low-moisture products, before isothermal state is reached within testing cells. The goal of this study was to determine Salmonella inactivation kinetics for high temperature, short-time experiments using inoculated seasoning. This study aimed to estimate a single set of inactivation kinetics, suitable for all time-temperature combinations. The thermal distribution inside the test cell for each temperature condition was simulated based on one-dimensional transient conduction, with constant convection. Microbial inactivation data from a previously published study were then used to estimate thermal inactivation parameters for the Weibull model (β, n and z) by using a mass average Salmonella concentration integration over the volume of the test cell. This approach showed that the Weibull model parameter n=1, and did not increase with temperature, contrary to that reported in the original study where the experiments were assumed to be isothermal. This result shows that the microbial inactivation was log-linear, and inactivation can be described with a single D- and z-value for all process conditions.
Abstract: Antimicrobial resistance (AMR) is a looming global concern and the associated genes are now considered emerging hazards because of their ability to proliferate antibiotic resistance. Understanding how horizontal gene transfer (HGT) occurs under fluid system conditions is a powerful step in determining how AMR is spread in the environment, animals and humans. Traditional pathogen dose-response models do not consider the potential body burden of AMR strains, which is the result of replication and gene transfer. There is a lack of information about HGT within dynamic systems like the animal and human gut as most studies are done under static conditions. In this study, in vitro experiments were conducted to quantify how different fluid parameters impact AMR transmission through HGT. E. coli was selected as it represents one of the most common commensal bacteria in human and animal intestine, as well as a common bacteria in environment. Parameters investigated are time, nutrient concentration, donor-recipient ratio, viscosity, and mixing rate. These factors depict the digestion process, diet, and the amount of resistant and susceptible bacteria ingested. Preliminary results showed a clear correlation between HGT levels and these parameters, highlighting the need for researchers to refine their model for better estimating development of AMR in environment, animals and humans.

This work was supported in part by Center for Health Impacts of Agriculture (CHIA), MSU

Poster Number: BAE-04
Authors: Younsuk Dong; Steven Safferman
Title: Simulation of Domestic Wastewater Land Application using Hydrus CW2D

Abstract: Domestic wastewater land application has been used for many years because of its low cost, energy use, and maintenance requirements, compared to a conventional wastewater treatment system. More than 60 million people in the United States depend on an individual onsite system or small community cluster system to treat their wastewater. The performance of treatment depends on the hydraulic and organic wastewater loadings, soil characteristics, and soil conditions. Currently, the design is based on empirical relationships, which do not account adequately for site- and waste-specific condition. Understanding the complexity of soil is important. The aerobic or anaerobic condition of the soil may result in nitrate leaching and metal mobilization into groundwater, respectively. In order to understand this mechanism, a numerical model was used to simulate the complex land application of wastewater treatment systems. Hydrus Constructed Wetland 2D (Hydrus CW2D), a finite element model, was selected for simulating the movement of water and multiple solutes in soil. This model was originally designed to simulate wastewater treatment in wetlands, but was also used in this research for wastewater land application. This modeling approach may provide minimum depth requirements for carbon degradation and allow for the optimization of operation parameters such as hydraulic and organic loading and dosing frequency to achieve conversion of nitrate to nitrogen gas.

Poster Number: BAE-05
Authors: Ian Hildebrandt; Bradley Marks
Title: Quantification of Statistical Power for Surrogate-Based Lethality Validation Studies

Abstract: Pathogen surrogates are commonly used to validate preventative controls. Identification of a surrogate is critical for surrogate-based validations, but the ultimate goal is to evaluate the efficacy of the preventative control. However, little has been reported on best methods for data interpretation in process validation studies. The goal was to quantify the impact of experimental design on the potential for a surrogate-based validation study to discriminate between effective and ineffective preventative controls. Multiple sampling plans were evaluated for the likelihood (statistical power) of correctly reporting effective or non-effective preventative controls. Using a Monte Carlo-based Bayesian approach, treatment samples were randomly generated and tested (using confidence and prediction intervals, α=0.05) to determine if target lethality was achieved, repeating this process 1,000 times. The percentage of results correctly classifying treatment effectiveness approximated the statistical power of the plan. Variables included the sampling design (≥3 samples before/after treatment, ≥2 replications), sampling error, achievable lethality, and replication error. With true mean lethality ≤ target lethality, all sampling plans achieved ≥99% likelihood of correctly indicating an ineffective treatment. Using the minimal sampling design on a barely-effective treatment, only 66% of the experiments indicated the treatment as effective, collecting 10 samples pre- and post-treatment with 5 replications increased this probability to 88%. Statistical power of sampling designs depended on preventative control effectiveness; largely effective or ineffective treatments required fewer samples than borderline effective treatments. The prediction interval was the most sensitive metric to evaluate treatment.

This work was supported in part by USDA NIFA AFRI CAP grant award # 2015-68003-23415
Abstract: Plant uptake and metabolism of emerging organic contaminants, such as personal care products, poses potential risks to human health. In this study, Jalapeno pepper plants were grown in hydroponic media containing both 14C-labeled and non-labeled triclocarban (TCC) in order to investigate the accumulation, distribution and metabolism of TCC following plant uptake. Results revealed that TCC was detected in all plant tissues, following the order of roots > stems > leaves > fruits in long-term exposure. After 12 weeks, TCC concentrations in these tissues were 19.7±2.0, 0.26±0.04, 0.11±0.002 and 0.04±0.007 µg/g dw, respectively. More importantly, a substantial portion of TCC taken up by plants was metabolized, especially in the stems, leaves and fruits. Hydroxylated TCC (e.g. 2'-OH TCC and 6-OH TCC) and glycosylated OH-TCC were found to be the main phase I and phase II metabolites in plant tissues, respectively. At the conclusion of this study, bound residues accounted for approximately 44.6, 85.6, 69.0 and 52.5% of all TCC species accumulated in roots, stems, leaves and fruits, respectively. Consequently, human exposure to TCC through consumption of pepper fruits is expected to be substantially higher when accounting for phytometabolism.

This work was supported in part by 1. National Institute of Food and Agriculture (NIFA) within the United States Department of Agriculture (USDA). 2. National Science Foundation (NSF).

Abstract: Green building design incorporates several measures intended to conserve resources, however these practices have the potential to negatively affect the water quality in distribution networks. Green building design often incorporates the use of low flow fixtures, energy efficient water heaters, and dual water systems to reduce the quantity of water consumed. Oversized piping networks in combination with reduced water consumption increases residence time and promotes pathogen growth inorganic contamination. Water heaters that employ recirculation techniques and operate at lower temperatures further exacerbate the decline in water quality. Dual water systems, such as rainwater collection, can possibly introduce additional water quality risks. However, the extent to which water quantity consumed impacts water quality is uncertain. This study conducted a survey of students, citizens, academics, and industry professionals that further indicated that water quality in green buildings is a pressing issue for commercial buildings, hospitals, and residences. The preliminary water sampling results from a pilot-study residence that employs many green building design techniques, yielded results that confirmed these concerns. Legionella, Pseudomonas aeruginosa, and Mycobacterium avium were all detected in the pilot home using QPCR. Pathogen growth while using municipal water was shown to be highest inside the energy efficient water heater and in the fixtures that were used least often. Higher concentrations of pathogens were found in each sampling location tested when rainwater was supplied to the building. These results confirm the need for greater study into the unintended consequences of green building design.

Abstract: Computer imaging with uniform, diffuse illumination is now widely used for automated detection of surface defects of apples; however, its performance is still short of meeting the industry’s expectations due to complex morphological and physiological characteristics, and a large variety of defects. Structured-illumination reflectance imaging (SIRI) offers a new modality for fruit defect detection. The technique, which uses sinusoidally-modulated structured illumination (SI) for sample imaging, is able to obtain two sets of images, i.e., direct component (DC) and amplitude component (AC). DC images, corresponding to those acquired under conventional uniform illumination, are useful for detecting many types of surface defects, while AC images, due to SI, are more effective for detecting subsurface defect and certain types of surface defect. The objective of this study is to demonstrate the potential of SIRI for detecting defects on apples by using AC, DC and their combinations. Images are acquired from ‘Delicious’ and ‘Golden Delicious’ apples, inflicted with various types of surface and subsurface defects, by using a specially assembled multispectral SIRI system under the illumination of two phase-shifted sinusoidal patterns. The acquired images are demodulated into DC and AC, which are then subjected to bi-dimensional empirical mode decomposition (BEMD) and selective reconstruction for image enhancement. Defect detection is performed on the enhanced images using three machine learning algorithms, i.e., random forest, support vector machine, and convolutional neural network. This study shows the capability of SIRI for enhanced defect detection of apples by combining DC and AC images, rather than using them individually.
Abstract: Anaerobic digestion is a biological process, bound to the biokinetics concepts. Efforts have been made in order to improve the biogas productivity focusing in improve the energy conversion of the microbes. In addition, is possible to improve the energy productivity by reducing the parasitic energy load. Mixing is generally cited as the largest contributor to the parasitic energy load of the power consumption. In order to reduce the parasitic load mixing energy input must be reduced. To reduce mixer load, it is necessary to understand the hydrodynamic and thermodynamic state of the substrate that is being mixed in the anaerobic digester. To better understand the biological and physical interaction of mixing, a series of experiments has been designed to evaluation traditional and innovative mixing approaches. The experiments aim to collect and compare the digestion performance and the hydrodynamics data of traditional pump mix systems and the PWM400® mixer develop by PAX Water Technologies, this unit is low electricity input mixer. In order to obtain a novel evaluation of the system, three different tracer mixing experiments were performed to obtain a mix of results: Lilly impeller in water, Lilly impeller in manure, centrifugal pump in manure. The mixing systems were introduced in a reactor built and instrumented to obtain hydrodynamics data as same as take samples for biological samples. The anaerobic digester used in the experiments was a 20 m3, cylindrical vessel, thermally insulated and instrumented specifically for this studies. Variables like electrical conductivity, temperature, and electrical current consumption were monitored.

This work was supported in part by Environmental Protection Agency

Poster Number: BAE-10
Authors: Rachael Sak; Sabyasachi Das; Chris Saffron
Title: Life Cycle Analysis of Decentralized Electrolysis for Upgrading Bio-Oil to Make Liquid Fuel

Abstract: Looking to a future of expanded biofuel market availability, it is necessary to fully understand the inputs to and outputs from any proposed system involving biomass cultivation, harvest, hauling, conversion, and end use. Life cycle assessment (LCA) is an analysis tool that can highlight system components for improvement in terms of environmental impacts. For the purposes of this LCA, attributional modelling is being applied for analysis of the cradle-to-gate-to-gate development of bio-oil from second generation biomass sources, such as hybrid poplar. The system being evaluated involves regional cultivation and the building of local pyrolysis facilities that will not only produce bio-oil but will, prior to shipping to a refinery, further upgrade and stabilize the bio-oil using electrowal catalysis powered using renewable electricity. The facility design coupled with low input cultivation and the return of biochar to the fields, is able to overcome impacts as significant as direct and indirect land use change in a reasonably short time frame, results that are worth considering when forming value propositions for plant biomass.

Poster Number: BAE-11
Authors: Jason Smith; Steve Saferman
Title: Characterization of Soil Macroporosity Using Image Analysis

Abstract: Farm fields have been named by several studies as contributors to recent high profile surface water impacts caused, in part, by Phosphorus (P) runoff. As non-point runoff from farm fields has been reduced, the assumption is that P is leaching through the soil, to tile drains, and then to surface water. This has led to discussions on more stringent winter manure management guidelines and limiting nutrient application rates, potentially resulting in lower crop yields. One of the key features of farm fields that has been shown to facilitate accelerated loss of soluble P to local waterbodies is the presence of preferential flow paths in the form of soil fractures or macropores. However, the ability to quantify macropore structures in such a way that makes it possible to differentiate macroporosity as a function of soil types or field cropping systems is poorly refined. In an effort to advance this understanding, the researchers are adopted and modified a dye tracer study popularized by Cey & Rudolph. Dyes were applied in contained areas to fields that were representative to those across Michigan to investigate the effect of till/no-till practices as well as soil horizons on macropore formation. Sites subjected to dye were excavated and analyzed for depth & bulk density of macropores using MATLAB based imaging technologies. The image analysis protocol was subsequently used to differentiate the extent to which macropore presence is seen at depth in fields with variable soil type and tillage practices.

This work was supported in part by Michigan Soybean Growers Association; Michigan Corn Growers Association; Michigan Wheat Growers Association
**Poster Number:** BAE-12  
**Authors:** Vinni Thekkudan Novi; Shan Shan; Evangelyn Alocilja  
**Title:** Antimicrobial Activity of Treated Chitosan-PVA Films in Drug Resistant Bacteria

**Abstract:** Around 2 million antibiotic resistant bacterial infections occur annually in the United States, out of which almost 23,000 deaths are recorded and about 19,000 of them are considered to be due to methicillin-resistant Staphylococcus aureus (MRSA) infections. Multidrug resistant Salmonella Typhimurium is another pathogen that caused a disease outbreak in the US through contaminated milk. It is estimated that drug resistant Salmonella strains has been a cause of around 6,200 cases of infection in the country annually. These pathogens can spread through contaminated water, food and human skin. The limited number of drugs available to treat such infections make it necessary to identify novel methods to prevent and fight them. This study focusses on developing antimicrobial films that can kill these pathogens. The films were synthesized by mixing chitosan, a natural biodegradable polymer having antimicrobial properties, with polyvinyl alcohol (PVA) in different compositions. Preliminary data showed that the films can kill 107 colony forming units (CFU) of S. aureus and drug resistant Salmonella Typhimurium strains in about half an hour with almost 100% efficiency. Additional studies on MRSA are currently underway. The film can be used in wound dressing materials to prevent injuries from getting exposed to antibiotic resistant bacterial contaminations.

*This work was supported in part by This study was funded by The Axia Institute, Michigan State University.*

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**Poster Number:** BAE-13  
**Authors:** Zhongyu Zhang; Christopher Saffron  
**Title:** Investigation of Pyrolysis Reaction Pathways Using Arabidopsis Thaliana Cells

**Abstract:** Even though biomass fast pyrolysis provides a widely-known route to renewable liquid fuels, the reaction network from reactants to products is not well defined. Prior research has explored single substances such as cellulose or glucose, alone or in simple mixtures, to trace the flux of reactant to product. However, raw lignocellulosic biomass is a much more complex mixture, leading to interactions amongst cellulose, hemicellulose, and lignin that alter the distribution of pyrolysis products. To develop an advanced understanding of the pyrolysis reaction network, isotopically labeled Arabidopsis thaliana cells are used as surrogate substrates. A. thaliana cells (referred to as T87 cells), are transferred from callus culture to liquid media and then heterotrophically grown to form differentiated cells that have secondary cell walls. The differentiated T87 cells have similar cell wall compositions, including both primary and secondary cell walls, as the xylem tissue in mature plants. Pyrograms obtained from pyroprobe-gas chromatography/mass spectrometry (py-GC/MS) of A. thaliana stem cuttings, T87 cells, and neat glucose reveal that the T87 cells respond to rapid heat treatment more like the stem cuttings than like glucose. Moreover, T87 cells can potentially be preferentially labeled, such that either the carbohydrate or lignin cell wall fractions can be enriched in 13C. In this regard, chemical characterization of A. thaliana cells will be presented and a methodology for incorporating isotopic labels into A. thaliana suspension culture using 13C glucose or phenylalanine will be described.

*This work was supported in part by National Science Foundation*
Chemical Engineering

Poster Number: CHE-01
Authors: Harshal M. Bambhania; Dr. John R. Dorgan
Title: Amorphous Poly(lactide) Polymers

Abstract: Polylactide (PLA) is a biodegradable and compostable thermoplastic aliphatic polyester produced from the annually renewable resources with a potential to replace petroleum-based polymeric materials. High molecular weight PLA is generally produced via ring opening polymerization of cyclic lactide which has two chiral carbon atoms. Type, degree of stereoregularity, molecular weight, copolymer composition and functionalities of PLA can have a significant impact on the mechanical properties like tensile strength, tensile modulus and percent elongation to break. Physical properties of the polymer including glass transition temperature (Tg), melting temperature (Tm), polymer flexibility and polymer lifetime can also be altered via structural modification of PLA. There is a significant processing benefit to lower temperatures including lower rates of hydrolytic degradation, oxidative degradation, lactide reformation, crystallization and better viscosity characteristics. Modulation of PLA stereochemistry can be used to fabricate amorphous polymers which exhibits lower Tg and hence faster biodegradation rate as compared to the crystalline PLA. Gel permeation chromatography (GPC), small-angle X-ray scattering (SAXS), X-ray diffraction (XRD), optical microscopy and differential scanning calorimetry (DSC) can be used to deduce the molecular weight, microstructure development, degree of crystallinity, crystallization behavior, microstructure, and thermal properties for the copolymers of PLA.

Poster Number: CHE-02
Authors: Sayli Bote; Alper Kiziltas; Deborah Mielewski; Ramani Narayan
Title: Bio-Based Polyurethane Flexible Foams for Automotive Applications

Abstract: Recently, biobased resources are being used in commercial products. For example, Braskem's polyethylene, Coca Cola's bio-polyethylene terephthalate, NatureWorks poly (lactic acid), and Ford Motor Company's polyurethanes. Bio-based products offer a closed loop and managed end-of-life solution. In this work, bio-based polyols (~47% renewable carbon content) were synthesized at Michigan State University. These polyols were used at Ford Motor Company with commercial petroleum-based polyols for making flexible polyurethane foams. It was observed that the mechanical properties of foams i.e. compression strength, tensile strength and tear strength increases with increasing bio-based polyol content. Compression set increases with increasing bio-based polyol content which could be due to presence of ester linkages. Ester linkages are hygroscopic in nature due to which they absorb moisture. The bio-based polyols are miscible with petroleum-based polyol and the flexible foams made using them are thermally stable. Thus, these flexible foams can be used in automotive applications e.g. engine cover applications or car seating applications.

This work was supported in part by Funding received through Ford Motor Company.

Poster Number: CHE-03
Authors: Aritra Chakraborty; Philip Eisenlohr; Pratheek Shanthraj
Title: Causes of Whisker Growth in Tin Thin Films Studied by Advanced Multi-Physics Simulations

Abstract: Tin whiskers pose a serious concern to device reliability in the electronics industry as they nucleate in unpredictable locations, can grow to a length of several millimeters, and are able to short-circuit different parts of the electronic assembly. Whiskers are believed to be formed by stress-driven diffusion of Sn atoms, where the stress is spatially variable due to the lattice anisotropy of β-Sn, resulting in spatially heterogeneous chemical potential. In this study, we perform a three-dimensional, full-field, chemomechanically coupled simulation of crystal plasticity deformation under a compressive stress due to thermal expansion mismatch to understand the overall dynamics in tin thin films and how those might be linked to whisker nucleation sites; investigate the influence of initial texture on stress evolution; and the effect of plastic anisotropy on the stress relaxation that also governs the overall mass transport.
**Poster Number:** CHE-04  
**Authors:** Kanchan Chavan; Scott Calabrese Barton  
**Title:** Modeling Study of Nano-Scaled Molecular Tunnels with Electrostatic Interaction

**Abstract:** Multi-step reaction can be carried out efficiently using integrated catalytic system for the manufacture of advanced materials, energy conversion and harvesting, and human-machine interfaces. Nature has shown effective way to carry out multi-step reaction through substrate channeling.1 Molecular tunneling2 and electrostatic guidance3 mechanisms of substrate channeling has been studied extensively in literature and has proven their potential for efficient substrate channeling with the minimum intermediate diffusional loss. Molecular tunneling restricts intermediate diffusion through tunnel wall between active sites, whereas, electrostatic guidance restricts intermediate through surface interaction. Incorporating these two mechanisms into multi-step reaction system can lead to innovative integrated catalytic system. In this work, continuum modeling has been performed on geometry consist of tunnel and two active sites confined within. Tunnel surface is oppositely charged as of intermediate to introduce electrostatic interaction. System is governed by diffusion and migration as well as reaction kinetics. Effect of reaction kinetics and transport has been studied and defined as Damköhler number. Effect of geometrical parameter on channeling efficiency is quantified by product yield. Minimizing intermediate access to the bulk and increasing driving force for the intermediate to transport to active site is required for efficient channeling.

**References:**

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**Poster Number:** CHE-05  
**Authors:** Qian Chen; Wei Lai  
**Title:** Structural and Electronic Study of P2 Na2/3[Ni1/3Ti2/3]O2 as Bi-Functional Electrode Materials

**Abstract:** With increasing research interests in sodium-ion batteries as a viable alternative energy storage technology based on the huge material abundance and low price, Na-ion insertion materials have been substantially investigated as potential electrode materials for sodium-ion batteries. The P2-type Na2/3[Ni1/3Ti2/3]O2 was identified as a promising bi-functional electrode material due to the coexistence of high redox potential for Ni and low redox potential for Ti and has shown good electrochemical performance as either anodes or cathodes. In this work, the structural and electronic properties of P2 Na2/3[Ni1/3Ti2/3]O2 were studied through density functional theory based first principle simulations. By virtually inserting or extraction sodium atoms from the structure, the lattice change of of P2 Na2/3[Ni1/3Ti2/3]O2 upon charge and discharge was calculated. The atomic charge, the chemical bonding and electronic structure were also studied to understand the chemistry of sodium intercalation and deintercalation in of the material.

**Poster Number:** CHE-06  
**Authors:** Sabyasachi Das; Christopher M. Saffron  
**Title:** Kinetic Parameter Estimation for Electrocatalytic Hydrogenation of Representative Pyrolysis Bio-oil compounds

**Abstract:** Electrocatalytic Hydrogenation of bio-oil derived from pyrolysis of biomass can serve as an integral part of the localized upgrading approach for producing gasoline-like biofuels. In this regard, electrocatalytic hydrogenation has been performed on representative bio-oil compounds at moderate temperatures and atmospheric pressures using electro-catalysts like Ru/ACC. A kinetic model has been developed to estimate the kinetic rate constants for the electrochemical and catalytic surface reactions for the electrocatalytic hydrogenation of a representative bio-oil compound, guaiacol on Ru/ACC cathode. The developed model includes equations to characterize all phenomena occurring in the electrochemical cell such as species bulk diffusion, electrical migration, adsorption and catalytic surface reactions occurring at the cathode. Bulk concentration vs time data were collected and fit into this model to estimate the reaction rate constants by means of non-linear sequential parameter estimation in Matlab. The next step is to perform the same analysis for other representative bio-oil compounds to be able to better characterize the electrocatalytic hydrogenation of bio-oil. This will lead to a better understanding of the process and serve as a crucial step towards scale-up of electrocatalytic hydrogenation as a keystone of novel pyrolysis-based bioenergy systems.
Abstract: Perfluoroalkyl substances (PFAS) are man-made fluorinated chemicals that have been released into the Earth’s environment. These compounds do not degrade naturally, are toxic to humans and animals, and are extremely difficult to remediate. There are over 13 of these compounds with varying carbon chain lengths found in nature; the 8 chain perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) are most prevalent. Current replacements for these compounds are the shorter carbon chain PFAS, perfluorobutane sulfonate (PFBS) and perfluorobutanoic acid (PFBA). Initial studies in literature show that electrochemical oxidation using boron doped diamond electrodes (BDD) is a successful technique used to degrade these compounds in wastewater samples. This study aims to show the role that current density plays in degrading the two most prevalent compounds and their replacements, both individually and in mixtures, using a BDD electrode stack. The stack comprises of two anodes and three cathodes, all of which are BDD double-side coated on niobium (Nb). The stack is placed into a constantly stirred batch reactor. These initial studies are analyzed with a fluoride ion selective electrode (ISE); temperature and pH are also monitored. Optimum electrochemical conditions will then be used to degrade varying initial concentrations of these compounds with subsequent analysis using liquid chromatography mass spectrometry (LC-MS) to determine reaction intermediates. Knowledge gained from these experiments can then be applied to real water samples polluted with PFAS.

This work was supported in part by Ford-MSU Alliance Program

Abstract: The goal of this project is to develop biobased long fiber-reinforced thermoplastic (LFT) composites for targeted automotive components, based on polylactide (PLA) resin, as well as modified PLA that can contribute to enhanced performance and address the well-known issues of melt strength, toughness, and low softening temperature. We have established that biobased cellulosic fibers such as viscose and rayon have key mechanical properties that allow them to function effectively as reinforcing fibers, especially for ductility and toughness. Composites based on these reinforcing fibers will be produced using the LFT technology. Apart from cellulosic fibers, conventionally used biobased fibers such as flax, hemp, and jute will be used to create a portfolio of novel biobased composites to replace currently used automotive interior parts. In conclusion, the proposed project aims to replace currently used automotive interior parts with a new generation of biobased long-fiber thermoplastics, using a polylactide matrix. The feasibility of the proposed processing method has been established using glass fiber as the reinforcing agent. The process is now being adapted to incorporate biobased fibers such as viscose, flax, hemp and jute. The properties of these novel composites are to be evaluated and mapped against the composites that are currently used to find an ideal substitute.

This work was supported in part by Ford-MSU Alliance Program

Abstract: The nonlinear viscoelastic behavior of polypropylene nanocomposite melts under large amplitude oscillatory shear flow (LAOS), was investigated using Fourier transform (FT) rheology. In general, three types of interactions occur in nanocomposites: entanglements between unattached polymer chains, entanglements of particle-attached chains with free chains, and particle-particle bridging (i.e. filler network). A nonlinear viscoelastic model has been developed in this work that accounts for different types of chain entanglements but neglects the filler network for sufficiently low filler loading. Polypropylene-clay nanocomposites were produced using concentrations of 3 and 5 wt% of silane treated nanoclay to ensure that among contributions from the three types of interactions, the filler-network contribution was negligible. To promote particle-polymer interactions, the silane treated clay was reacted with a maleated polypropylene compatibilizer. The intensity ratio I3/I1 of the third order harmonic to the first order harmonic of the shear stress as well as the zero-strain limit nonlinearity parameter Q0 were determined as a function of frequency through FT rheology experiments. The observed trends in nonlinear rheology under LAOS were then compared to results from the nonlinear viscoelastic model developed by Hershey and Jayaraman (2018).
**Poster Number:** CHE-10  
**Authors:** William G. Killian; Aseel M. Bala; Lars Peereboom, James E. Jackson; Carl T. Lira  
**Title:** Simulation- and Spectroscopy-Guided Modelling of Associating Systems

**Abstract:** Spectroscopic and quantum calculations provide valuable insight to quantify the effects of hydrogen bonding. Hydrogen bonding molecules form aggregates whose sizes are highly temperature and concentration dependent. Process models that incorporate hydrogen bonding phenomena exhibit dramatic improvement of quantitative modeling of vapor-liquid equilibrium (VLE) and liquid-liquid equilibrium (LLE), and such accuracy is efficient design of industrial separations. Spectroscopy, namely infrared (IR) and nuclear magnetic resonance (NMR), provide insight into the presence of associated species. However, accurate interpretation of instrumental data has remained elusive. This work leverages molecular dynamics simulations and quantum mechanics to guide the interpretation of spectral data, leading to more accurate quantification. From this, parameters essential for thermodynamic process modelling are extracted and used to predict the effects of association on bulk fluid mixture properties. Examples are shown for alcohols.

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**Poster Number:** CHE-11  
**Authors:** Lisaura Maldonado-Pereira; Matthew D. Schweiss; Ilce G. Medina-Meza PhD  
**Title:** Cholesterol Oxidation Products Profile in North American Diet

**Abstract:** Formation of cholesterol oxidation products (COPs) in food is promoted by several factors. The most important triggers are: 1) ingredients and food formulation, 2) food processing and meal preparation, and 3) food handling, packaging and storage conditions. COPs accumulation in several tissues and organs due to the frequent consumption of COPs-containing foods has been associated to chronic diseases, such as cancer, atherosclerosis, and several neurological diseases such as Parkinson and Alzheimer. Several in vitro studies have demonstrated that COPs exert their cytotoxic activity at low concentrations (as low as 25 nM), whereas pathological responses seem to be compound-specific. Because of the widespread consumption of processed foods in the U.S., the application of exposure-based methods for addressing health risks associated with unavoidable process-formed ingredients is critical. The aim of this research is to evaluate the formation of COPs in the most consumed food products in the US. We applied different omics techniques such as lipidomics, cholesterolomics and processomics to address the influence of different cooking conditions (roasting, boiling, baking, pan cooking and microwaving) in the formation pathways. Major pathways of formation were assessed and their oxidation products in positions C-7, C-25. Results from this study may be helpful for the analysis of other processed food products to elucidate the processing parameters that most significantly influence the formation of COPs.

**Poster Number:** CHE-12  
**Authors:** Angélica V. Medina-Cucurella; Timothy A. Whitehead  
**Title:** Pro Region Engineering of NGF by Deep Mutational Scanning Enables a Yeast Platform for Conformational Epitope Mapping of Anti-NGF Monoclonal Antibodies

**Abstract:** Neurotrophins are a large family of proteins that regulate the development, function, and survival of neurons in the peripheral and central nervous system. These proteins are associated with several diseases including neurodegenerative disorders. For example, nerve growth factor (NGF) has been found as a mediator of multiple chronic pain conditions. Thus, potential anti-NGF monoclonal antibodies (mAbs) have been developed to function as antagonists of NGF by blocking the downstream signaling pathway. However, a major limitation is the recombinant expression of NGF in an active conformation recognizable by mAbs. Here we present deep sequencing driven methods to develop a yeast display platform to increase the production of folded displayed NGF. We evaluated the function of 1,737 single point mutants and found over 49 variants that significantly improve the folding activity after two rounds of high throughput screening. When three different enhancing mutations were combined, the amount of folded NGF increased by 23-fold, allowing us to find conformational epitopes for those mAbs. Finally, we validated this platform by showing that our experimentally determined tanezumab epitope (a humanized mAb) largely overlapped with the previously solved tanezumab- mouse NGF structure.

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**Poster Number:** CHE-13  
**Authors:** Alex Mirabal; Dr. Scott Calabrese Barton  
**Title:** Scanning Electrochemical Microscopy of Nanoscale Enzyme Spots in Conductive Hydrogels

**Abstract:** Natural enzymatic cycles have evolved to efficiently react a substrate at multiple sites in sequence due to efficient transport of the intermediates between sites, preventing side reactions and loss of intermediates to the bulk. Nanoscale (~10 nm) mechanisms of transport have been found in literature [1]. The increased concentration surrounding subsequent active sites due to these transport mechanisms can help overcome unfavorable thermodynamics. 

The engineering of cascades of catalyst can mimic these mechanisms in order to minimize intermediate diffusion to the bulk, reducing exposure to competitive side reactions and prevent exposure of harmful intermediates to the bulk. Quantitative descriptions of nanoscale transport via intermediates in solution can be achieved by scanning electrochemical microscopy [2], which allows for in-situ analysis of kinetic systems. Electrochemical detection of sub-micron platinum nanoparticles have recently become possible [2], however, detection of enzymatic systems remains elusive due to the decreased kinetic activity, with a single documentation of nanometer resolution involving enzymes [3]. The enhanced resolution is partially due to physically defining “caves” allowing for enhanced topographical and electrochemical signals. 

Glucose Oxidase is a highly active enzyme that undergoes an electrochemically active reaction that can be probed with redox couples, such as ferricyanide [7], and generation-consumption reaction detection such as peroxide formation [4-6]. Detection of enzymatic spots on a flat HOPG surface in a redox active hydrogel thin film shows the nanoscale detection of enzyme substrates with no topographically enhanced resolution provides a strong indication of the transport away from enzymatic species for kinetic analysis of the enzymes and transport of the product species as a step towards analysis of enzymatic cascades.

*This work was supported in part by Army Research Office*

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**Poster Number:** CHE-14  
**Authors:** Amrita Oak; Christina Chan  
**Title:** Novel Role of Transmembrane Domain of IRE1alpha Protein During Activation and its Implications in Progression of Cancer

**Abstract:** The endoplasmic reticulum (ER) is the site for protein synthesis, folding and maturation. The unfolded protein response (UPR) is activated in response to a disruption of ER homeostasis. IRE1α is a transmembrane serine-threonine protein kinase/endoribonuclease and one of the ER stress sensor proteins that is activated during the UPR. Its failure to correct ER stress is implicated in the pathology of many diseases.

Palmitate (PA) activates the UPR in various cell types. An increase in free fatty acid levels is observed in various cancers (e.g. hepatocellular carcinoma) and the altered fatty acid metabolism is required to sustain tumor cells. The established method of activation of IRE1α is through dimerization mediated through its luminal domain. However, the mechanism by which PA activates IRE1α is unclear. 

We hypothesize that PA activates IRE1α through a non-canonical luminal-domain independent mechanism. Each amino acid in the transmembrane domain was mutated to alanine to observe the effect on dimerization. A bimolecular fluorescence (BiFC) assay was used to probe the importance of these residues in dimerization and activation of IRE1α. We confirmed that palmitate induces the dimerization of the transmembrane domain of IRE1α to activate IRE1α. We also identified a W457 residue in the transmembrane domain of IRE1α that forms a part of the dimer interface on IRE1α. Elucidating the mechanism by which fatty acids alter tumor cell metabolism will lead to a deeper insight into developing ways to hinder cancer progression.

*This work was supported in part by NSF, NIH*
**Poster Number:** CHE-15  
**Authors:** Thanaphong Phongpreecha; Jason D. Nicholas; Thomas R. Bieler; Yue Qi  
**Title:** Computational Design of Metal Oxides to Enhance the Wetting and Adhesion of Silver-based Brazes on Yttria-Stabilized-Zirconia

**Abstract:** Ag-CuO is a broadly used reactive air brazing (RAB) system for effectively bonding ceramics and metal interfaces, especially for sealing yttria stabilized zirconia (YSZ) to metals in solid-oxide fuel cells (SOFCs). To understand the superior performance of this braze, density functional theory (DFT) calculations were employed to investigate two mechanisms that can potentially increase the work of adhesion (W\textsubscript{adh}) and hence reduce the wetting angle of Ag on YSZ. It was found while the formation of Ag–dissolved O clusters at the Ag–YSZ interface can promote wetting, a much greater wetting angle reduction comes from the formation of CuO interlayers between Ag and YSZ. Further, the W\textsubscript{adh} of an Ag/CuO and CuO/YSZ interface was found to be significantly higher than that of an Ag/YSZ interface. Based on simulation obtained-insights into metal to oxide bond formation, a simple descriptor was developed to predict Ag/oxide interface energies, predict Ag/oxide W\textsubscript{adh}, and search for potential oxide interlayers capable of promoting the wetting and adhesion of Ag on YSZ. Many simple metal oxides (single cation) were examined, however their W\textsubscript{adh} with Ag was less than that of an Ag/CuO interface. Expanding the search to multi-cation oxides led to several promising candidates, such as CuAlO\textsubscript{2}, CuGaO\textsubscript{2}, and Cu3TiO\textsubscript{4}; all of which are also stable in the reducing SOFC conditions. Depending upon their solubility in molten Ag, these newly-identified oxides could either be pre-applied as wetting promoting interlayers or directly incorporated into Ag to form new reactive air brazes.

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**Poster Number:** CHE-16  
**Authors:** Neda Rafat; Paul S. Satoh; R. Mark Worden  
**Title:** Electrochemical Enzyme Immunoassay Biosensor  

**Abstract:** An Electrochemical Enzyme Immunoassay Biosensor (EEIB) is being developed that combines the advantages of immunoassays and electrochemical biosensors. The biosensor interface contains redox enzymes co-immobilized with antibodies for the target antigen with on the working electrode of an amperometric device. When a liquid sample containing the target antigen is added, the immobilized antibodies bind to the antigen with extremely high selectivity and affinity. This binding event triggers a redox reaction cascade that generates an electric current whose magnitude gives a quantitative indicator of the antigen’s concentration. A redox-recycling scheme internally amplifies the current to increase the biosensor’s sensitivity. The EEIB interface has been adapted to a disposable electrode array platform for portable, cost-effective applications that require rapid, quantitative measurement of a target analyte with high affinity, selectivity, and sensitivity.

*This work was supported in part by NSF*

**Poster Number:** CHE-17  
**Authors:** E. M. Straley; S. M. Dorfman; J. D. Nicholas  
**Title:** Validation of Ruby Thin Films as On-Board Stress Sensors  

**Abstract:** Ruby crystallites have been used in the geology and high pressure mineral physics to measure hydrostatic stress for decades, but stress measurements from ruby thin films have never before been confirmed for accuracy. Thin film ruby stress sensors offer the benefits of being able to measure non-hydrostatic stress with very high spatial resolution and thus can be used to measure stress in-situ in a variety of environments; therefore, it is critical to ensure that the measurements from ruby thin films are validated before future experiments use ruby thin films. The presented work takes ruby thin films deposited via PLD onto two separate single crystal substrates, measures the stress across the surface of the sample via fluorescence peak, then uses a multi-beam optical stress sensor to measure the average stress and confirm the results of the fluorescence-detected stress. Biaxial stresses up to 2.5 GPa were obtained and confirmed for accuracy, thus proving that ruby thin films can be used as in-situ stress sensors.

*This work was supported in part by National science foundation (NSF)*
**Poster Number:** CHE-18  
**Authors:** Hong-Kang Tian; Bo Xu; Yue Qi  
**Title:** Interlayer to Prevent Li Dendrite Growth into LLZO – a Computational Insight Based on Li Nucleation Tendency  

**Abstract:** Solid electrolytes are considered to be able to suppress the Li dendrite growth due to its high shear modulus. However, Li dendrites are still found to grow inside the pores and along grain boundaries, but the driving force for its growth is still unclear. In this paper, garnet-type solid electrolyte Li7La3Zr2O12 (LLZO) is chosen to be studied by Density Functional Theory (DFT), because of its high conductivity and stability against Li metal. Cubic LLZO (c-LLZO) structure was investigated to understand the nucleation of Li metal on the pores surfaces inside c-LLZO. The partial density of states (PDOS) and the difference of charge transfer was analyzed when excess electrons were added to the c-LLZO surface. It was found that the additional electrons would be trapped on the La atoms at the (110) surfaces, which tends to pass the electrons to the adsorbed Li-ions on the surface and reduce them to Li metal. Also, two interlayers of tetragonal LLZO (t-LLZO), which has been shown to be produced at Li/LLZO interface, and Li2PO2N, which is the structure of Atomic Laser Deposition-LiPON, were studied on the tendency of trapping electrons. It was found that the additional electrons would disperse on the surface of t-LLZO, but for Li2PO2N, the electrons would migrate into bulk region instead. Such different tendency of attracting electrons makes Li2PO2N to be a possible coating material that might suppress the Li dendrite growth in LLZO.

*This work was supported in part by Nanostructures for Electrical Energy Storage (NEES), an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Basic Energy Sciences under Award number DESC0001160.*

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**Poster Number:** CHE-19  
**Authors:** Daniel Vocelle; Olivia Chesniak; Mitch Smith; Christina Chan; S. Patrick Walton  
**Title:** Role of Nanoparticle Characteristics in Intracellular siRNA Delivery  

**Abstract:** Understanding the endocytosis and intracellular trafficking of short interfering RNA (siRNA)-delivery vehicle complexes remains a critical bottleneck in designing siRNA delivery vehicles for highly-active RNA interference (RNAi)-based therapeutics1. In this study, we show that dextran functionalization of silica nanoparticles (SNPs) enhanced uptake and intracellular delivery of siRNAs in human lung carcinoma cells. Using pharmacological inhibitors for endocytotic pathways, we determined that our complexes are endocytosed via a previously unreported mechanism for siRNA delivery in which dextran initiates scavenger receptor-mediated endocytosis through a clathrin/caveolin-independent process. Using electron and confocal microscopy for intracellular studies, we were able to determine that siRNA-SNP dissociation and siRNA strand separation occur within acidic vesicles in a time dependent manner. Our findings suggest that siRNA delivery efficiency could be enhanced by incorporating dextran into existing delivery platforms to activate scavenger receptor activity across a variety of target cell types.

*This work was supported in part by National Institutes of Health (GM079688, RR024439, GM089866, CA176854, DK081768, DK088251), MSU Foundation, National Science Foundation (CBET 0941055, 1510895, 1547518), MUCI, and the Center for Systems Biology.*

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**Poster Number:** CHE-20  
**Authors:** David Vogelsang; Robert Maleczka; Andre Lee  
**Title:** Alternative Path for Purification of Organo-Chlorosilanes  

**Abstract:** Chlorosilanes are typically functionalized with Grignard reagents and further distilled to obtain pure materials available for diverse applications. Among them, synthesis of polysiloxanes and polysilsesquioxanes have several uses in daily life products. Temperature sensitive groups such as styryl are challenging to process due to polymerization at temperatures higher than 60 °C. Other larger groups can decompose before they reach their boiling temperature even under vacuum conditions. This work intends to present an alternative path for production of clean organo-chlorosilanes making use of chemical substitutions and column chromatography. The proposed route starts with the reaction between a Grignard reagent and a monochlorinated alkoxysilane. Then, separation of the reaction products and unreacted materials was done using a silica packed column. Once the modified alkoxysilane is isolated, substitution of methoxy groups for chlorine groups can be done in a process without residual components reaching average 90% yield of clean organo-chlorosilanes. styryltrichlorosilane was characterized by GC-MS, NMR and then reacted with double decker silsesquioxanes.

*This work was supported in part by Office of Naval Research.*

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Poster Number: CHE-21  
Authors: Yuelin Wu; Scott Calabrese Barton; Andre Lee  
Title: Investigate the Disappearance of Cu9Al4 from the Cu-Al Ball Bond Interface

Abstract: Cu-Al wire bonding is a major interconnect technology used in electronic packages. Corrosion-induced failure of the bond interface poses a long-term service reliability concern. Understanding its failure mechanism is critical for developing mitigating strategies. Between the Cu ball and the Al pad, there are two thin layers of Cu-Al intermetallics: Cu9Al4 and CuAl2. Although being nobler than CuAl2 and Al, Cu9Al4 disappeared from the bond interface in humidity reliability tests. The reason for its disappearance remains unclear. To address this issue, we compared the corrosion rates of Cu, Cu9Al4, CuAl2, and Al in various potential failure scenarios using their anodic polarization curves. The results reveals that the disappearance of Cu9Al4 is due to the crack penetration of the interface between Cu9Al4 and CuAl2. This crack penetration leads to the separation of Cu and Cu9Al4 from CuAl2 and Al. For the Cu-Cu9Al4 couple, Cu9Al4 the anode corrodes much faster due to the strong galvanic effect imposed by a larger area of Cu. For the CuAl2-Al couple, Al the anode does not corrode faster due to the weak galvanic effect imposed by a small area of CuAl2. Both Cu and CuAl2 are protected as the cathodes. Therefore, Cu9Al4 appears to corrode faster than Cu, CuAl2, and Al. The crack penetration of the interface between Cu9Al4 and CuAl2 might be attributed to the alumina layer between them and the internal stress buildup associated with the intermetallic transformation.

This work was supported in part by Semiconductor Research Corporation (SRC)
**CIVIL ENGINEERING**

**Poster Number:** CE-01  
**Authors:** Ankit Agrawal; Venkatesh Kodur  
**Title:** Residual Response of Reinforced Concrete Beams after Exposure to Design Fires

**Abstract:** Results from residual capacity tests on six fire exposed reinforced concrete (RC) beams are presented in this paper. Two of the beams were fabricated using high strength concrete (HSC), and the other four beams were fabricated using normal strength concrete (NSC). These beams were loaded to simulate stress conditions as experienced in a typical building, and then subject to heating under distinct fire exposure scenarios that can occur in building compartments. Subsequently, upon cool down to ambient conditions, the beams were loaded to failure to evaluate their residual capacity. The test variables included concrete strength (permeability), load ratio during fire exposure, and fire exposure scenario. Data from these residual capacity tests was used to compare residual response of high strength concrete (HSC) and normal strength concrete (NSC) fire exposed beams. Results from the tests indicate that residual capacity of HSC beams is greater than NSC beams for similar fire exposure scenarios, owing to greater compressive strength of HSC. Moreover, majority of the temperature induced spalling in the beams occurs during cooling phase of fire exposure rather than the heating phase. Furthermore, the type of fire scenario and load level has significant influence on the residual response of fire damaged RC beams, and should be accounted for when evaluating residual capacity of fire damaged RC beams. Data generated from these tests is being utilized for validating numerical models specifically developed for tracing residual response of RC beams.

*This work was supported in part by The authors wish to acknowledge the support of United States Agency for International Development (through Pakistan-US Science and Technology Cooperative Program grant PGA-2000003665) and Michigan State University for undertaking this research.*

**Poster Number:** CE-02  
**Authors:** Sharif Alazhary; Parviz Soroushian  
**Title:** Value-Added Use of Non-Wood Biomass Combustion Ash Towards Production of Sustainable, Economical and High-Performance Geopolymer Concrete

**Abstract:** Non-wood biomass ash-based hydraulic cement formulations were developed to meet the ASTM C1157 requirements for the ‘General Use’ class of hydraulic cements. Values of wheat straw, corn stalk, and rice hull combustion ashes as raw materials for production of hydraulic cements suiting concrete production were evaluated. The biomass ash was supplemented with other abundant waste and natural materials in order to produce a balanced chemistry for production of hydraulic cements. Test methods and criteria were developed for qualification of readily available non-wood biomass ashes as raw materials for production of hydraulic cements. Besides the ASTM C1157 requirements, moisture stability was found to be an important consideration in development of non-wood biomass ash-based hydraulic cements. This required further refinement of the cement chemistry in order to produce moisture-resistant hydration products. Besides processing at moderate temperature, the hydraulic cement was milled for size reduction, activation and further compounding to produce a hydraulic cement that meets standard requirements. Steps were taken to optimize the formulation and processing conditions of the biomass ash-based hydraulic cement. The end product is an economically viable cement with relatively low energy content and carbon footprint that meets standard requirements for general use in production of concrete.

*This work was supported in part by United States Agriculture Department*
**Poster Number:** CE-03  
**Authors:** Areej Almalkawi; Parviz Soroushian  
**Title:** Sustainable Hydraulic Cements Manufactured by Energy-Efficient Mechanochemical Processing of Abundant Natural and Byproduct Raw Materials  

**Abstract:** The chemistry of conventional Portland cement, that is based primarily on calcium silicates, limits the potential for use of industrial byproducts, and forces the use of energy-intensive and polluting production processes. This chemistry has remained practically unchanged over the past two centuries. The goal of this research is to develop an alternative hydraulic cement chemistry that meets today’s widely accepted standard requirements but allows for the use of sustainable and low-cost processing techniques, and broadens the selections and volumes of abundant industrial byproducts in the production process. The alternative hydraulic cement chemistry pursued here would take advantage of the long track record established for the calcium silicate-based chemistry, but would introduce elements of alkali aluminosilicate cement chemistry to achieve improved performance and sustainability. One primary objective of this research is to avoid the decomposition of carbonate raw materials, but to transform them into metastable forms that would allow for concomitant carbonation and hydration reactions in the course of concrete production where the resultant hydrates and carbonates would make complementary contributions towards formation of high-performance binders. An effort will be made to meet or surpass the performance requirements of hydraulic cements for concrete production, and significantly lower the energy content, carbon footprint and cost of cement production without radically departing from the base chemistry that is broadly accepted for infrastructure applications of concrete.  

*This work was supported in part by The work reported herein was funded by the U.S. Army Corps of Engineers Grant No. W9132T-16-C-0003 U.S. Army – United States.*

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**Poster Number:** CE-04  
**Authors:** S. Alogla; Prof. V. Kodur  
**Title:** Quantification of Transient Creep Effects in Reinforced Concrete Columns under Fire  

**Abstract:** Concrete structures possess favorable fire-resistant properties compared to other forms of construction such as steel and timber; however, concrete still experience temperature-induced degradation when exposed to fire in the form of loss of strength and stiffness, spalling, cracking, and large deformations. Under exposure to fire, concrete undergo high deformations compared to what is typically experienced under ambient temperature conditions. When temperature in concrete exceeds 500°C, most of the experienced deformations under load are attributed to transient creep strain. Transient creep strain is known to show significant increase at high temperature and stress levels. However, the effect of transient strain creep on response of reinforced concrete columns is not well established. Further, several conditions can magnify the influence of experienced transient creep effects in reinforced concrete columns. Such conditions include: load level, exposure scenario, and number of exposed sides of the column. In this study, the influence of transient creep on response of reinforced concrete columns is quantified under different conditions of fire exposure. A 3D finite element model is developed in ABAQUS to trace the behavior of RC columns under fire exposure by accounting for transient creep effects. A set of numerical studies are carried out utilizing the developed model to quantify the effect of transient creep in concrete columns under different fire scenarios, load levels, and number of exposure sides. Results from the numerical studies clearly indicate that severe fire exposure induces higher capacity degradation in RC columns in much shorter duration than exposure to a standard building fire. Moreover, asymmetric thermal gradients resulting from two or three side fire exposure on a column increase transient creep deformations and, thus, affect fire resistance. Overall, results from the analysis infer that neglecting transient creep can lead to lower axial displacements and, thus, overestimation of fire resistance in RC columns, particularly when subjected to severe fire scenarios and with higher thermal gradients.  

*This work was supported in part by Scholarship from Qassim University - Saudi Arabia*
**Abstract:** The elastic instability of shallow domes offers reliable and reversible deformations that could be used in structures subjected to cyclic loading and high deformation demands. The interest in studying these domes originates from the fact that they can snap-through to a new configuration within their elastic range of response and snap-back with or without a restoring external force without damage. In this work, numerical and experimental studies were carried out to examine the effects of the geometric and material properties on the response of cosine-curved domes (CCD) under concentrated load at the apex. This is achieved by conducting a parametric study using finite element (FE) analysis on the controlling geometric parameters and material properties of the CCDs. Experimental tests on 3D printed CCDs were conducted to validate the FE models and to determine whether certain behaviors physically exist and in agreement with analysis results. Three types of response were identified and discussed based on the force-displacement and strain energy-displacement curves. Limitations on the geometric parameters that govern the reversibility of the original shape and the energy state after loading are also identified. In addition, empirical relations to estimate the buckling load and maximum elastic displacement were developed. Good agreement was observed using the determined limits on the geometric parameters and the developed relations with the results from FE analysis and experimental tests.

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**Poster Number:** CE-06  
**Authors:** Danilo Balzarini; Karim Chatti; Imen Zaabar  
**Title:** Impact of Pavement Structural Response on Rolling Resistance and Fuel Economy

**Abstract:** Reduction in vehicle fuel consumption is one of the main benefits considered in technical and economic evaluations of road improvements. The present study investigates the increase in vehicle energy consumption caused by the structural response of pavements to a moving load. Simulations have been conducted of a heavy truck moving along seven rigid sections and ten flexible sections, in summer and winter conditions. The results show that, in summer conditions, the energy dissipated is higher for flexible pavements, while it is comparable to that for rigid pavements in winter.

*This work was supported in part by University of California Davis and California Dept of Transportation Award # 201401725-03*

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**Poster Number:** CE-07  
**Authors:** Srishiti Banerji; Venkatesh Kodur  
**Title:** Predictive Model for Evaluating Fire Induced Spalling in Ultra High Performance Fiber Reinforced Concrete (UHPFRC) Members

**Abstract:** UHPFRC is an innovative type of concrete with high compressive strength (over 150 MPa) and durability characteristics. However, one of the major drawbacks of this concrete is poor fire performance due to faster degradation of strength and its susceptibility to fire induced spalling. At present, there are no predictive models for evaluating spalling in UHPFRC members. This is mainly due to lack of reliable high temperature material properties of UHPFRC. Furthermore, test standards for property evaluation of UHPFRC at elevated temperature do not exist. Adding to absence of high temperature material characterization properties, is the complexity of spalling, which can be explosive in nature sometimes. To this end, a hydrothermal numerical model for predicting fire induced spalling is developed at Michigan State University using FORTRAN. The model is based on principles of structural mechanics and thermo-dynamics using the conservation of mass and energy to predict temperature and coupled pore pressure across concrete cross-section using finite difference method (FDM). The resulting tensile stress from pore pressure is checked against temperature-dependent tensile strength of UHPFRC obtained from experiments and published research to evaluate risk of spalling. The developed spalling model is applied to evaluate and compare fire induced spalling in concrete slabs made of normal strength concrete (NSC), high strength concrete (HSC) and UHPFRC subjected to ISO 834 standard fire.

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**Poster Number:** CE-08  
**Authors:** Pratik Bhatt; Venkatesh Kodur  
**Title:** Response of Steel Reinforced Polymer Strengthened Beams Subjected to Fire

**Abstract:** This poster presents the response of steel reinforced polymer (SRP) strengthened reinforced concrete (RC) beams exposed to fire. The response is evaluated, from linear elastic stage to collapse under fire conditions, using a macroscopic finite element based numerical model. The model applies a member level approach wherein, temperature dependent sectional moment curvature (M-α) relations are utilized for evaluating the response of strengthened RC beam under combined effect of loading and fire conditions. The model accounts for temperature dependent properties of constituent materials, specifically temperature induced bond degradation between concrete and strengthening material, together with all possible failure limit states in evaluating response. The numerical model is validated by comparing thermal and structural response parameters of FRP strengthened RC beams against the data measured in fire tests.
**Poster Number:** CE-09  
**Authors:** Mateo Burbano; Yadu Pokhrel  
**Title:** Hydrological, Agricultural, and Ecological Effects of Climate Change and Hydropower Dam in the Mekong River Basin

**Abstract:** Large hydropower dams in the Mekong river basin have disrupted the hydrological and ecological systems across the basin by altering the magnitude and seasonality of flow, blocking sediment transport, altering fisheries and livelihood of downstream inhabitant, and change the flood pulse to the Tonle Sap Lake. Despite significant controversies that surround the existing dams, hundreds of new dams are planned for the near future, which are expected to cause an irreversible damage to the hydro-agro-ecological systems. Existing studies have focused on the effects of dams on the environment, however an understanding between the integrated effects of the dams when combined with the adverse hydrologic consequences of climate change hasn’t been explored yet. This study addresses the effects of climate change and the alarming effects of mismanaged human activities on the hydrology of the Mekong River water system. The study also identifies existing challenges of studying the region whilst observing natural-human systems with a consistent method. Our method employs observed data of river discharge, and water level to examine the impacts of dams on downstream floodplain dynamics. We also use remote sensing data to examine the changes in land use, dam construction, and agricultural and irrigation expansion. Our future plan is to use an integrated hydro-agro-ecological model to examine the potential future effects of climate change and proposed dam across the river basin.

*This work was supported in part by NASA under the award 80NSSC17K0259. We thank the Research Program on Water, Land, and Ecosystems (WLE), Greater Mekong for providing the dam database used in Figure 1.*

**Poster Number:** CE-10  
**Authors:** Meghna Chakraborty; Steven York Stapleton; Mehrnaz Ghamami  
**Title:** Speed Limit Policy in Michigan: the Effects on Air Pollution and Human Health

**Abstract:** In 2017, the Michigan Department of Transportation (MDOT) raised the posted speed limit on 614 miles of rural freeway from 70 mph to 75 mph, and the truck speed limit was raised from 60 mph to 65 mph on all non-urban freeways statewide. The environmental consequences of such a move were paid little attention while weighing this policy change. As several other states consider raising speed limits, it is important to understand the environmental impacts in states with higher traffic volumes, such as Michigan. To this end, speed data during the before and after periods were collected in the summer of 2017. In total, 85 sites were selected, 26 of which were control sites and 59 sites were study sites. The change in average space mean travel speed, weighted by volume, was computed and was used in determining the average fuel economy based on literature values. Analysis revealed that speeds of passenger cars along study corridors and trucks statewide changed significantly, and therefore, the change in emissions was computed for these locations using vehicle miles traveled (VMT) data. Emissions were calculated considering the change in fuel consumption based on travel speeds using known emission values per given quantity of fuel. Finally, emissions were used to determine the economic cost to human health. In total, it was found that fuel consumption increased by 5.94 million gallons of gasoline and 11.6 billion gallons of diesel, resulting in an additional annual cost to human health of 7,340,000 USD.

**Poster Number:** CE-11  
**Authors:** Suyog Chaudhari; Yadu Pokhrel  
**Title:** High-resolution modeling of the Amazon water cycle with existing and proposed hydropower dams

**Abstract:** Dam construction in the Amazon river basin is in proliferation even though the existing ones have been surrounded by controversies from environmental experts and downstream riparian communities. Currently, 147 dams are under construction in the Amazon basin. These dams are continued to be built in a way that disrupts river ecology, causes large-scale deforestation, and negatively affects both the food systems nearby and downstream communities. In this study, we explore the impacts of the existing and proposed hydropower dams on the hydrological fluxes across the Amazonian Basin by incorporating human impact modules in an extensively validated regional hydrological model called LEAF-Hydro-Flood (LHF). We conduct two simulations, one in offline mode, forced by observed meteorological data for the historical period of 1990-2016 and the other in a coupled mode using the Weather Research and Forecasting (WRF) regional climate model. In this study, we particularly focus on the changes in terrestrial water storage and streamflow during the period of dam operations with and without human impacts. It is certain that the Amazon will undergo some major hydrological changes (e.g. decrease in streamflow) because of the compounded effects of new dams and climate change. This study helps us understand and represent processes in a predictable manner and enhances our ability to evaluate future scenarios with dams and other major human influences while considering climate change in the basin. It also provides important insights on how to minimize the downstream hydrological and ecological impacts when redesigning large hydropower dams.

*This work was supported in part by NSF INFEWS Award #1639115*
Poster Number: CE-12
Authors: Fatemeh Fakhrmoosavi; Ali Zockaie; Khaled Abdelghany; Hossein Hashemi
Title: Network Contraction Using an Iterative Learning Approach: Path Finding Problem in Stochastic Time-varying Networks Considering Link Travel Time Correlations for Multi-class Users

Abstract: Shortest path-finding in stochastic networks has attracted the attention of transportation researchers in recent years. Multiple optimal path-finding problems are defined in the literature based on different reliability rules including a reliability-based path-finding algorithm by Zockaie et al. (2016). Introducing an efficient optimal path-finding algorithm in terms of computational effort is also important due to its many applications in transportation such as in-vehicle route guidance systems and vehicle routing problems. The proposed algorithm by Zockaie et al. (2016) requires solving deterministic shortest path problems for different link travel time realizations to create a set of candidate paths. This stage is the most complex computational part. This study aims to improve the computational efficiency by extracting a sub-network for any interested Origin-Destination pairs. The network extraction is based on the comparison of pessimistic and optimistic solutions resulting from minimum and maximum travel times in all network links. The assumption of being all links in the network at their worst/best operation case is less probable as the distance between origin and destination increases. Therefore, the objective of this paper is to study the realizations of link travel times in order to propose realistic bounds for the maximum/minimum link travel times. Therefore, an iterative learning approach is proposed to make use of the produced data within the process and update the optimistic/pessimistic link travel times in each 10 iterations of the stochastic shortest path-finding algorithm. The proposed methodology is implemented on the large-scale Chicago downtown network. Resultantly, the optimal path and the network size are compared between cases with and without network contraction. The results demonstrate significant reduction in the number of nodes which represents a great computational improvement.

Poster Number: CE-13
Authors: Fatemeh Fakhrmoosavi; Ali Zockaie; Hani S. Mahmassani; Yu (Marco) Nie
Title: A Formulation Framework for the Reliability-Based User Equilibrium Problem in Dynamic Stochastic Networks with Correlated Travel Times and Multi-Class Users

Abstract: Transportation network users are heterogeneous and they may value travel time reliability differently. Furthermore, it is widely accepted that link travel time distributions are related to link flows in transportation network. This calls for considering the reliability-based user equilibrium problem in stochastic networks. There exists a limited studies on formulating certain instances of the reliability-based user equilibrium problem under simplified assumptions. However, realistic formulations that recognize essential properties of the dynamic traffic flow processes in networks, the resulting travel time correlation patterns, and the heterogeneity of users have not been addressed in the literature. Therefore, this study formulates a user equilibrium traffic assignment problem in general stochastic time-varying networks. In this problem, link travel times are congestion-dependent random variables that vary over time and exhibit general correlation patterns which reflect spatial and temporal network flow processes. To formulate this problem, a fixed-point formulation is presented followed by a system of Variational Inequalities (VI). A gap function is then defined for this VI formulation and based on this gap, a non-linear minimization problem is presented. In this minimization problem, assuming an underlying path flow assignment in the network, the utility of the current existing paths can be evaluated and be compared with the optimal path utility. The proposed solution procedure of this study is applied to an actual large-scale network of Chicago in addition to a medium-size test network. The numerical results show satisfactory application of the algorithm and its sensitivity to different parameters such as users’ valuation of reliability or correlation structure.
**Poster Number:** CE-14  
**Authors:** Fatemeh Fakhrmoosavi; Ali Zockaie; Hani S. Mahmassani  
**Title:** A Scenario-Based Approach for the Reliability-Based User Equilibrium Problem in Dynamic Stochastic Networks Considering Travel Time Correlations and Heterogeneous Users

**Abstract:** Travel time reliability needs to be considered in transportation network planning, as it is a major factor in travelers’ route choice. Furthermore, each traveler’s route choice decision, considering the reliability measure, affects the reliability of travel time for other travelers in the network. This calls for considering the reliability-based user equilibrium (RBUE) problem in stochastic networks. Studies to date regarding RBUE problem formulations and solution algorithms have been limited to simplified assumptions or very small networks. Zockaie et al. (2018) presented an RBUE problem formulation framework, which considers travel time correlation patterns in addition to heterogeneity of users’ behavior. However, in this study, congestion patterns are related to link travel time distributions and correlations through a simplified analytical formulation. Therefore, there is still the need to account more realistically for the probabilistic nature of time and flow-dependent travel times in the RBUE models. This study aims to propose a methodology to solve RBUE problem in stochastic time-varying networks considering travel time correlations and heterogeneous users with actual applications in realistic large-scale networks. The presented methodology updates link travel time distributions and correlations based on flow-dependent relations. Multiple simulation runs are conducted considering scenarios based on real-world observations, in order to get time-dependent travel time distributions and correlations and updating them within each iteration of the descent direction method. An iterative solution procedure is presented in this study for the RBUE traffic assignment problem, which minimizes a defined gap function. The approach is implemented and tested on an actual large-scale network of Chicago, where 86 scenarios are simulated to generate the initial travel time distributions and correlations. The numerical results show satisfactory application of the algorithm and its sensitivity to the valuation of reliability by users and the correlation structure.

**Poster Number:** CE-15  
**Authors:** Angela Farina; Annick Anctil; Emin Kutay  
**Title:** The Polymer Coated Rubber (PCR) as a Modifier to Improve the Mechanical Performance of Hot Mix Asphalt: Laboratory Evaluation and Sustainability Assessment

**Abstract:** Performance of asphalt mixtures has been improved in the last decades by employing polymer modifications. In the recent years, the use of crumb rubber (CR) from end-of-life tires in hot mix asphalt mixtures (HMAs) has been widely adopted with several techniques (e.g. wet, dry, terminal blend). One of those techniques is called ‘polymer coated rubber’ (PCR), which is produced by mixing particles of CR with a polymer emulsion such as styrene-butadiene-styrene or styrene-butadiene-rubber.

In this work, the mechanical performance in road pavements and cost of PCR employed with dry technology in HMAs is assessed. The scope of the current project is to provide a comprehensive evaluation of PCR by combining laboratory performance testing and Life Cycle Assessment (LCA). Laboratory tests are performed on samples of HMAs containing 1% of PCR by weight of the total mixture and compared to reference samples not containing PCR (control mixtures). LCA is employed to evaluate environmental impacts of Global Warming Potential and Gross Energy Requirement due to the production of HMAs containing PCR in comparison to control mixtures. Inventory data related to quantity, energy consumption, and transportation of raw and composite materials are collected. Life Cycle Cost (LCC) is used to assess the potential cost of this technology. Preliminary results obtained by laboratory tests and associated environmental impacts will be presented. The project is funded by Michigan Department of Environmental Quality. The PCR is provided by Dongré Laboratory Services Inc.

*This work was supported in part by Michigan Department of Environmental Quality*

**Poster Number:** CE-16  
**Authors:** Ali Imani Azad; Suihan Liu; Rigoberto Burgueno  
**Title:** Shear Energy Dissipation through Bistable Inclined Beam Mechanism

**Abstract:** Dissipating energy under shear loads is advantageous for the structures during the lateral excitations like earthquake, or wind. This study proposes a new concept of metamaterials with periodically arranged inclined beams to achieve large energy dissipation under shear loading condition. Each unit inclined beam is bistable and experiences snap-through buckling in its elastic regime. By properly connecting the unit beam elements, multiple energetically transitions are obtained in the micro-level with controllable amount of energy dissipation. A finite element model is generated using ABAQUS with planar 2D elements, and numerical simulation is conducted using dynamic solver to study the mechanical responses of the micro and macro structures, for the titled beam elements in a single, a column, and a periodical planar configuration. The numerical results provide evidence to support the design hypothesis, which will be verified by experimental and theoretical results in our future work.

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**Poster Number:** CE-17  
**Authors:** Anthony Ingle; Timothy Gates  
**Title:** Rural Two-lane Two-way Highway Safety Performance

**Abstract:** This study involves the development of safety performance functions (SPFs) for two-lane two-way segments located along rural roadways under the jurisdiction of the state of Michigan. Extensive databases were developed that resulted in the integration of traffic crash information, traffic volumes, and roadway geometry information. After these data were assembled, an exploratory analysis of the data was conducted to identify general crash trends. This included assessment of the base models provided in the Highway Safety Manual (HSM), as well as a calibration exercise, which demonstrated the goodness-of-fit of the HSM models across various site characteristics. Michigan-specific SPFs were estimated, including simple models that consider only annual average daily traffic (AADT). More detailed models were also developed, which considered additional geometric factors, such as posted speed limits, number of lanes, and the presence of shoulder and rumble strips along the edge of the roadway. Crash modification factors (CMFs) were also estimated, which can be used to adjust the SPFs to account for differences related to these factors. Ultimately, the results of this study provide the Michigan Department of Transportation (MDOT) with a number of methodological tools that will allow for proactive safety planning activities, including network screening and identification of high-risk sites.

*This work was supported in part by This work was supported in part by Michigan Department of Transportation*

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**Poster Number:** CE-18  
**Authors:** Mohammad Kavianipour; Laura Hohnstadt; Mehrnaz Ghamami; Ali Zockaie  
**Title:** Assessing the Environmental Impact of Electric Vehicles and Conventional Vehicles Considering Different Batteries and Electricity Mix for Different Market Shares

**Abstract:** Electrical Vehicles (EV) have long been considered as a solution to alleviate the Green House Gas (GHG) emissions emanating mostly from gasoline burned as fuel in conventional vehicles. Providing charging infrastructure for EVs is inevitable in order to make them a viable option for users. Building more charging stations comes at the expense of more GHG emissions, which can be counted for through a life cycle analysis. On the other hand, larger batteries demand fewer charging stations, however, manufacturing higher range batteries might lead to more emissions itself. Electricity generation mix also affects GHG emissions associated with its production. Other factors like gasoline and motor production make network emission estimation even more challenging. We have calculated the GHG emissions for the optimal combinations of battery range and infrastructural setting considering various sources for electricity and electric vehicle market share through a scenario based analysis to minimize the total network emission. We have implemented an SA model developed by the same authors, which determines the location of charging stations and number of charging spots within them for different battery ranges and market shares. Intercity network of Michigan is used as the case study and results has been consistent with other studies while providing more details about the network emission mix. The results indicate that investing in infrastructure while having batteries with lower capacity is the best strategy to reduce GHG emission in transportation networks.

**Poster Number:** CE-19  
**Authors:** Mohammad Kavianipour; Mehrnaz Ghamami; Ali Zockaie; Laura Hohnstadt  
**Title:** Refueling Infrastructure Planning in Intercity Networks Considering Route Choice and Travel Time Delay for Mixed Fleet of Electric and Conventional Vehicles

**Abstract:** Since the recent development of battery technology for electric vehicles, a lack of charging stations and range anxiety are no longer significant concerns for intracity trips. However, for intercity trips, range anxiety is still a major issue. This calls for more investments in building charging stations and advancing battery technology. This study suggests a configuration for plug-in electric vehicle charging infrastructures to support long-distance intercity trips of electric vehicles at the network level. A model is proposed which minimizes the total system cost including infrastructure investment (building charging stations/spots) and travel time delays (charging time, waiting time in the queue and detour time to access charging stations). This study advances the existing gaps in the literature by capturing realistic patterns of travel demand and considering flow-dependent charging delay at charging stations. The proposed model is formulated as a mixed integer program with nonlinear constraints. The optimization problem is solved for an intercity network considering the influence of charging station locations on traffic assignment with a mixed fleet of electric and conventional vehicles using Simulated Annealing algorithm. The numerical experiments show satisfactory application of the model for the Intercity network in Michigan. The results suggest that with the current market share and charging stations setting, a significant investment is needed to support intercity trips for electric vehicles without range anxiety issues and with acceptable delays. Furthermore, the required infrastructure and battery investments are calculated to support intercity trips with acceptable delays for hypothetical increased market shares and battery size in future.
Abstract: Network Fundamental Diagram (NFD) incorporates the average flow and average speed in the network level. It is implemented to design strategies for network-wide traffic control and congestion pricing. Estimating NFD for heterogeneously distributed flows coming from an asymmetric and time-varying origin-destination demand matrix is a challenging problem. In a recent study by Zockaie et al. (2018), a resource allocation problem accounting for limited resources for data collection is solved to find the optimal location of fixed measurement points and optimal sampling of probe trajectories. However, they employed a given ground truth NFD under certain conditions to find the optimal set of observations, which is the main shortcoming of their study. In this paper, we extend their proposed framework to capture the stochasticity in the ground truth NFD due to weather conditions, freeway daily throughput and accidents. The proposed model is a mixed integer problem with non-linear constraints known to be NP-hard and Simulated Annealing algorithm is implemented to solve it. Using a calibrated simulation-based dynamic traffic assignment model of Chicago downtown network, we present successful application of the proposed model and solution algorithm to estimate NFD in a stochastic network. We accounted stochasticity by considering the actual traffic data for 86 days. We calibrated the model for 60 scenarios while testing the calibrated model for 26 more scenarios. The results provide optimal links for installing loop detectors and optimal ODs for probe trajectory implementation, which can be used to estimate the state of network on the NFD.

This work was supported in part by Prestressed Concrete Institute

Poster Number: CE-21
Authors: Puneet Kumar; V.K.R. Kodur
Title: An Approach for Performance-Based Fire Design of Precast Prestressed Concrete Structures

Abstract: Precast prestressed concrete structures are widely used in building and bridge applications due to their cost effectiveness, superior quality, and inherent high fire resistance. Currently, fire resistance of these structures is assessed based on prescriptive based approaches which are derived from standard fire tests on floors. Realistic fire scenarios in parking structures can be significantly different from standard or compartment fires, thus, current assessment of fire resistance for PC floors may not reflect realistic fire performance. This paper lays out a rational design approach for evaluating fire resistance of PC structures. A finite element based numerical model, built in ANSYS, is applied to evaluate fire performance of PC structures under various fire scenarios -including that can result in a parking structure. Results from these numerical studies clearly indicate that fire resistance predictions for PC floors under current prescriptive approaches are too conservative and rational approach lead to higher fire resistance under realistic fire and loading conditions. Therefore, use of this strategy will lead to rational and cost effective design of prestressed concrete structures while ensuring better degree of fire safety as compared to current prescriptive approaches.

This work was supported in part by Prestressed Concrete Institute

Poster Number: CE-22
Authors: Yogesh Kumbargeri EIT; Ilker Boz PhD; M. Emin Kutay PhD PE
Title: Quantifying the Effect of Binder/Aggregate Application Rates on Chip Seal Characteristics via Digital Image Processing and Sweep Tests

Abstract: In an effort to improve understanding of the relationship between the binder/aggregate application rates and the final microstructure of chip seals, image processing techniques were used to quantify percent embedment (PE) and aggregate orientation. The loss of aggregates were measured at different binder/aggregate application rates using a modified version of the ASTM D7000 sweep test. The reasons behind the observed trends of aggregate loss with respect to the binder/aggregate application rates were explained by using the PE and aggregate orientations measured via digital image processing. A new parameter called “Theoretical Percent Embedment” was also introduced for proper analysis of application rates with respect to the cumulative aggregate loss from the sweep test. It was observed that the aggregates orient on their flattest side as the binder application rate increases and aggregate application rate decreases. Image analysis results clearly indicated that as the aggregate application rate increases, the ‘lever and wedge’ effect causes the aggregates to disorient from their flattest side, making them more prone to be picked by shear forces (e.g., the forces caused by the traffic). Therefore, it is important not to use too much aggregates in chip seal projects and there exists an optimum aggregate application rate to create the best microstructure that includes densely packed aggregates lying on their flattest side.

This work was supported in part by Michigan Department of Environmental Quality (MDEQ)
Poster Number: CE-23  
Authors: Saratchandra Kundurthi; Suhail Hyder Vattathurvalappil; Rajendra Prasath Palanisamy; Mahmoodul Haq  
Title: Understanding Thermal Gradients within Bond-Lines of Reversible Joints Introduced by Manufacturing Processes  

Abstract: Reversible adhesive joints offer advantages of design flexibility and quick bonding when compared with conventional bonding techniques. However, they come with their own set of challenges, one of them being non-uniform heating due to the induction coil induced magnetic fields used to heat the adhesive; and also due to the quenching (non-uniform cooling) effect upon removal of the magnetic field and exposure to room temperature. Such thermal gradients result in residual stresses within the adhesive layer, which ultimately decrease the joint strength. In this study, numerical modeling was performed to predict the temperature distribution inside the adhesive layer during the joint manufacturing process. A magneto-static simulation was performed to estimate the magnetic field strength distribution inside the adhesive bond layer and subsequently incorporated as a heat source in a transient thermal simulation to predict the temperature distribution over time. The predictions were then experimentally validated by means of fiber optic temperature sensors sandwiched between two adhesive films subjected to the same induction heating cycle. Preliminary results show promise towards accurate measurements of residual/locked-in adhesive stresses and create the launchpad for strength prediction in bonded structural joints.  

This work was supported in part by American Chemistry Council (ACC)

Poster Number: CE-24  
Authors: Mingzhe Li; Weiyi Lu  
Title: Strong and Tough Hybrid Hydrogels Reinforced by Liquid Nanofoam  

Abstract: Hydrogels, consisting of 3D cross-linked polymer networks and large amount of water (>50%), have great potential and promise for many biomedical and industrial applications due to their unique biocompatible and biomimetic properties. However, most synthetic hydrogels suffer from poor mechanical properties. In the past, intensive efforts have been devoted to the development of strong, tough and highly stretchable hydrogels. Despite their successes, it remains challenging to combine several extraordinary mechanical properties within one material, due to structural heterogeneity and lack of energy dissipation mechanisms. To address this challenge, we propose to employ an advanced liquid-based energy dissipative material, the liquid nanofoam (LN), to develop novel hybrid hydrogel. We hypothesize that by integrating nanoporous particles into the liquid-based hydrogel, LN will be formulated and encapsulated in the 3D polymer network, and thus the mechanical strength and toughness of the hybrid hydrogel will be significantly enhanced simultaneously. To test this hypothesis, hydrogel containing nanoporous silica particles has been synthesized. The extremely large energy dissipation capacity of LN based on the liquid infiltration mechanism has been successfully converted into the toughness of the resultant hybrid hydrogel. In addition, nanoporous particles with functionalized outer surface also perform as both chemical and physical cross-linkers to reinforce the hydrogel polymer network. Its compressive strength, toughness, swelling behavior and morphology have been characterized by various experimental techniques including confined and unconfined compression tests, swelling tests and SEM. Our results show that both the mechanical strength and toughness have been remarkably enhanced. This study provides the first working mechanism to independently control the strength and toughness of hydrogel, which offers a new design strategy of next-generation "soft and wet" materials with high strength and toughness.
Abstract: Moisture in pavement subsurface layers has a major influence on pavement performance. In flexible pavements, variation in moisture content over time in subsurface layers, predominantly in base layer significantly depend on water infiltration after precipitation, subsurface temperature and surface conditions. Surface cracks, untreated shoulders and side ditches are the major sources of moisture change in unbound layers. Consequently, base layer resilient modulus (MR) is adversely affected, which ultimately leads to premature failure in pavements and reduced service life. This paper presents data-based methodology and approach for quantifying the effect of infiltration through surface cracking in flexible pavement performance. The models developed based on the seasonal monitoring program (SMP) data show that increase in the amount of cracking will increase the base moisture content. In addition, the moisture content increases with higher (%) passing sieve 200 and greater TDR depths. With lower subsurface temperatures and higher HMA thickness the moisture content decreases. As the moisture content in the base layer increases, its resilient modulus decreases. However, the decrease in base MR is about 3 percent and 33 percent for the pavement sections in DF/DNF and WF/WNF regions, respectively. The impact of MR reduction on the long-term predicted cracking show that with decrease in base MR, amount of surface cracking increased especially for thinner pavements. It is also shown from the data that for pavements in dryer climates the total cracking may not have significant impact on the base MR. To be proactive, the cracks should be sealed when the extent of low severity surface cracking is low.

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Poster Number: CE-26
Authors: Shariat Mobasser; Hassan Waseem; Robert D. Stedtfel; Syed A. Hashsham
Title: Fabrication and Validation of Screen Printed Electrode using PalmSense 4

Abstract: Water pollution due to heavy metals including copper, arsenic, and lead is a recognized problem worldwide. Electrochemistry allows instrument simplicity, cost effectiveness, and portability. Recent advances in electrochemical sensors have led to the use of screen-printed electrodes (SPE) and much smaller field-deployable devices capable of measuring metals, organics, and many other compounds with excellent accuracy. Both SPE and field deployable electrochemical instruments have received less attention to measure contaminants such as dioxins and antibiotics. We are developing a SPE consisting of Acetylcholinestrase and nano-Zinc to detect dioxin. Initial performance of SPE is being evaluated using Palmsens4 - a field deployable commercially available electrochemical device and square wave voltammetry (SWV). A current of 1μA-1mA and potential of -0.5- 0.1V was used to test the performance of the device using copper as a surrogate. A calibration curve was prepared using a dilution range yielding a limit of detection of 4.33 ppb and limit of quantification of 13.15 ppb. This initial results show that the overall system can be used for other metal contaminants. Next step is to validate the method for dioxin using SPE and AchE.

Poster Number: CE-27
Authors: Hamid Mohammadi; Roozbeh Dargazany
Title: Thermo-Oxidative Aging of Elastomers

Abstract: Polymers are one of the most important materials due to the high increase of their usage in industrial applications. Obviously, they should be able to endure different environmental stresses. It is known that these environmental stresses change polymer’s behavior through time which leads to limitation on their operating time. Therefore, knowing these effects in hope of finding a way to control them is of high financial importance.

In this study, thermo-oxidative aging of elastomers as a representative of chemical aging is examined. Thus, a micro-mechanical model within the framework of continuum mechanic is proposed. The basic assumption regarding the model is based on the idea that through aging a second network with shorter chains starts to create. Therefore, the strain energy is constituted from two independent contributions from initial soft network and created brittle network. These strain energies were computed by integration of entropic energy of polymer chains in each direction of a micro-sphere. The model demonstrates good agreement with different experimental data on relaxation and intermittent tests.
Title: A Micro-mechanical Model for Inelastic Response of Double-Network Hydrogels

Abstract: Hydrogels are by nature brittle and easily fractured at extremely low stresses even under compression. Double network (DN) hydrogels, consisting of two contrasting and interpenetrating polymer networks, are considered as perhaps the toughest soft materials. Such properties make them an excellent substitute for load-bearing tissues such as tendons, muscles, and cartilages. While recent advances in the process and characterization of the DN gels have led to significant improvement in their properties, our understandings of the load transfer mechanism within them remain sparse and inconclusive. Here, a micromechanical model of the constitutive response of DN gel in quasi-static deformation is developed which can be particularly used to elucidate the inelastic features such as permanent damage during deformation. The proposed model enables us to describe the damage and the way it influences the microstructure of the gel. The model is validated against the tensile tests on DN gels. History-dependent softening of the hydrogels under large deformation is taken into account similar to the stress softening in rubber-like materials, namely the Mullins effect. Here, a new concept is developed to characterize the behavior and damage of gels under large deformation. Irreversible chain detachment and decomposition of the second network are explored as the underlying reasons for the nonlinear inelastic phenomenon. The continuum damage approach based on the thermodynamic representation of the network evolution theory and the concept of integration over the unit sphere is utilized to describe the constitutive behavior of the material. The model contains a few number of material constants and shows good agreement with cyclic uni-axial tensile test data.

Poster Number: CE-29
Authors: Gopikrishna Musunuru; Syed Waqar Haider
Title: Development of Decision Trees for Cluster Assignment Based on Different Classification Algorithms

Abstract: The pavement-ME software used for pavement design requires specific types of traffic data to design new or rehabilitated pavement structures. Among the needed data are vehicle class distribution (VCD), monthly adjustment factors (MAF), hourly distribution factors (HDF), and axle load spectra (ALS). The axle load spectra are based on four axle types (single, tandem, tridem and quad). State Highway Agencies (SHA) have classification and weigh-in-motion (WIM) sites to collect the required traffic data. Three input levels are established based on the data availability. Level 1 indicates that there is site-specific data from a nearby WIM station. If site-specific data are unavailable, the averages from nearby sites (regional) with similar traffic characteristics can be used as Level 2 data. Level 3 data would be the statewide averages and are typically used when Levels 1 and 2 are unavailable for a site. The use of different data levels poses a risk of over or under-designing pavement structures because of the data accuracy.
Traffic inputs can be hard to characterize when site-specific data are unavailable. Data mining techniques such as cluster analyses are used to identify WIM sites with similar traffic patterns to develop Level 2 inputs. A classification model is required to allocate a new site to an appropriate cluster. The most commonly used classification model is a decision tree. While decision trees are extremely fast and easy to interpret, they are prone to overfitting (i.e., low bias and high variance) resulting in weak predictive models. Therefore, multiple decision trees were constructed using the general technique of bootstrap aggregating (using Breiman's random forest algorithm) to correct the overfitting of a single decision tree. The results of this study demonstrate a practical solution for the local highway agencies to assign a site to different clusters.

This work was supported in part by Michigan Department of Transportation

Poster Number: CE-30
Authors: T. M. Ngasala; S. J. Masten; M.S. Phanikumar
Title: An Interdisciplinary Evaluation of Domestic Water Contamination and the Public Health Impacts in Informal Settlements of Dar es Salaam City, Tanzania

Abstract: Poor access to wastewater management services in many informal settlements of urban areas results in improper discharge of sewage which contaminate water sources. The current study was done in one of the urban informal settlements of Dar-es-Salaam City that experience water scarcity and has no access to sewer system. The objectives were 1) to understand the current household practices for access to water and wastewater management 2) to evaluate strategies to improve water quality, sanitation and public health by determining the extent of coverage and efficacy of wastewater treatment systems. Combination of household, key informant surveys and field inspection were conducted to understand the current sanitation facilities used, their performance, operation and maintenance in order to create geo-spatial mapping of community assets. Survey results revealed more than 50% of the respondents dispose grey-water outside their premises or in septic system. Nearly 60% of septic systems fill up within a month and two years, and often create sewage overflows especially during rainfall season. Seventy-one percent of community members rely on wells that are too close to septic systems and 39% are connected to city water with distribution pipes leaking and located near sewage ditches. Spatial mappings showed the density of septic systems per square meter and their proximity to water sources with seventy-two percent of 47 wells identified being located less than 15 meters from septic systems (WHO minimum: 30 meters). The proposed interdisciplinary approach is expected to develop risk-based intervention strategies that will improve the existing wastewater management systems.

This work was supported in part by Environmental Science and Policy Program (ESPP) - MSU

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Poster Number: CE-31  
Authors: Rajendra Prasath Palanisamy; Yiming Deng; Mahmoodul Haq  
Title: Estimation of Elastic Moduli in Multi-Directions using a Conformable Sensing Skin

Abstract: Tailoring the structural properties through strategic lamina layup is one of the biggest advantages that fiber reinforced polymer (FRP) composites offer. These FRP composites are designed to handle complex mechanical, thermal and diffusion loading, and the damage is accumulated over time. While many non-destructive (NDE) techniques are available to determine the flaw(s) or defects, the gradual degradation in elastic properties cannot be detected until the flaw is formed. Initial work in our group on determining the degradation of adhesive under cyclic loading has shown that the guided wave/lamb-wave technique is an excellent method to back-calculate the elastic properties (modulus) and its degradation over time. In this work, instead of one actuation-receiving sensor pair, an array of sensors were used to determine the elastic properties (Modulus) in multiple directions. Furthermore, since most automotive structural components are curved, hence this research aims at developing a conformable sensing skin that estimates the elastic moduli in multiple directions including curved surfaces. A Single-Transmitter-Multiple-Receiver (STMR) Piezo-ceramic based sensor array is embedded to a conformable skin, called as sensing skin. The developed sensing skin can be attached to any surface using pressure sensitive adhesive. Lamb wave velocities measured between transmitter and receiver nodes at different directions along with genetic algorithm help in reconstruction of unknown elastic modulus. A finite element and experimental validation of this technique on isotropic and orthotropic material are presented here. Experiments were conducted on an AMS4027 grade Aluminum plate (2mm thickness) and a 12 layer bi-directional Glass Fiber Reinforced Plastic (GFRP) composite (6mm thickness). The developed skin and the approach is not limited to FRP composites but can be used in a wide range of applications.

This work was supported in part by US Dept. of Transportation Award # DTRT13-G-UTC44

Poster Number: CE-32  
Authors: Shabnam Rajaei; Karim Chatti  
Title: Mechanistic Modeling of the Effect of Pavement Surface Texture and Roughness on Vehicle Rolling Resistance

Abstract: Rolling resistance plays an important role in vehicle fuel consumption. Understanding the interaction between tire and pavement surface is important for improving the prediction of rolling resistance. In this study, the effect of pavement surface roughness and texture (mega-, macro-, and micro-texture) on rolling resistance is being investigated mechanistically. The goal of the study is to assess the relative importance of each surface scale.

In roughness scale, the energy dissipation due to vehicle dynamics is investigated using a mechanistic approach based on quarter-car model. The influence of the pitch and roll angles will also be added in the future.

In the mega-texture scale the problem is divided into two parts; effect of mega-texture on vehicle dynamics which is tackled similar to the previous scale; and effect of mega-texture on tire vibration, which is investigated by developing a full 3D finite element tire model.

In macro-texture scale, the effect of surface on tire vibration, bending, and tread deformation is investigated. The influence on tire vibration is similar to the previous scale; However, since the addition of the small wavelengths of macro-texture to the tire model makes the process computationally expensive, the modeling of the contact should be separated from the tire model.

In micro-texture scale, the effect of micro-texture on tire rubber energy loss is being assessed through multi-scale surface decomposition. In each scale, the pavement surface is considered as a simple sinusoidal wave and the cumulative energy loss in the rubber due to the different surfaces is calculated.

Poster Number: CE-33  
Authors: Salina Ramli; Parviz Soroushian  
Title: Economically Viable Ultra-Rapid-Hardening Hydraulic Cement and Concrete Materials

Abstract: A new class of ultra-rapid-hardening hydraulic cements is under development with a hybrid chemistry that makes complementary use of the rapid hydration, alkali-activation and carbonation reactions. This ultra-rapid-hardening hydraulic cement surpasses today’s standard requirements, satisfying the 90-minute strength requirements in 60 minutes. The novel chemistry as well as the activation of the blend of raw materials via input of mechanical energy enable achievement of distinctly high early strengths. Furthermore, the new ultra-rapid-hardening hydraulic cement provides a desired fresh mix workability and adequate initial set time to allow for timely mixing and application. It also meets the requirements relevant to dimensional and chemical stability of ultra-rapid-hardening hydraulic cements. Another element of this research concerns development of optimum mix designs which enable full mobilization of the inherent qualities of the ultra-rapid-hardening hydraulic cement in the context of high-early-strength concrete materials. Rapid pavement repair is the initial application targeted for the end products of this research program.
**Poster Number:** CE-34  
**Authors:** Ali Zockaei; Meead Saberi; Ramin Saedi  
**Title:** Optimal Locating of Fixed Measurement Points and Sampling of Probe Trajectories to Estimate Network Fundamental Diagram in Heterogeneous Networks

**Abstract:** Network Fundamental Diagram (NFD) or Macroscopic Fundamental Diagram (MFD) represents dynamics of traffic flow at the network level. It is used to design various network-wide traffic control and pricing strategies to improve mobility and mitigate congestion. NFD is well defined when congestion distribution in the network is homogenous. However, in real world networks, traffic is often heterogeneously distributed and initiated from an asymmetric and time-varying origin-destination (OD) demand. In this paper, we formulate a resource allocation problem to find the optimal location of fixed measurement points and sampling of probe trajectories to estimate the NFD, accounting for network traffic heterogeneity and limited resources for data collection. Data from probe trajectories are used to estimate space-mean speed while data from fixed detectors are used to estimate traffic flow. Thus, the proposed model does not require an aggregate penetration rate of probe vehicles as a priori to be known, which is one of the main contributions of this study. The proposed model is a mixed integer problem with non-linear constraints known to be NP-hard. A heuristic solution algorithm (Simulated Annealing) is implemented to solve the problem. Using a calibrated simulation-based network model of downtown Chicago, we present a successful application of the proposed model and solution algorithm to estimate NFD. The results demonstrate the sensitivity of the NFD estimation accuracy to the available budget (number of fixed measurement points and probe trajectories). We show that for a fixed proportion of OD trajectories, the increase in the proportion of fixed detection points increases the accuracy of NFD estimation as expected. However, when the proportion of fixed detection points is set to be constant, the increase in the proportion of OD trajectories does not necessarily improve the estimated NFD. Results also hold true when varying demand is used to emulate variation in day-to-day traffic patterns.

**Poster Number:** CE-35  
**Authors:** Ramin Saedi; Rajat Verma; Ali Zockaei; Mehrnaz Ghamami; Timothy Gates  
**Title:** A Framework for Incorporating the Network-wide Fundamental Diagram into Large-scale Emission Estimation

**Abstract:** Estimation of vehicular emissions is one of the main challenges encountered by urban planning agencies and municipalities. Microscopic emission models are sophisticated and detailed, but are effective only at facility-level or in small networks. Macroscopic models operate well on large networks, but often fail to consider traffic flow dynamics. This study proposes a mesoscopic approach that accounts for effects of traffic flow dynamics in the emission model. The concept of network-wide fundamental diagram (NFD), which relates network-wide average values of traffic flow and density, has recently gained popularity among transportation planners for monitoring traffic flow at network level. In this paper, we extend this concept to build a framework for estimating vehicular emissions. To this end we integrate an existing microscopic emission model with a mesoscopic traffic simulation tool to calibrate and validate a network-wide emission model. The model is calibrated for the metropolitan network of Chicago (that includes around 4,800 links) through linear regression based on average traffic flow, density, and vehicle classification. To this end, we analyzed trajectory data of about 800,000 simulated vehicles under various scenarios using actual data of 15 days. The results demonstrate satisfactory model calibration with acceptable deviation from the underlying microscopic model. The proposed framework in this study successfully shows that for a large-scale network, vehicular emissions can be reasonably estimated using NFD. The results of this study enable system planners to monitor emissions under different travel demand-supply conditions and find optimal policies to control the level of pollution in large cities.

**Poster Number:** CE-36  
**Authors:** Hadi Salehi; Saptarshi Das; Shantanu Chakrabarty; Subir Biswas; Rigoberto Burgueno  
**Title:** Structural Health Monitoring and Assessment using a Network of Self-Powered Thru-Substrate Wireless Sensors: A Machine Learning Methodology

**Abstract:** This study presents a novel methodology for structural health monitoring (SHM), using a self-powered sensing concept, within the context of machine learning (ML). The proposed method is based on the interpretation of data provided by a self-powered discrete analog wireless sensor used to measure the structural response along with an energy-efficient pulse switching technology employed for data communication. A system using such an energy-aware sensing technology demands dealing with power budgets for sensing and communication of binary data, resulting in missing data received at the SHM processor. Numerical studies were conducted on an aircraft wing stabilizer subjected to dynamic loading to evaluate and verify the performance of the proposed methodology. Several features, i.e., patterns or images, were extracted from the strain response of the structure. The obtained features were fed into a ML methodology incorporating pattern recognition and learning algorithms for damage diagnosis of the wing. In the present study, a data fusion model based on spatial-temporal integration response of the sensor nodes is proposed to enhance damage detection accuracy. Further, the reliability of the proposed methodology was validated through an uncertainty analysis. The results demonstrate that the developed SHM methodology employing ML is efficient in detecting damage, even with noisy discrete binary data, from a novel self-powered sensor network.

*This work was supported in part by National Science Foundation*
**Poster Number:** CE-37  
**Authors:** Talal Salem; Parviz Soroushian  
**Title:** Value-Added Use of Carbon Emissions as Raw Materials for Production of Hydraulic Cement

**Abstract:** Portland cement and most other hydraulic cements rely upon an alkaline medium to enable hydration and ensure the stability of hydration products. Therefore, acidic media are avoided in formulation and processing of common hydraulic cements. Carbon dioxide generates an acidic medium, and could thus be viewed as incompatible with Portland cement and other common hydraulic cements. This research is based on the hypothesis that the acidic media formed by carbon dioxide can destabilize mineral structures that embody alkaline constituents, releasing relatively high quantities of alkaline materials which more than compensate for the initial raise in acidity caused by the introduction of carbon dioxide. It is further hypothesized that the carbon dioxide used in processing of hydraulic cements can yield finely crystalline carbonates with desired binding effects. Successful implementation of this research would transform production of hydraulic cement from a major source of carbon emission to a means of capturing carbon dioxide from combustion emissions for use as a valuable raw material.

*This work was supported in part by Department of Energy*

**Poster Number:** CE-38  
**Authors:** Aksel Seitllari; M. Emin Kutay  
**Title:** Use of Soft-Computing Tools to Predict Progression of Percent Embedment of Aggregates in Chip Seals

**Abstract:** In this study, soft computing and multilinear regression techniques were employed to develop models for prediction of progression of chip seal percent embedment depth (Pe). The model uses the inputs such as cumulative equivalent traffic volume, Vialit test results, dust content of aggregates, and initial embedment depth. Multilinear regression (MLR), adaptive neuro-fuzzy system (ANFIS) and artificial neural network (ANN) techniques were used to estimate the Pe. The contribution of the variables effecting Pe were evaluated through a sensitivity analysis. The results indicate that while most of the proposed models were able to predict the Pe reasonably, the artificial neural network model performed the best.

**Poster Number:** CE-39  
**Authors:** Sanghoon Shin; Yadu Pokhrel  
**Title:** Modeling Storage and Extent Dynamics of Large Man-Made Reservoirs at the Continental Scale

**Abstract:** Over the past decade, significant progress has been made in developing reservoir schemes in large scale hydrological models to better simulate hydrological fluxes and storages in highly managed river basins. These schemes have been successfully used to study the impact of reservoir operation on global river basins. However, improvements in the existing schemes are needed for hydrological fluxes and storages, especially at the spatial resolution to be used in hyper-resolution hydrological modeling. In this study, we developed (1) a river-reservoir-floodplain routing scheme at the grid scale of 5km or less and (2) an advanced reservoir operation schemes applicable in regional and global hydrological models. Instead of setting reservoir area to a fixed value or diagnosing it using the area-storage equation, which is a commonly used approach in the existing reservoir schemes, we explicitly simulate the inundated storage and area for all grid cells that are within the reservoir extent. The advancement of reservoir operation scheme is made by the analytical analysis for the existing schemes and by the newly incorporated novel calibration features. Results of the seasonal dynamics of reservoir storage, reservoir release, and inundated extent show good agreement with ground-observations and satellite measurements over the contiguous US. It is expected that the incorporation of the newly developed reservoir scheme in large-scale land surface models (LSMs) will lead to improved simulation of river flow and terrestrial water storage in highly managed river basins.

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WaterCube Project of Michigan State University (GR100096)*
**Poster Number:** CE-40  
**Authors:** Mehrnaz Ghamami; MohammadHossein (Sam) Shojai  
**Title:** A Design Framework for a Multi-Modal Public Transportation System with Focus on Mixed-Fleet Bike Sharing Systems

**Abstract:** Bike sharing is garnering increasing popularity worldwide. On the other hand, electric bikes (E-bikes) as a relatively recent transportation technology, enjoy extended range and are less physically demanding, compared to regular bicycles. E-bikes can thus be incorporated into regular bike sharing systems to attract more users. This study aims at capturing the users' preference, while accounting for investors' restrictions and societal cost and benefits of each mode. The problem is formulated as a mixed integer non-linear problem, with non-linear objective function and constraints. The problem is thus computationally challenging and a metaheuristic algorithm based on simulated annealing (SA) algorithm is proposed for problem solution. The performance of the algorithm is tested in this study and convergence patterns are observed. The main findings of this study include, but are not limited to: 1) as the health benefit increases, which result from increase in the medical expenses, the system requires more pedelecs, while reducing the number of shared bikes, e-scooter and bus, 2) the most popular public modes are bus and pedelec, because these two modes (bus and pedelec) are less costly and have the ability to cover longer distances in comparison to similar modes (i.e. e-scooter/car and bike), and 3) for small communities with short commuting distances, as users would not choose fuel consuming modes, the model proved insensitive to fuel cost.

**Poster Number:** CE-41  
**Authors:** Harprinderjot Singh; Mehrnaz Ghamami; Hadis Nouri; Timothy Gates  
**Title:** Autonomous, Shared Autonomous and Conventional Vehicles on the Road: A Trade-Off between VMT, Costs and Emission Production

**Abstract:** Autonomous vehicles (AV) and Shared autonomous vehicles (SAV) have promising benefits to the transportation system. Some of these benefits are increased safety, increased mobility, reduction in parking demand, emission reduction, etc. The claimed benefits can significantly increase the adoption rate of these vehicles, causing significant increase in vehicle miles travelled (VMT) in the transportation system. This may increase the overall emission production and operating costs of the vehicles. Hence, it is required to determine the optimum vehicle type (Conventional vehicles, AVs or SAVs) under different circumstances that will increase the overall system benefits. This study proposes an optimization model to estimate the system cost considering emission production, waiting time, operating cost and ownership cost of vehicles, with the vehicle type as the decision variable. The model captures the trade-off between the benefits of increased mobility and emission reduction from efficient driving and the drawbacks of increased VMT. A stochastic model is developed to capture the uncertainty in VMT increases due to the adoption of AVs and SAVs. The model is applied to a hypothetical signalized arterial system and sensitivity analysis is performed on demand and cost parameters of the proposed system. The case study results suggest that under current conditions, system cost would be minimum if the entire fleet is replaced by SAVs. The overall emissions will be reduced by about 90% with the adoption of SAVs. It is worth noting that the deterministic model overestimates the system cost in comparison to the stochastic model.

**Poster Number:** CE-42  
**Authors:** Roya Solhmirzaei; Venkatesh Kodur  
**Title:** Comparative Behavior of Ultra High Performance Fiber Reinforced Concrete Beams without Stirrups Under Flexural and Shear Loading

**Abstract:** This study presents comparative behavior of Ultra-High Performance Fiber Reinforced Concrete (UHPFRC) beams under flexural and shear loading. Four large scale UHPFRC beams with different reinforcement ratios were tested under dominant shear and flexural loading. The beams were not provided with any shear reinforcement in order to take advantage of high tensile strength offered by UHPFRC. Two of the beams were tested under dominant shear loading and remaining two beams were tested under dominant flexural loading. Comparative results indicate that UHPFRC beams, without stirrups, subjected to shear loading did not experience any reduction in either ductility or moment capacity. This enhancement in performance can be attributed to improved tensile cracking resistance, and enhanced shear strength due to bridging effect of fibers in Ultra-High Performance Concrete (UHPC).
Poster Number: CE-43  
Authors: Monisha Solipuram; Parviz Soroushian
Title: Energy-Efficient Transformation of Iron Slag into a Hydraulic Cement for Concrete Production

Abstract: Metallurgical slags are produced at large and growing quantities across the world. One specific slag, blast furnace slag generated in the course of extracting iron from ore, has been amorphized (by sudden cooling) for use as a partial replacement for Portland cement. The main thrust of this research is to develop a hydraulic cement that relies primarily on slag as raw material. This goal is achieved by pursuing the concept of a chemical cement where the hydration reactions occurring in the case of Portland cement are replaced with through-solution chemical reactions for production of a solid binder. This alternative vision for a hydraulic cement enables the use of sustainable methods of processing the predominantly waste raw materials into a hydraulic cement, and could expand the range of metallurgical slags that could be used for cement production.

This work was supported in part by The project is funded by EPA

Poster Number: CE-44  
Authors: Steven Stapleton; Anthony Ingle; Meghna Chakraborty; Timothy Gates
Title: Safety Performance Functions for Rural Two-Lane County Road Segments

Abstract: Safety performance functions (SPFs) were developed for federal aid and non-federal aid rural two-lane county roadway segments in Michigan. Five years of crash data (2011-2015) were analyzed for greater than 6,800 miles of rural county roadways, covering 29 of Michigan’s 83 counties and representing all regions of the state. Three analyses were conducted for total and injury crashes: 1.) paved federal aid county segments, 2.) paved non-federal aid county segments, and 3.) non-federal aid county segments (paved and unpaved) with annual average daily traffic volumes below 400. To account for the unobserved heterogeneity associated with differing design standards between counties, a random effects negative binomial model with a county-specific random effect was utilized. Not surprisingly, the county SPF results were generally different than would be expected on state-maintained facilities. County federal aid roadways showed a higher crash occurrence rate than county non-federal aid, the Highway Safety Manual (HSM) two-lane rural roadways model, and state-maintained rural highways in Michigan. County non-federal aid paved roadways showed performance that was remarkably similar to the HSM base rural two-lane roadway model, while gravel roadways showed a greater crash occurrence rate. The presence of a curve with a design speed below 55 mph had the greatest impact on crash occurrence and showed strong association with total and injury crash occurrence across all county road classes. Increasing driveway density was also found to be associated with increased crash occurrence. However, lane width, roadway surface width, and paved shoulder width had little to no impact on crashes.

This work was supported in part by Michigan Department of Transportation

Poster Number: CE-45  
Authors: Suhail Hyder Vattathurvalappil; Mahmoodul Haq
Title: Experimental and Numerical Characterization of quasi-static compression in Tri-Axial Braided CFRP Crush-Tubes

Abstract: Lightweighting and stringent safety requirements govern the design and development of crush tubes in automotive applications. Tri-axial carbon sleeve based crush tubes have been used in the past as excellent alternatives to conventional metal tubes. An efficient design process of composite crush-tube demands better understanding of its material behavior at the meso or micro scale, where the damage initiates.

In this work, micromechanical models were developed and experimentally validated from ‘simple material model (tensile behavior)’ to a ‘full-crush tube (structural behavior)’. First, single layer tri-axial weave (60o/0o/60o) carbon fiber samples were manufactured and subjected to quasi-static tensile testing. Numerical modeling was performed in commercial software ABAQUS®/GENOA® CAE while the unit cell depicting the realistic weave morphology was created in TEXGEN® software. Upon validating the tensile behavior, the numerical model was used to predict the structural behavior of the crush tube. Next, a crush-tube (internal dia. 3in. and length 6in) was manufactured and tested in quasi-static compression (2 mm/min.) Digital Image correlation (DIC) was used both at the material level and structural level. DIC images showed that scissoring effect caused due to extension of the tensile coupon results in matrix cracking followed by de-bonding between tows and matrix. Specific energy absorption predicted using the numerical model agreed well with those of crush tests. Future work would extend this work at higher strain rates, multiple laminae, and hybrid material (i/glass/carbon/aramid) to aid in better design of braided crush tubes.
Abstracts of the 2018 Engineering Graduate Research Symposium, Michigan State University

**Poster Number:** CE-46  
**Authors:** Sveetha Venkatachari; M Z Naser; V K R Kodur  
**Title:** Egress Parameters Influencing Emergency Evacuation in High-rise Buildings

**Abstract:** Fire in buildings pose a significant threat to the structural system as well as occupants. Incidents of fire in the past have shown that buildings are vulnerable to excessive damage or even collapse. Further, rapid spread of fire and smoke in buildings can hinder the process of evacuation resulting in loss of human life. Such situations call for a reliable egress system for safe evacuation of occupants from the building under fire in minimal time. The required duration for occupants to reach a location of safety is typically described by geometry and arrangement of egress components, occupant load, speed, etc. In addition, updating the occupants and first responders with much-needed situational awareness such as accessible stairwells and exits during the disaster can be a contributing factor in determining the duration of rescue operation. This work examines evacuation scenarios and human behavior in high-rise buildings exposed to fire. A parametric study is carried out considering three buildings of varying storey heights (20 storey, 40 storey and 80 storey) subjected to fire conditions. The effect of critical parameters such as location, number and size of the egress paths on the evacuation process is evaluated. The building egress time is estimated under normal conditions (to simulate fire evacuation drill) and fire conditions with and without situational awareness. Results from the study shows that the current provisions in the code for minimum width and number of stairwells might not be sufficient in the case of high-rise buildings exceeding a critical height for successful evacuation.

**Poster Number:** CE-47  
**Authors:** Yehua Wang; V.K.R. Kodur  
**Title:** Mechanical Properties of Prestressing Steel Wire at Elevated Temperatures

**Abstract:** In recent times, prestressed steel structures have been used extensively in the construction industry in China. As a consequence, fire safety design of the structures has become more and more important. However, the basic technique data are not available in the analysis of the fire resistance of prestressed steel structures. In this paper the details of the experimental study of the mechanical properties of prestressing steel wire at elevated temperatures are presented. Tensile coupon steady tests were conducted at temperatures in the range of 20°C to 600°C to investigate the mechanical properties of 1670 Grade, φ5, low-relaxation prestressing steel wires which are commonly used in prestressed steel structures in China. The curves of elastic modulus, yield strength and ultimate strength versus different temperatures are obtained and equations for predicted these mechanical properties are proposed. Furthermore, the test results are plotted and compared with the prediction from the British and European standards, and also compared with the test results obtained by other researchers. The discrepancies between the results are analyzed. In addition, the ratios of ultimate strength to yield strength, the contracting ratios of rupture sections of prestressing steel wire are presented in the paper. Furthermore, the stress-strain curves at different temperatures of prestressing steel wires are described and compared with the models proposed by European standards. At last a stress-strain model that can accurately describe the stress-strain relationship of prestressing steel wire at elevated temperatures is proposed.

**Poster Number:** CE-48  
**Authors:** Lijiang Xu; Mingzhe Li; Wei Yi Lu  
**Title:** Influence of Nanopore Size on Yield Strength of Ceramic Nanofoams

**Abstract:** Light-weight and strong materials are desired for many applications including airplanes, automobiles, mobile electronics and biomedical devices, to improve energy efficiency, as well as the load carrying capability. One of the most commonly used light-weight materials is foam. However, its application is hindered by lack of strength, since its yield strength is proportional to its density by first order of estimation. In order to develop light but strong materials, i.e. increase the specific yield strength, one possible solution is ceramic foams with nanoscale pores due to the unique size effect of ceramics. It has been demonstrated that the defects, i.e. the pre-exist micro-cracks, in bulk ceramics significantly lower the elastic limit of these materials. Common ceramics fracture at a stress much lower than the yield strength. By reducing the size of ceramics, the density as well as the initial length of the micro-cracks decrease dramatically, and thus the strength of the material is much improved. Based on the size effect, we hypothesize that for ceramic nanofoams, the specific yield strength (i) can be significantly improved when the thickness of the pore wall is less than one micron; and (ii) increases with reduced wall thickness. To test our hypotheses, we have selected three grades of nanoporous silica spheres with same porosity and particle size but different nanopore size. The average nanopore sizes of the selected silica nanofoams are 12 nm, 100 nm, and 200 nm, respectively, which have been converted into the nanopore wall thicknesses by using the particle size, porosity and SEM imaging. Nano-indentation tests have been conducted to characterize the hardness of individual nanoporous silica particles by atomic force microscopy (AFM). As all three silica nanofoams have same porosity and matrix material, they have the same density. The measured hardness is directly compared to reveal the effect of reduced nanopore wall thickness on specific strength of ceramic nanofoam. In addition, the specific hardness of solid silica particle (sand grain) found from literature has been also used to compare with our experimental data.
COMPUTATIONAL MATHEMATICS,
SCIENCE AND ENGINEERING

Poster Number: CMSE-01
Authors: Eduardo Augusto Barros de Moraes; Mohsen Zayernouri; Mark M. Meerschaert
Title: Phase-Field Model Uncertainty Quantification for Structural Failure due to Fatigue

Abstract: We present a non-isothermal, thermodynamically consistent phase field model for structural damage and fatigue. Damage is considered as a continuous dynamical variable, and fatigue is treated as a continuous internal variable. This continuum approach allows the modeling of crack initiation, propagation and coalescence. However, many parameters of the model cannot be measured directly through experiments, leading to uncertainty in quantities of interest. In this poster we present examples showing that the uncertainty from parameters can directly affect the damage evolution, and present two useful methods to quantify the uncertainty in this context, Monte Carlo and Stochastic Collocation.

This work was supported in part by MURI

Poster Number: CMSE-02
Authors: Thomas Chuna
Title: Solving the Inverse Laplace Transform via Bayesian Inference

Abstract: We focus on how to solve an ill-posed inverse Laplace transform arising from the analytic continuation of quantum Monte Carlo data. The status quo for solving this inverse problem is the maximum entropy method (MEM). MEM is a Bayesian inference approach which uses an entropic prior, to introduce information about the spectrum. We compare the various methods for solving MEM via a novel deterministic approach which studies fundamental assumptions about an inverse image’s dependence on the entropic prior.

Poster Number: CMSE-03
Authors: Zane Crawford; Shanker Balasubramaniam
Title: Bayesian Analysis of Differential Equations

Abstract: Many numerical solvers exist to solve differential equations for some domain given a number of initial conditions. In the problems of interest, the differential equations are assumed to be deterministic, and can be solved with methods such as Euler, Runge-Kutta, and Adams-Basforth to perform an integral based on some quadrature rule. These methods use successive approximations of the dependent variable to find a valid solution to the differential equation, with the approximations contributing to the error. However, because the true value of the solution to the differential equation is not known, a probabilistic framework can be formed. In this work, we review Bayesian analysis to solve differential equations, in which the differential equation is treated as a Bayesian inference problem. An algorithmic approach to solving partial differential equations will be presented and compared to other explicit and implicit numerical methods. Results solving problems in one dimension will be presented.

This work was supported in part by Department of Energy Computational Science Graduate Fellowship

Poster Number: CMSE-04
Authors: Michael Crockatt; Andrew Christlieb; Cory Hauck
Title: A Two-Grid Defect Correction Method for Radiation Transport Using IDC

Abstract: We present a two-grid defect correction method for radiation transport using integral deferred correction. This method is a variation of a hybrid approach for radiation transport in which the angular flux is decomposed into collided and uncollided components to which low- and high-resolution discrete ordinates approximations are applied, respectively. The novelty of the method stems from the fact that the defect correction iteration accounts for errors in both temporal and angular variables simultaneously. A test problem in two-dimensional Cartesian geometry consisting of a dense, spherical body radiating into a vacuum is used to demonstrate the ability of the two-grid defect correction method to accurately resolve transitions between collisionality regimes.
**Title:** Unbinding Pathway for pk11195 and TSPO Complex

**Abstract:** Translocator Protein (TSPO) is located in the mitochondrial membrane of eukaryotic organisms, particularly in steroid synthesizing cells. While not much is known about the function of TSPO, its protein expression in brain cells is upregulated in certain neurological conditions, including brain inflammation (BI). Furthermore, studies have shown the upregulation is more than just an indication; TSPO specific ligands may have therapeutic effects in the treatment of BI. It has been shown that increasing the therapeutic window of BI treatment requires ligands that bind to TSPO with longer residence time, increasing pharmacological activity.

To develop ligands with long residence times, it is critical to understand the unbinding kinetics of existing ligands. Molecular dynamics simulations (MD) can provide such information, but are limited by large energy barriers between transitional states that are difficult to overcome. However enhanced sampling methods are able to overcome these barriers and can give insight into rare events. We use one such method, WEExplore, a variant of the weighted ensemble algorithm, to simulate the unbinding kinetics of pk11195, a ligand with a high affinity to TSPO. We use many independent simulations to obtain a statistical representation of the free energy landscape. Our goal is to uncover the unbinding pathway of pk11195, and we report our progress towards this goal. Using this pathway, a Markov State model was built, which represents the statistical likelihood of pk11195 transitioning from one conformation to another. From these results, new ligands can be designed that exhibit longer residence times when bound to TSPO.

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**Title:** Simulations of Thermal Heating from Active Galactic Nuclei in Galaxy Clusters

**Abstract:** Observations from the last decade have revealed the existence of cool-core clusters, galaxy clusters with a cooling time much shorter than the dynamical time. Recent work suggests that clusters may be thermally stable due a central heating mechanism such as an active galactic nucleus (AGN) that prevents cooling. Previous analytical work in one dimension has shown that thermal heating from a central AGN with a power-law radial profile, where the heating exceeds cooling at near and far radii but not in an intermediate region, may produce a stable cluster with an isentropic entropy profile in the core and an isothermal profile outside the cluster. To test this, I simulated idealized galaxy clusters using the ENZO code with thermal heating from a central AGN. Thermal heating as a function of radius was injected proportional to the radius to a fixed exponent in (-3,-2) for each run. Total thermal feedback was set equal to the total rate of cooling in the cluster. I present entropy profiles, phase plots, and heating and cooling rates versus radius and time for several simulations. Previous numerical work with thermal and kinetic feedback through a precessing jet has shown self-regulating AGN activity. However, the kinetic feedback requires too high a spatial resolution to be useful for large cosmology simulations. A model with purely thermal feedback with the same self-regulation could be incorporated into larger simulations.

*This work was supported in part by NASA*

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**Title:** Operator-Based Uncertainty Quantification of Fractional PDEs, Application to Anomalous Transport

**Abstract:** Fractional differential equations, as a well-structured generalization of their integer order counterparts, provide a rigorous mathematical tool to describe anomalous behavior and nonlocal history dependent effect in multi-physics complex systems. The inherent non-local nature of such integro-differential operators, which complies primarily with the essential anomaly of underlying stochastic processes, allows us to model phenomena across multiple time and space scales. Their applications extend to a large volume of research on viscoelastic materials with memory, non-Brownian transport phenomena in porous media, wave propagation in disordered materials, non-Gaussian processes in turbulent flows, non-Newtonian fluids and rheology, multi-scale patterns in biological tissue, system identification, and automatic control. We develop an uncertainty quantification framework in the context of fractional differential equations, in which we characterize different sources of uncertainties and then, propagate their associated randomness to the system response. The excessive computational costs are a common challenge in most uncertainty propagation techniques as they generally instruct operations of forward solver for many realizations of random parameters. We overcome this challenge by employing a non-intrusive scheme, which constructs a discrete sample set of random space by using spars grid generators. We further develop the forward solver by formulating a fast, stable, and convergent Petrov-Galerkin spectral method in the physical domain to simulate each realization of random inputs.

*This work was supported in part by the Air Force Office of Scientific Research Young Investigator Program (YIP) award on: ‘Data-Infused Fractional PDE Modeling and Simulation of Anomalous Transport’ [FA9550-17-1-0150].*
**Poster Number:** CMSE-08  
**Authors:** LaRose Ryan  
**Title:** Classical Simulation of Quantum Circuits

**Abstract:** We describe, implement, and test the performance of distributed memory simulations of quantum circuits on the MSU Laconia Top500 supercomputer. Using OpenMP and MPI hybrid parallelization, we first use a distributed matrix-vector multiplication with one-dimensional partitioning and discuss the shortcomings of this method due to the exponential memory requirements in simulating quantum computers. We then describe a more efficient method that stores only the $2^n$ amplitudes of the $|\psi>$ qubit state vector and optimize its single node performance. In our multi-node implementation, we use a single amplitude communication protocol that maximizes the number of qubits able to be simulated and minimizes the ratio of qubits that require communication to those that do not, and we present an algorithm for efficiently determining communication pairs among processors. We simulate up to 30 qubits on a single node and 33 qubits with the state vector partitioned across 64 nodes. Lastly, we discuss the advantages and disadvantages of our communication scheme, propose potential improvements, and describe other optimizations such as storing the state vector non-sequentially in memory to map communication requirements to idle qubits in the circuit.

**Poster Number:** CMSE-09  
**Authors:** Mehdi Samiee; Mohsen Zayernouri; Mark M. Meerschaert  
**Title:** Multifractal Modeling of Turbulent Mixing

**Abstract:** The advection of particles by a turbulent flow is important in turbulent mixing, combustion, pollution, and studies of atmospheric boundary layers. The statistical properties of so-called “passive scalar” turbulence exhibit anomalous behavior, including long-range memory or non-local spatial interactions. Fractional PDEs (FPDEs) are emerging as a powerful tool for modeling such anomalous phenomena. Here, advection-dispersion equations involving the fractional Laplacian are proposed as an Eulerian stochastic model for passive scalar dispersion in homogeneous incompressible turbulent flows. Considering Eulerian and Lagrangian approaches, we investigate the advection of passive scalars in some canonical problems, including mixing layer and isotropic decaying turbulence, where the corresponding velocity fields are provided by Direct Numerical Simulation (DNS). The exponent of the fractional Laplacian term in the Eulerian approach is determined from the intermittent behavior of the passive scalar turbulence.

This work was supported in part by This work was supported by the AFOSR Young Investigator Program (YIP) award on: Data-Infused Fractional PDE Modelling and Simulation of Anomalous Transport (FA9550-17-1-0150) and by the MURI/ARO on Fractional PDEs for Conservation Laws and Beyond: Theory

**Poster Number:** CMSE-10  
**Authors:** Jorge Suzuki; Mohsen Zayernouri  
**Title:** Generalized Fractional-Order Visco-Elasto-Plasticity with Damage for Anomalous Materials

**Abstract:** In this work we introduce an efficient framework that uses a generalized, fractional-order visco-elastic model, coupled to a fractional visco-plastic component and a modified Lemaitre damage model to introduce material degradation. The visco-plastic/damage coupling is thermodynamically consistent, with the constitutive laws derived using appropriate fractional-order Helmholtz free-energy potentials. The dissipation potential for visco-plasticity is defined as a time-fractional yield function. The damage potential has the same form as the classical Lemaitre's approach, but the damage energy density release rate is described by a fractional-order potential. We perform a time-fractional integration of the resulting system of FODEs using a fractional return-mapping algorithm, with fast convolution scheme to achieve computational complexity $O(n \log(n))$. The model is then implemented in a Finite Element framework for the analysis of geometrically nonlinear trusses.
**Poster Number:** CMSE-11  
**Authors:** Hao Wang; Anshul Kundaje; Jianrong Wang  
**Title:** Systematic Delineation of Enhancer Regulation by Probabilistic Modeling of CRISPR Screening Data

**Abstract:** Genetic screening by CRISPR provides a valuable approach to dissect regulatory enhancers and the mechanisms. Unlike essentiality-analysis on genes, it is difficult to accurately identify essential enhancers directly from the observed CRISPR data. This critical barrier stems from the complex regulatory functions of enhancers: 1) enhancers are highly cell-type specific and there is a lack of validated sets of essential enhancers for diverse cellular contexts as gold-standard; 2) enhancers involve different combinatorial transcription factor (TF) binding, which is largely unknown; and 3) long-range enhancer regulation is mediated by 3D chromatin interactions.

We developed a new hierarchical Bayesian model and an efficient MCMC inference algorithm to simultaneously predict functionally essential enhancers for specific cellular contexts, underlying combinatorial TF binding sites, and the downstream regulated gene pathways. In addition to CRISPR data, our model integrates DNA sequence features and 3D enhancer-promoter interactions.

We applied our model on a CRISPR screening dataset of ~3k enhancers in K562 cancer cell-line. The algorithm identified ~1k enhancers as essential for K562, which are supported by significant sgRNA fold changes, stronger H3K4me1 and DNase I signals, and denser interactions with genes. Furthermore, distinct subsets of essential enhancers are classified based on their associations with combinatorial TF bindings, i.e. regulatory grammar. Notably, GATA factor binding motif is inferred, along with other de-novo motifs co-occur with GATA, providing novel insights on the functional domains of different enhancers. The model also predicts long-range target genes regulated by enhancers. These genes show elevated essentiality scores and are enriched in specific biological pathways, e.g. PI3K-AKT pathway and leukocyte migration, highlighting functional roles of distal regulatory genetic variants.

Our integrative computational approach effectively leverage multiple channels of information to improve our understanding of CRISPR screening data, enhancer regulation mechanism, and non-coding variants in human disease.

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**Poster Number:** CMSE-12  
**Authors:** Anna Yannakopoulos; Arjun Krishnan  
**Title:** Weak Semi-supervised Machine Learning on Gene Expression Data

**Abstract:** Complex diseases such as autism spectrum disorder or coronary artery disease are caused by several perturbed cellular mechanisms associated with hundreds of interacting genes. However, identifying which genes are actually linked to a particular disease is a significant challenge. For example, patients diagnosed with the same disease might have distinct sets of genetic causes. Most mutations have only small-to-moderate effects on the disease, making them hard to detect. Furthermore, identifying all the associated genes requires extremely large populations of patients. These complications make the comprehensive identification of disease-associated genes impossible through traditional genetic screenings. One approach is to use machine learning (ML) to build upon currently known disease-associated genes to identify others based on hundreds of thousands of human genetic and molecular data that is publicly available. However, this approach is not straightforward because genes are linked to diseases with varying levels of confidence, ranging from strong experimental evidence to weak circumstantial associations. Though all of these gene-disease linkages can hold valuable information, traditional ML algorithms do not incorporate examples with varying levels of evidence. We have developed a suite of ML methods that can systematically incorporate such "weighted" prior information. Furthermore, we have extended these disease-gene prediction methods for use with noisy, low-quality data sets wherein some data is known to be less certain, but not which data.

*This work was supported in part by MSU Engineering Distinguished Fellowship & MSU Startup Funds for AK*
COMPUTER SCIENCE

Poster Number: CSE-01
Authors: Faraz Ahmed; Moritz Steiner; Utkarsh Goel; Martin Flack; Stephen Ludin; Alex X. Liu
Title: Characterizing Impact of Network, Device, and Protocol Dynamics on Web Performance

Abstract: Over the years World Wide Web has evolved into a complex ecosystem that is built on the interconnections between Content Providers (CPs), Content Distribution Networks (CDNs) and Internet Service Providers (ISPs). In order to achieve high user engagement, CPs design visually appealing web pages that are composed of several static and dynamic objects such as images, HTML files, CSS style sheets, JavaScripts etc. Prior studies have shown that besides web page designs, user engagement is also dependent on how quickly a web page is rendered on the user’s screen. Web page load time is a key performance metric that represents web browsing performance. Page load time (PLT) directly impacts user’s web browsing quality of experience and hence affects user engagement. User QoE is affected by a wide range of factors such as time of day, serving Radio Network Controller (RNC), cellular device type, smartphone application, content provider, browser version, OS version, IP protocol version, and server side configurations. In this task, we aim to identify the dimensions that impact QoE the most so that cellular networks, external administrative domains like content providers, CDNs, device manufacturers, can then use these findings to jointly optimize user QoE.

Poster Number: CSE-02
Authors: Kamran Ali; Alex X. Liu; Kazuhito Koishida
Title: AirSense: Bringing WiFi Based Activity Recognition to Smart-Home Assistants

Abstract: In this work, we have proposed signal processing techniques and deep learning architectures to bring device-free sensing to smart-home devices such as Amazon Alexa, Google Home and Microsoft Invoke.

This work was supported in part by Microsoft Research

Poster Number: CSE-03
Authors: Salman Ali; Alex X. Liu
Title: Detecting Objects Using Ultrasound on a Commodity Device

Abstract: Object type detection has important applications in computer science and security domain. Till now it has been done with complex hardware and signal processing techniques requiring specialized equipment. In this paper, we propose to use ultrasound acoustic signals in the range 17-22 KHz on a smartphone device to distinguish between different object surfaces. The key idea is to use smartphone speakers to send ultrasound acoustic signal beacons and receive them after reflection from an object using microphone. Features related to different signal changes are then calculated and minor variations are observed and fed into a learning classifier network. Using learned features overtime, the system then recognizes the surface of the material and eventually the object itself. The system is built on an android smartphone and tested on several object surfaces. The method can also be used as a context generation and recognition tool to identify different environments.

Poster Number: CSE-04
Authors: Pranshu Bajpai; Richard Enbody
Title: Evolution of Key Management in Ransomware

Abstract: Cryptovirii are malicious programs that encrypt user data with the goal of extorting money from the victim in exchange for file decryption. WannaCry, Petya, CryptoLocker and TeslaCrypt are some of the more notable examples of such ransomware. In this study, we present how several key management models are deployed in these ransomware with the objective of providing a deeper comprehension of potential flaws in cryptoviral infections and how they have evolved and grown more resistant over time. We introduce and explore the answers to several crucial questions such as how and where the encryption key generated, where is it stored, and how is it used to encrypt user data? How is the decryption key protected by the attacker and is there a possibility of recovering this key without paying the ransom? The ultimate objective of our research is to discover, study and exploit cryptographic, strategic and operational flaws in ransomware in order to mitigate this formidable threat to organizations and individuals.
Poster Number: CSE-05  
Authors: Sudipta Banerjee; Arun Ross  
Title: Generating an Image Phylogeny Tree for Near-Duplicate Images  

Abstract: Consider an image that is subjected to a sequence of simple photometric transformations such as gamma correction, histogram equalization, brightness and contrast adjustment, etc. This would result in a family of transformed images. Given a set of such "near-duplicate" images, we develop a method that automatically deduces the relationship between these images and constructs an Image Phylogeny Tree (IPT) that captures their evolutionary structure (i.e., which image originated from which one). We advance the state of the art by (a) first using basis functions derived from Legendre Polynomials and Gaussian Radial Basis Functions to model the relationship between every image pair, and (b) then using the estimated parameters of the model to determine the probability that one image directly evolved from the other. Experiments confirm the potential of the scheme in generating reliable IPTs in the context of photometrically modified images.

Poster Number: CSE-06  
Authors: Inci M. Baytas; Cao Xiao; Fei Wang; Anil K. Jain; Jiayu Zhou  
Title: Deep Embedding Learning for Heterogeneous Attributed Hyper-Networks  

Abstract: Heterogeneous hyper-networks provide an efficient way to model and analyze data with complicated multi-modal and composite interactions. To be able to perform common prediction tasks on such networks, a distributed vector representation for each node is required. Network embedding aims to learn low-dimensional vector representations for the nodes while preserving and highlighting the prominent structure of the network. However, it becomes challenging when there are multiple modalities and more than two nodes in one edge as in heterogeneous attributed hyper-networks. In this study, a heterogeneous attributed hyper-network embedding approach is proposed. A deep model is designed to learn a projection to a common low-dimensional embedding space for different types of nodes along with a tuplewise similarity function. Complicated and non-linear nature of the tuplewise relationships is addressed by the aforementioned deep model which is optimized with a ranking based loss function to improve the similarity scores of hyperedges in the embedding space. Thus, the learned embedding aims to preserve the structure of the hyper-network after the projection and improve the performance of predictive tasks on heterogeneous hyper-networks. The proposed method is tested on synthetic and real world datasets and its performance is compared with popular network embedding methods.

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National Science Foundation under grants IIS-1565596 and IIS-1615597

Poster Number: CSE-07  
Authors: Denton Bobeldyk; Arun Ross  
Title: Predicting Eye Color from Near Infrared Iris Images  

Abstract: Iris recognition systems typically acquire images of the iris in the near-infrared (NIR) spectrum rather than the visible spectrum. The use of NIR imaging facilitates the extraction of texture even from darker color irides (e.g., brown eyes). While NIR sensors reveal the textural details of the iris, the pigmentation and color details that are normally observed in the visible spectrum are subdued. In this work, we develop a method to predict the color of the iris from NIR images. In particular, we demonstrate that it is possible to distinguish between two categories of eye color in the NIR spectrum by using the BSIF texture descriptor: {blue, green, hazel} and {brown}. Experiments on the BioCOP 2009 dataset containing over 43,000 iris images indicate that it is possible to distinguish between these two categories of eye color with an accuracy of ~90%. This suggests that the structure and texture of the iris as manifested in 2D NIR iris images divulge information about the pigmentation and color of the iris.

This work was supported in part by the NSF Center for Identification Technology Research at West Virginia University.
Poster Number: CSE-08  
Authors: Garrick Brazil; Xiaoming Liu  
Title: Autoregressive Pedestrian Detection

Abstract: Pedestrian detection traditionally uses box-based annotations for supervision, which carry few details on fine-level semantics. In this work, we show how an autoregressive loss can be leveraged in order to discover and focus on more semantically meaningful features which enhance the classification power of pedestrian detection. We first propose a encoder-decoder-encoder network, which enables our network to learn semantically rich features at a diverse set of strides. We utilize deconvolution and feature compression in order to keep the overhead of our enhanced architecture light and efficient. Using a multi-feature stride network along with an autoregressive loss policy enables our framework to achieve state-of-the-art performance on Caltech and KITTI datasets for pedestrian detection.

Poster Number: CSE-09  
Authors: Kai Cao; Anil K. Jain  
Title: Fingerprint Synthesis: Evaluating Fingerprint Search at Scale

Abstract: A database of a large number of fingerprint images is highly desired for designing and evaluating large scale fingerprint search algorithms. Compared to collecting a large number of real fingerprints, which is very costly in terms of time, effort and expense, and also involves stringent privacy issues, synthetic fingerprints can be generated at low cost and does not have any privacy issues to deal with. However, it is essential to show that the characteristics and appearance of real and synthetic fingerprint images are sufficiently similar. We propose a Generative Adversarial Network (GAN) to generate 512×512 rolled fingerprint images. Our generative model for rolled fingerprints is highly efficient (12ms/image) with characteristics of synthetic rolled prints close to real rolled images. Experimental results show that our model captures the properties of real rolled fingerprints in terms of (i) fingerprint image quality, (ii) distinctiveness and (iii) minutiae configuration. Our synthetic fingerprint images are more realistic than other approaches.

This work was supported in part by IARPA

Poster Number: CSE-10  
Authors: Jiao Chen; Yanni Sun  
Title: Viral Genome Assembly Using Incomplete Reference

Abstract: Characterizing viral genomes and strains from metagenomics data is computationally difficult due to the high similarity between strains, heterogeneous coverage of viruses, and the sheer data size. The reference-based virus analysis, while serves as the main stream pipeline, still suffers from the lack of quality or complete genomes for viruses with high mutation rate or novel viruses. In this work, we developed a hybrid method that conducts strain-level de novo assembly using only partial or remotely related reference genomes. It has utilities in identifying RNA viral strains with high mutation rates such as HIV, HCV from clinical metagenomic data. Or it can be applied to identify possibly novel viruses that contain functional sites of interests to the researchers. In this case, the reference sequences are a single or multiple functional sites, which are usually protein coding genes. Our tool is designed to output the whole virus genome containing the target genes rather than just a gene sequence. We applied our tool to both simulated and real viral metagenomic data set. In the first real data sets, we show the analysis of several RNA viruses in a blood plasma metagenomic data set. In the second data set, we demonstrate that using remotely related virus genome from an animal, we can fully recover the SARS virus. In summary, our tool provides a complementary utility to existing virus analysis software.
Poster Number: CSE-11  
Authors: Anurag Chowdhury; Arun Ross  
Title: Speaker Verification in Degraded Audio Signals  

Abstract: An automated speaker verification system compares the voice information in two audio samples and determines if they correspond to the same individual or not. The performance of such a system is adversely affected by several types of noise that can drastically degrade the quality of the audio samples. In this work we propose a deep learning-based speaker verification system that uses both Mel-Frequency Cepstral Coefficients (MFCC) and Linear Predictive Coding (LPC) for representing audio signals. In this regard, we construct a 1D Convolutional Neural Network (1D-CNN) whose input consists of both MFCC and LPC features stacked together in a two-channel configuration. The features themselves are extracted from audio frames of fixed temporal expanses. The MFCC features are believed to capture acoustic characteristics as perceived by the human ear ("perception"), while the LPC features are believed to capture the vocal tract characteristics of the speaker ("production"). The proposed 1D-CNN is observed to learn noise-robust speaker dependent characteristics from the combination of MFCC and LPC features. Experimental results convey the efficacy of the proposed algorithm.

This work was supported in part by Federal Bureau of Investigation - Biometric Center of Excellence (FBI-BCOE)

Poster Number: CSE-12  
Authors: Tarang Chugh; Kai Cao; Anil K. Jain  
Title: Fingerprint Spoof Buster  

Abstract: The primary purpose of a fingerprint recognition system is to ensure a reliable and accurate user authentication, but the security of the recognition system itself can be jeopardized by spoof attacks. This research addresses the problem of developing accurate, generalizable, and efficient algorithms for detecting fingerprint spoof attacks. Specifically, we propose a deep convolutional neural network based approach utilizing local patches centered and aligned using fingerprint minutiae. Experimental results on three public-domain LivDet datasets (2011, 2013, and 2015) show that the proposed approach provides state-of-the-art accuracies in fingerprint spoof detection for intra-sensor, cross-material, cross-sensor, as well as cross-dataset testing scenarios. For example, in LivDet 2015, the proposed approach achieves 99.03% average accuracy over all sensors compared to 95.51% achieved by the LivDet 2015 competition winners. We also present a graphical user interface, called Fingerprint Spoof Buster, that allows the operator to visually examine the local regions of the fingerprint highlighted as live or spoof, instead of relying on only a single score as output by the traditional approaches.

This work was supported in part by Intelligence Advanced Research Projects Activity (IARPA) Grant

Poster Number: CSE-13  
Authors: Melissa Dale; Arun Ross  
Title: A Medical Imaging Interface: Stem Cell Detection in MRI Images  

Abstract: The detection and tracking of stem cells is essential for evaluating the success of targeted stem cell based therapy. We design a user interface to allow radiologists and other medical experts to visualize the output of an automated cell detection method developed by Afridi et al. This method is based on a convolutional neural network (CNN) that employs transfer learning principles to leverage CNNs that were previously trained using labeled images from a different problem domain. In designing this interface, we are concerned not only with the accuracy of the results but also the speed, performance, and usability of the interface. Our goal is to create an intuitive interface that will be useful to medical professionals whose primary concern is the detection of these stem cell spots in MRI slices, as well as computer scientists who are interested in the underlying methodologies. We are currently investigating the addition of multiple CNN architectures to the interface. In the interest of continually improving stem cell spot detection, the interface will allow experts to supplement the limited training data that is currently available by providing additional annotations and labeling of stem cells. This additional data will then be used to retrain the CNNs and further improve stem cell detection accuracy.

This work was supported in part by National Institute of Health
Poster Number: CSE-14  
**Authors:** Debayan Deb; Anil K. Jain  
**Title:** Automatic Lemur Identification  
**Abstract:** Lemurs are among the world's most endangered mammals. Loss in habitat, hunting pressures, and illegal trafficking contribute to an ongoing threat to their survival. In addition, current methods for tracking individual lemurs often involve invasive measures such as capturing and tagging techniques that pose further threat. We aim to build a non-invasive, robust and efficient method of individual lemur identification through a computer-aided face recognition specifically designed for lemur identification.

Poster Number: CSE-15  
**Authors:** Tyler Derr; Chenxing Wang; Suhang Wang; Jiliang Tang  
**Title:** Node Relevance Measurements in Online Signed Social Networks  
**Abstract:** Measuring node relevance is fundamental to social network analysis, which has been proven to benefit many network analysis tasks and applications such as link prediction, node classification, community detection, search and recommendations. The majority of existing node relevance measurements focused on unsigned social networks (or networks with only positive links). However, social media provides mechanisms that allow online users to specify negative links in addition to positive ones. For example, Slashdot users can create foe links; users in Epinions can establish distrust relations; while users in Facebook and Twitter can block or unfriend others. Thereby, social networks with both positive and negative links (or signed social networks) become ubiquitous in social media and have attracted increasing attention in recent years. On the one hand, it is evident from recent studies that negative links have added value in a number of analytical tasks. On the other hand, the availability of negative links challenges existing node relevance measurements designed for unsigned networks. Hence, we need dedicated node relevance measurements for signed social networks. In this paper, we present an initial and comprehensive investigation on signed relevance measurements and design numerous relevance measurements for signed social networks from both local and global perspectives. Empirical experiments on four real-world signed social networks demonstrate the importance of negative links in building signed relevance measurements and their effects on social network analysis tasks, specifically link prediction and tie strength prediction.  

*This work was supported in part by Tyler Derr and Jiliang Tang are supported by the National Science Foundation (NSF) under grant number IIS-1714741 and IIS-1715940.*

Poster Number: CSE-16  
**Authors:** Rahul Dey; Vishnu Boddeti  
**Title:** Pedestrian Simulation for Data Reinforced Situational Awareness  
**Abstract:** Autonomous driving capabilities are increasingly becoming smarter and more popular. In order to train an autonomous vehicle to drive safely, it needs to be exposed to a variety of situations. This becomes even trickier in the case of pedestrians as there can be a number of precarious situations that are not very common but must be learnt by the autonomous driving model to drive safely. For example, a kid running on the street or a person walking on the street while texting. The idea of this project is to generate such situations artificially so that the autonomous model can be trained to make quick decisions when such a situation arises. We use an enhanced model of Generative Adversarial Networks (GANs) to learn to generate pedestrian images. The GAN is supervised using a pose-estimation model that gives feedback to the GAN on the quality of the pedestrian image generated using a Conditional Random Fields (CRF) Model. The idea is to generate pedestrian images with the pose, gender, orientation, and other attributes supplied during run-time.
Poster Number: CSE-17
Authors: Nan Du; Yanni Sun
Title: Improve the Sensitivity of Detecting Long Read Overlaps Using Grouped Short kmer Matches

Abstract: Single-molecule, real-time sequencing (SMRT) developed by Pacific BioSciences produces longer reads than secondary generation sequencing technologies such as Illumina. One key step in genome assembly using long reads is to quickly determine the overlap regions between reads and use that information to create an overlap graph. Because PacBio data has higher sequencing error rate and lower coverage than popular short read sequencing technologies (such as Illumina), efficient detection of true overlaps requires specially designed algorithms. In particular, there is still a need to improve the sensitivity for detecting small overlaps or overlaps with low sequence identity. Addressing this need will enable better assembly for metagenomic data produced by the third generation sequencing technologies.

In this work, we designed and implemented an efficient overlap detection program for PacBio reads based on kmer hits. While using kmer hits for detecting read overlap has been adopted by several existing programs, our method uses a group of short kmer hits to increase the sensitivity in detecting small overlaps between long reads. Group kmer hit was originally designed for remote homology search. We are the first to apply group hit to long read overlap detection. The experimental results of applying our pipeline to both simulated and real PacBio data showed that our method enables more sensitive overlap detection, especially for PacBio data sets of low sequencing coverage.

Poster Number: CSE-18
Authors: Joshua Engelsma; Kai Cao; Anil Jain
Title: RaspiReader: Open Source Fingerprint Reader

Abstract: We open source an easy to assemble, spoof resistant, high resolution, optical fingerprint reader, called RaspiReader, using ubiquitous components. By using our open source STL files and software, RaspiReader can be built in under one hour for only US $175. As such, RaspiReader provides the fingerprint research community a seamless and simple method for quickly prototyping new ideas involving fingerprint reader hardware. In particular, we posit that this open source fingerprint reader will facilitate the exploration of novel fingerprint spoof detection techniques involving both hardware and software. We demonstrate one such spoof detection technique by specially customizing RaspiReader with two cameras for fingerprint image acquisition. One camera provides high contrast, frustrated total internal reflection (FTIR) fingerprint images, and the other outputs direct images of the finger in contact with the platen. Using both of these image streams, we extract complementary information which, when fused together and used for spoof detection, results in marked performance improvement over previous methods relying only on grayscale FTIR images provided by COTS optical readers. Finally, fingerprint matching experiments between images acquired from the FTIR output of RaspiReader and images acquired from a COTS reader verify the interoperability of the RaspiReader with existing COTS optical readers.

This work was supported in part by IARPA, NIST

Poster Number: CSE-19
Authors: Qiaozi Gao; Shaohua Yang; Joyce Chai; Lucy Vanderwende
Title: What Action Causes This? Reasoning and Explaining with Commonsense Causality Knowledge

Abstract: We humans share a vast amount of commonsense causality knowledge. For example, given a verb (e.g., grind) and a noun (e.g., coffee beans), we can predict the effect on the state of the world caused by this action. Given an image, for example, showing many small cucumber pieces, we can infer some external action (e.g., cut) on a cucumber could cause such state. However, artificial agents often do not have this kind of basic commonsense causality knowledge, which makes it difficult for these agents to work with humans and to reason, learn, and perform actions. To address this issue, this work presents an approach that acquires commonsense causality knowledge from human natural language. A novel cost efficient approach was developed to further connect the causality knowledge with the state of the world captured by images with minimal supervision.

This work was supported in part by This work is supported by IIS-1617682 from the National Science Foundation.
Poster Number: CSE-20
Authors: Sixue Gong; Vishnu Boddeti; Anil Jain
Title: Intrinsic Dimensionality of Face Representation

Abstract: Analyzing large amounts of high-dimensional data is an issue of fundamental importance in computer vision. The majority of high-dimensional data in computer vision, for example, face features, are in fact, not truly high-dimensional. Rather, the collective behavior of a large number of degrees of freedom can be often described by a handful of variables. From a geometric point of view, the data are embedded in a high-dimensional space, but can be sufficiently projected into a space of a much lower dimension without loss of information. This observation justifies the use of dimensionality reduction approaches to estimate the intrinsic dimensionality (ID) and build various mapping systems to obtain the intrinsic manifold. Here, we analyze this issue by focusing on the optimal number of degrees of freedom that is needed to capture the notable features of a given face representation. By estimating the ID of the manifold where a face representation lies, we are able to learn a more efficient and compact feature representation. Furthermore, ID affords the discriminative information on the face features and allows more accurate capacity estimates of the feature representation.

Poster Number: CSE-21
Authors: Steven Hoffman; Madison Elyse Bowden; Arun Ross
Title: Is this Real? Presentation Attack Detection in Iris Recognition Systems

Abstract: This work addresses the problem of presentation attacks against iris recognition systems. Iris recognition systems attempt to recognize individuals based on their iris patterns typically acquired in the near-infrared spectrum. However, it is possible for an adversarial user to circumvent the system by presenting a deliberately modified iris pattern or a fake iris pattern. These are called presentation attacks (PAs). Examples of PAs include (1) using printed images of another person’s iris, (2) presenting a fake eye, (3) displaying an eye image on a Kindle, or (4) wearing cosmetic contact lenses to mask one’s own iris pattern. To detect such attacks, we develop a deep convolutional neural network (CNN) that can determine if an input eye image corresponds to an attack or not. By sampling image patches from both the iris region and the periocular region, the proposed CNN is able to extract discriminatory features for effective presentation attack detection. Upon testing our algorithms on several image datasets of real and fake eyes, we observed True Detection Rates as high as 100% at a False Detection Rate of 0.2% in both intra-dataset and cross-dataset experiments.

This work was supported in part by IARPA

Poster Number: CSE-22
Authors: Hamid Karimi; Jiliang Tang
Title: Toward End-to-End Deception Detection in Videos

Abstract: Nowadays people especially online users tend to adopt videos to disseminate or record information. Videos have become an increasingly popular source to deliver deceptive content. Meanwhile, there are various real-world applications such as video ads, airport screenings, courtroom trials, and job interviews where deception detection can play a crucial role. Hence, there are immense demands on deception detection in videos. Moreover, videos contain rich information such as vocal, visual and temporal information, which provide great opportunities for advanced deception detection. Nevertheless, deception detection in videos faces few challenges. First, video data is inherently complex. It is naturally multi-modal and contains complicated temporal dependencies. Second, deception detection needs to offer large degree of interpretability to aid us in understanding deception in more depth. This is quite challenging because of the complexity of deceptive videos. Finlay, videos usually lack detective labels in many real-world applications. Aiming at addressing the aforementioned challenges, in this paper, we study the problem of deception detection in videos. In particular, we propose an end-to-end framework DEV to detect Deceptive Videos which a) automatically captures rich information of videos, b) provides interpretable deception cues, and c) is robust to the small number of training data. Experimental results on real-world videos demonstrate the effectiveness of the proposed framework and further experiments are conducted to understand important factors on detection detection in videos.
Poster Number: CSE-23  
Authors: Douglas Kirkpatrick; Arend Hintze  
Title: Manipulating Spatial Representations in Evolved Robot Brains

Abstract: In the future, robots will need to explore and construct internal representations of complex environments autonomously. Instead of being provided with navigational data, they will need to create their own maps from experience. We developed a measurement that not only quantifies the amount of internal representations that an agent has about it’s environment, but also localizes where this information is stored in the evolved brain of the robot. Here we explore the option to transplant localized spatial memories from an experienced robot to a novice. This is particularly important because we are working with evolved robot brains of which we know neither the topology or the function of individual components.

Poster Number: CSE-24  
Authors: Alexander Lalejini; Charles Ofria  
Title: Evolving Event-driven Programs with SignalGP

Abstract: We introduce SignalGP, a new genetic programming (GP) technique designed to provide evolution direct access to the event-driven programming paradigm, allowing evolved programs to handle signals from the environment or from other agents in a more biologically inspired way than traditional GP approaches. In SignalGP, signals direct computation by triggering the execution of program modules (i.e. functions). In this work, we apply SignalGP in the context of linear GP. We use our implementation of SignalGP to demonstrate the value of capturing the event-driven programming paradigm in GP by evolving programs to solve two problems where the capacity to react to external signals is crucial. We also discuss ways in which SignalGP can be generalized beyond our linear GP implementation.

This work was supported in part by NSF Graduate Research Fellowship

Poster Number: CSE-25  
Authors: Kaixiang Lin; Renyu Zhao; Zhe, Xu; Jiayu Zhou  
Title: Efficient Large-Scale Fleet Management via Multi-Agent Deep Reinforcement Learning

Abstract: Large-scale online ride-sharing platforms have substantially transformed our lives by reallocating transportation resources to alleviate traffic congestion and promote transportation efficiency. An efficient fleet management strategy not only can significantly improve the utilization of transportation resources but also increase the revenue and customersatisfaction. It is a challenging task to design an effective fleet management strategy that can adapt to an environment involving complex dynamics between demand and supply. Existing studies usually work on a simplified problem setting that can hardly capture the complicated stochastic demand-supply variations in high-dimensional space. In this paper, we propose to tackle the large-scale fleet management problem using reinforcement learning, and propose a contextual multi-agent reinforcement learning framework including two concrete algorithms, namely contextual deep $Q$-learning and contextual multi-agent actor-critic, to achieve explicit coordination among a large number of agents adaptive to different contexts. We show significant improvements of the proposed framework over state-of-the-art approaches through extensive empirical studies.

Poster Number: CSE-26  
Authors: Yaojie Liu; Amin Jourabloo; Xiaoming Liu  
Title: Learning Deep Models for Face Anti-Spoofing: Binary or Auxiliary Supervision

Abstract: Face anti-spoofing is the crucial step to prevent face recognition systems from a security breach. Previous deep learning approaches formulate face anti-spoofing as a binary classification problem. Many of them struggle to grasp adequate spoofing cues and generalize poorly. In this paper, we argue the importance of auxiliary supervision to guide the learning toward discriminative and generalizable cues. A CNN-RNN model is learned to estimate the face depth with pixel-wise supervision, and to estimate rPPG signals with sequence-wise supervision. Then we fuse the estimated depth and rPPG to distinguish live vs. spoof faces. In addition, we introduce a new face anti-spoofing database that covers a large range of illumination, subject, and pose variations. Experimental results show our model achieves the state-of-the-art performance on both intra-database and cross-database testing.

This work was supported in part by This research is based upon work supported by the Office of the Director of National Intelligence (ODNI), Intelligence Advanced Research Projects Activity (IARPA), via IARPA R&D Contract No. 2017-17020200004.
Poster Number: CSE-27
Authors: Boyang Liu; Jiayu Zhou; Pang-Ning Tan
Title: A Framework for Predicting Geospatial Multiscale Nested Data

Abstract: Multilevel modeling is a powerful statistical method that has been widely used to characterize interactions between predictor (independent) and response (dependent) variables at multiple levels of analysis. Multilevel modeling has found great success in various fields such as ecology due to its ability to detect complex patterns such as cross-scale interactions (CSI) between processes operating at different spatial or temporal scales. This paper revisits the multilevel modeling approach from a machine learning perspective, specifically, from the viewpoint of multi-task learning (MTL). We show that multilevel modeling makes a strong assumption about the generative process of the data, which if violated, may lead to incorrect interpretation of CSI present in the data. In addition, due to the stronger bias in its assumption, the prediction accuracy of such method can be inferior compare to existing multi-task learning approaches, especially when applied to datasets with limited training examples in each group. However, the MTL cannot give the estimation of CSI although it has better prediction power compared to the MLM. In order to overcome the issue, we proposed a novel method called multitask multilevel modeling with mean imputation to get both accurate prediction result and stable CSI. By assuming the spatial continuity of regional variable, the localized regional variable can be imputed from the mean value. Our method is tested in both synthetic data and real data. The result shows our method outperformed both multitask learning and multilevel modeling in terms of prediction and explainable ability.

This work was supported in part by Liminology

Poster Number: CSE-28
Authors: Farzan Masrour; Pang Ning Tan; Abdol-Hossein Esfahanian
Title: Attributed Network Representation Learning Approaches for Link Prediction

Abstract: Network representation learning algorithms seek to embed the nodes of a network into a lower-dimensional feature space such that nodes that are in proximity to each other share a similar representation. In this paper, we investigate the effectiveness of using network representation learning algorithms for link prediction problems. Specifically, we demonstrate the limitations of existing algorithms in terms of their ability to accurately predict links between nodes that are in the same or different communities, nodes that are topologically distant from each other, and nodes that have low degrees. We also show that incorporating node attribute information can help alleviate this problem and compare three different approaches to integrate this information with network representation learning for link prediction problems. Using five real-world network datasets, we demonstrate the efficacy of one such approach, called SPIN, that can effectively combine the link structure with node attribute information and predict links between nodes in the same and different communities without favoring high degree nodes.

Poster Number: CSE-29
Authors: Vahid Mirjalili; Sebastian Raschka; Arun Ross
Title: Semi-Adversarial Neural Networks: A New Paradigm for Imparting Privacy to Face Images

Abstract: Biometrics is the automated process of recognizing individuals based on their physical and behavioral traits such as face, fingerprints and iris. More recent research has established the possibility of automatically deducing additional information about an individual, such as age, gender and ethnicity, from their biometric data. This has heightened privacy concerns associated with biometric data. In this work, we investigate the possibility of preserving the biometric utility of face images while perturbing its demographic content. In this regard, we design a semi-adversarial neural network that can modify or an input face image such that an automated face matcher can successfully utilize it, while a demographic classifier, such as an automated gender predictor, is confounded. The contributions of this work include (a) formulation and design of a new convolutional autoencoder (CAE) architecture that is semi-adversarial; (b) development of a new CAE training method based on auxiliary classifiers and novel loss functions; and (c) evaluation of proposed method on multiple face datasets. Extensive experiments confirm the efficacy of the proposed network in extending soft biometric privacy to face images.

This work was supported in part by National Science Foundation (NSF)
Abstract: In this work, we report vulnerabilities in Multipath TCP (MPTCP) that arise because of the crosspath interactions between MPTCP subflows. Multipath TCP (MPTCP) is an IETF standardized suite of TCP extensions that allow two endpoints to simultaneously use multiple paths between them. We present two attacks to exploit these vulnerabilities. In the connection hijack attack, an attacker takes full control of the MPTCP connection by suspending the subflows he has no access to. In the traffic diversion attack, an attacker diverts traffic from one path to other paths. These vulnerabilities are very fundamental and affect everyone on the internet as MPTCP is being used by both the iOS and android. Proposed vulnerabilities fix, changes to MPTCP specification, provide the guarantees that MPTCP is at least as secure as TCP and the original MPTCP. Our proposed solution has been made part of the MPTCP standard.

Poster Number: CSE-31
Authors: Duong Nguyen; Aleksey Charapko; Sandeep Kulkarni; Murat Demirbas
Title: Optimistic Execution in Key-Value Stores

Abstract: Limitations of CAP theorem imply that if availability is desired in the presence of network partitions, one must sacrifice sequential consistency, a consistency model that is more natural for system design. We focus on the problem of what a designer should do if she has an algorithm that works correctly with sequential consistency but is faced with an underlying key-value store that provides a weaker (e.g., eventual or causal) consistency. We propose a detect-rollback based approach: The designer identifies a correctness predicate, say P, and continue to run the protocol, as our system monitors P. If P is violated (because the underlying key-value store provides a weaker consistency), the system rolls back and resumes the computation at a state where P holds. We evaluate this approach in the Voldemort key-value store. Our experiments with deployment of Voldemort on Amazon AWS shows that using eventual consistency with monitoring can provide 20-40% increase in throughput when compared with sequential consistency. We also show that the overhead of the monitor itself is small (typically less than 8%) and the latency of detecting violations is very low. For example, more than 99.9% violations are detected in less than 1 second.

Poster Number: CSE-32
Authors: Dinh-Luan Nguyen; Kai Cao; Anil K. Jain
Title: Robust Minutiae Extractor: Integrating Deep Networks and Fingerprint Domain Knowledge

Abstract: We propose a fully automatic minutiae extractor, called MinutiaeNet, based on deep neural networks with compact feature representation for fast comparison of minutiae sets. Specifically, first a network, called CoarseNet, estimates the minutiae score map and minutiae orientation based on convolutional neural network and fingerprint domain knowledge (enhanced image, orientation field, and segmentation map). Subsequently, another network, called FineNet, refines the candidate minutiae locations based on score map. We demonstrate the effectiveness of using the fingerprint domain knowledge together with the deep networks. Experimental results on both latent (NIST SD27) and plain (FVC 2004) public domain fingerprint datasets provide comprehensive empirical support for the merits of our method. Further, our method finds minutiae sets that are better in terms of precision and recall in comparison with state-of-the-art on these two datasets. Given the lack of annotated fingerprint datasets with minutiae ground truth, the proposed approach to robust minutiae detection will be useful to train network-based fingerprint matching algorithms as well as for evaluating fingerprint individuality at scale. MinutiaeNet is implemented in Tensorflow: https://github.com/luannd/MinutiaeNet

Poster Number: CSE-33
Authors: Kurt A. O’Hearn; Abdullah Alperen
Title: Efficient, Scalable Techniques for Charge Assignment in ReaxFF Molecular Dynamics Applications

Abstract: Polarizable, reactive methods, which incorporate range-limited quantum mechanics-like (QM) interactions based on bond-order potentials, have been shown to be an effective combination of the advantageous characteristics of QM and classical methods. As such, the objective of this work is to enhance the efficiency and scalability of the reactive force field (ReaxFF) approach in molecular dynamics applications on shared memory platforms. Specifically, efforts are focused on optimization of the most costly phase of simulation, the global charge assignment phase. Krylov subspace iterative approaches are employed for solving the large sparse symmetric linear systems defining the underlying charge models. The results of work on accelerating the convergence rate of these iterative techniques via various preconditioning techniques are presented for several charge models including charge equilibration (OEq), electronegativity equilibration (EE), and atom-condensed Kohn-Sham density functional theory approximated to second order (ACKS2). Furthermore, efforts on parallelization of computation and application of preconditioning factors and the overarching solver are also discussed.
Poster Number: CSE-34  
Authors: Hasan Metin Aktulga; Fazlay Rabbi; Md. Aflibuzzaman  
Title: Towards an Efficient Data Dependency Driven Parallel Task-Based Implementation of Eigen Solver

Abstract: The development of fast algorithms for sparse matrix computations has had an enormous impact in the field of data analytics and scientific computing. Many problems in these domains involve sparse matrix computation in the form of solver for system of linear equations, eigen solver, LU decomposition, graph representation etc. Sparse matrix computations are the main kernel of these problems. In this study, we present the data dependency driven parallel task based implementation details of two eigen solver algorithms i.e., LOBPCG and Lanczos algorithms. The main computational kernels of LOBPCG are the sparse matrix-matrix multiplication(SpMM), Sparse Matrix vector Multiplication(SpMV) which are tall-skinny matrix operations. The SpMVs and level-1 BLAS operations are the building blocks of Lanczos. This study is focused towards dividing and expressing the full computational model of these two eigen solvers as a series of tasks and then creating a Directed Acyclic Graph (DAG) of the full execution flow based on the data dependencies among these tasks. The goal is to design a DAG partitioner that maximizes the data reuse and cache efficiency and exploits full task parallelism. Our partitioner leverages the OpenMP tasking model to provide more flexible synchronizations based on the data access relationship among the tasks.

Poster Number: CSE-35  
Authors: Mohammad Roohitavaf  
Title: DKVF: A Framework for Rapid Prototyping and Evaluating Distributed Key-value Stores

Abstract: We present our framework DKVF that enables one to quickly prototype and evaluate new protocols for key-value stores and compare them with existing protocols based on selected benchmarks. Due to limitations of CAP theorem, new protocols must be developed that achieve the desired trade-off between consistency and availability for the given application at hand. Hence, both academic and industrial communities focus on developing new protocols that identify a different (and hopefully better in one or more aspect) point on this trade-off curve. While these protocols are often based on a simple intuition, evaluating them to ensure that they indeed provide increased availability, consistency, or performance is a tedious task. Our framework, DKVF, enables one to quickly prototype a new protocol as well as identify how it performs compared to existing protocols for pre-specified benchmarks. Our framework relies on YCSB (Yahoo! Cloud Servicing Benchmark) for benchmarking.

Poster Number: CSE-36  
Authors: Renu Sharma; Arun Ross  
Title: Presentation Attack Detection in Iris Systems Based on Human Behavior and Scene Analysis

Abstract: Biometric systems use the biological traits of an individual such as face, fingerprints, iris and voice to recognize an individual. These systems are being increasingly deployed in a number of unattended access control applications where a user directly interacts with the biometric sensor with limited or no oversight. Such systems are vulnerable to presentation attacks, where an adversary can present a fake or altered biometric trait in order to circumvent the system. Our research work focuses on detecting such attacks in the context of an iris system by analyzing human posture and behavior during their interaction with the iris sensor. Most of the current methods for detecting presentation attacks are invoked after the image has been acquired by the sensor. Our approach, in contrast, is to detect any anomalies in the scene prior to image acquisition. Such anomalies may pertain to, for instance, an adversary holding a plastic eye or a printed image of the iris in hand; or an electronic device such as a kindle for displaying an iris image or video to the system. The proposed approach can be extended to other biometric modalities such as fingerprints or face.

This work was supported in part by Intelligence Advanced Research Project Activity (IARPA)
Abstract: Over the past several years, the performance of state-of-the-art face recognition systems has been significantly improved, due in a large part to the increasing amount of available face datasets and the proliferation of deep neural networks. This rapid increase in performance has left existing popular performance evaluation protocols, such as standard LFW, nearly saturated and has motivated the emergence of new, more challenging protocols (aimed specifically towards unconstrained face recognition). In this work, we employ the use of parts-based face recognition models to further improve the performance of state-of-the-art face recognition systems as evaluated by both the LFW protocol, and the newer, more challenging protocols (BLUFR, IJB-A, and IJB-B). In particular, we employ spatial transformers to automatically localize discriminative facial parts which enables us to build an end-to-end network where global features and local features are fused together, making the final feature representation more discriminative. Experimental results, using these discriminative features, on the BLUFR, IJB-A and IJB-B protocols, show that the proposed approach is able to boost performance of state-of-the-art face recognition systems. The proposed approach is not limited to one architecture but can also be applied to other face recognition networks.

Poster Number: CSE-38
Authors: Joel Stehouwer; Xiaoming Liu; Jingfeng Liu
Title: Surveillance Face Identification Dataset

Abstract: Face recognition has a wide range of applications from biometrics, mobile devices, entertainment and leisure, and surveillance. Many challenges for short distance applications have been well addressed, but many challenges remain for long distance applications. Research in computer vision is data-driven, as evidenced by the widespread use and significant impact of datasets such as ImageNet, MNIST, and LFW. We propose a new dataset, the Surveillance Face Identification Dataset, to enable research to address the challenges of long distance face recognition in a surveillance environment. This dataset features three tiers of difficulty that will allow for incremental improvement in performance as recognition systems become more robust to these challenges. Also proposed is a new method for efficient, dense annotation of objects in videos. The performance of this method is analyzed to demonstrate its efficiency. The SFI dataset is proof of the value and precision of this annotation method.

Poster Number: CSE-39
Authors: Mengying Sun; Inci M. Baytas; Zhangyang Wang; Jiayu Zhou
Title: Subspace Network: Deep Multi-Task Censored Regression for Modeling Neurodegenerative Diseases

Abstract: Over the past decade a wide spectrum of machine learning models have been developed to model the neurodegenerative diseases, associating biomarkers, especially non-intrusive neuroimaging markers, with key clinical scores measuring the cognitive status of patients. Multi-task learning (MTL) has been extensively explored in these studies to address challenges associated to high dimensionality and small cohort size. However, most existing MTL approaches are based on linear models and suffer from two major limitations: 1) they cannot explicitly consider upper/lower bounds in these clinical scores; 2) they lack the capability to capture complicated non-linear effects among the variables. In this paper, we propose the Subspace Network, an efficient deep modeling approach for non-linear multi-task censored regression. Each layer of the subspace network performs a multi-task censored regression to improve upon the predictions from the last layer via sketching a low-dimensional subspace to perform knowledge transfer among learning tasks. Under mild assumptions, for each layer the parametric subspace can be recovered using only one pass of training data. Empirical results demonstrate that the proposed subspace network quickly picks up correct parameter subspaces, and outperforms state-of-the-arts in predicting neurodegenerative clinical scores using information in brain imaging.
**Poster Number**: CSE-40  
**Authors**: Thomas Swearingen; Will Drevo; Bennett Cyphers; Alfredo Cuesta-Infante; Arun Ross; Kalyan Veeramachaneni  
**Title**: ATM: A Distributed, Collaborative, Scalable Software Platform for Automated Machine Learning  

**Abstract**: Machine learning systems are being used in a large number of applications to make an automated decision based on an input set of observations. For example, these systems can be used to assess the susceptibility of an individual to a certain disease; predict changes in stock prices; or determine if an email message is a spam or not. In order to facilitate this, machine learning systems use pattern classifiers such as Support Vector Machines, Neural Networks, Decision Trees, Random Forests, and K-Nearest Neighbor to render decisions. A practitioner often has to experiment with a large number of classifiers during the training phase in order to select a suitable one. This is often done using a trial-and-error approach that can be both costly and ineffective. Further, each classifier has a number of hyperparameters that must be "tuned" (e.g., before using the Decision Tree method, the maximum depth of the tree must be decided); this further impedes the classifier selection process. To mitigate this issue, we develop a software platform called Auto-Tuned Model (ATM) that automates the classifier selection and hyperparameter tuning process, and produces a ranked list of potential classifiers along with their hyperparameters. To demonstrate ATM's usefulness, we evaluate it on existing datasets and compare our results against those reported in OpenML, a website for uploading datasets and tracking the results of machine learning pipelines as formulated by humans. ATM analyzed 47 datasets in OpenML and was able to deliver a solution better than the one designed by humans ~30% of the time. Further, while OpenML users take an average of 100 days to deliver a near-optimal solution, ATM can produce a solution in less than a day.

*This work was supported in part by National Institute of Justice (NIJ)*

**Poster Number**: CSE-41  
**Authors**: Debayan Deb; Tarang Chugh; Elham Tabassi  
**Title**: Altered Fingerprint Detection  

**Abstract**: Fingerprints have been used to identify individuals for more than a century. Being one of the more reliable biometrics, it has been widely used by law enforcement for background checks, criminal investigations, and border crossing identity verifications. While current Automated Fingerprint Identification Systems (AFIS) are quite accurate and reliable, their performance drops when dealt with poor quality fingerprint images whose friction ridge information are degraded or destroyed. Due to this degradation in performance, individuals aiming to evade law enforcement are able to obfuscate (or alter) their fingerprints to avoid revealing their true identities. Therefore, the automated detection of altered fingerprints is of high interest to law enforcement. This project addressed this need. Specifically, we employed deep learning techniques to develop a binary classifier which received a fingerprint image as input and classified it as a valid fingerprint or an altered fingerprint. This is a supervised learning task for which we used real-world operational valid and altered fingerprints for training and testing of our model. Our model has a true detection rate of 98% at false positive rate of 2%. Our model outperforms previous work which had a true detection rate of 70% at a similar false positive rate using same data.

**Poster Number**: CSE-42  
**Authors**: Fengyi Tang; Jiayu Zhou; Hiroko Dodge  
**Title**: Using Dialogue Simulation for Performance Improvement and Data Augmentation in Off-Conversational Prediction Task  

**Abstract**: Dialogue modeling is classically used to generate task-oriented responses to user query or to generate open-domain conversations with user. In this paper, we train a human-agent dialogue systems by observing only human-human responses in conversations. We show how such a dialogue system can be used for data augmentation and performance improvement in off-conversation prediction tasks. We propose a framework which contains 4 main components: (1) skip-thought embedding of response utterances, (2) training customized user-simulator for each subject, (3) training a reinforcement learning agent to learn a unified action-value function for query-answer responses for the task of interest, and (4) using trained agents to generate new dialogue episodes for data augmentation and prediction. We evaluate the performance of this framework on classification of mild-cognitive impairment (MCI) with utterance data from 41 OHSU patients. Our pipeline achieved 78.6% AUC on 5-fold validation with our current framework, an improvement over a previous benchmark study (72.5% AUC with sparse SVM). Additionally, our agent learned individualized policies for producing query sequences which can minimize the number of turns required to make accurate diagnostic predictions.
**Poster Number:** CSE-43  
**Authors:** Vidhya Tekken-Valapil; Sorrachai Yingchareonthawornchai; Sandeep Kulkarni; Eric Torng; Murat Demirbas  
**Title:** Monitoring Partially Synchronous Distributed Systems Using SMT Solvers

**Abstract:** In this paper, we discuss the feasibility of monitoring partially synchronous distributed systems to detect latent bugs, i.e., errors caused by concurrency and race conditions among concurrent processes. We present a monitoring framework where we model both system constraints and latent bugs as Satisfiability Modulo Theories (SMT) formulas, and we detect the presence of latent bugs using an SMT solver. We demonstrate the feasibility of our framework using both synthetic applications where latent bugs occur at any time with random probability and an application involving exclusive access to a shared resource with a subtle timing bug. We illustrate how the time required for verification is affected by parameters such as communication frequency, latency, and clock skew. Our results show that our framework can be used for real-life applications, and because our framework uses SMT solvers, the range of appropriate applications will increase as these solvers become more efficient over time.

*This work was supported in part by This work is partially supported by NSF CNS 1329807, NSF CNS 1318678, and XPS 1533802.*

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**Poster Number:** CSE-44  
**Authors:** Adam Terwilliger; Garrick Brazil; Xiaoming Liu  
**Title:** Recurrent Flow-Guided Segmentation Prediction

**Abstract:** Reasoning about the future is a crucial element to the deployment of real-world machine learning systems. Specifically, garnering semantics about the future of an urban scene is essential for the success of autonomous driving. Our work utilizes video data from the Cityscapes dataset to predict the semantic segmentation mask of nineteen classes (pedestrian, car, road, etc.) for future frames of the video sequence. We built a unique system that combines three distinct components: current-frame segmentation network, optical flow network, and convolutional LSTM. Our approach differs from past work through its use of an end-to-end learnable warp layer that directly applies optical flow to convolutional features generated by the current-frame network. Additionally, to the best of our knowledge, this is the first attempt to utilize a recurrent network for future segmentation prediction. This convolutional LSTM allows our method to take advantage of all past frames, where past work was limited to using four past frames. These three components work together to achieve competitive performance on both short-term and mid-term future segmentation prediction.

*This work was supported in part by University Distinguished Fellowship (UDF)*

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**Poster Number:** CSE-45  
**Authors:** Luan Tran; Xiaoming Liu  
**Title:** Nonlinear 3D Face Morphable Model

**Abstract:** As a classic statistical model of 3D facial shape and texture, 3D Morphable Model (3DMM) is widely used in facial analysis, including model fitting, image synthesis, etc. Conventional 3DMM is learned from a collection of well controlled 2D face images with associated 3D face scans, and represented by two sets of PCA basis functions. Due to the type and amount of training data, as well as, the linear bases, the representation power of 3DMM can be limited. To address these problems, this paper proposes an innovative framework to learn a nonlinear 3DMM model from a large set of unconstrained face images, without collecting 3D face scans. Specifically, given a face image as input, a network encoder estimates the projection, shape and texture parameters. Two network decoders serve as the nonlinear 3DMM to map from the shape and texture parameters to the 3D shape and texture, respectively. With the projection parameter, 3D shape, and texture, a novel analytically differentiable rendering layer is designed to reconstruct the original input face. The entire architecture is end-to-end trainable with only weak supervision. We demonstrate the superior representation power of our nonlinear 3DMM over its linear counterpart, and its contribution to face alignment and 3D face reconstruction.
Abstract: Latent fingerprint recognition describes the analysis and identification of fingerprints found at crime scenes. These latent prints, or "finger marks", are imprinted haphazardly and are often obscured, incomplete, or poorly defined. For this reason, their analysis was long left to forensics experts. The biometrics industry has taken on this challenge and has been working towards a "lights-out" approach. This describes a recognition system that is fully automated from start to finish, requiring no human input. In this type of system, an investigator might provide an image of a latent, and they would receive some potential matches from a fingerprint database.

This process sounds very convenient and efficient, but can the investigator really be confident in these results? To evoke this confidence, we have created a GUI to accompany the lights-out latent recognition system that is currently under development in MSU's Pattern Recognition and Image Processing (PRIP) Lab. This GUI shows the investigator a comparison of the input image along with each of the potential matches in turn. The particular features that the system found to be in correspondence are highlighted on the images for the investigator to verify. Additionally, the investigator can visually walk through the matching steps to see how the system arrived at its decision. This visual confirmation complements numerical data to showcase the success of our latent recognition system.

This work was supported in part by Intelligence Advanced Research Projects Activity (IARPA)

Abstract: Social media has become a valuable tool for hackers to spread misleading content through compromised accounts. Previous research has focused on applying supervised learning algorithms to detect the compromised accounts. However, given that hackers are known to change their strategies to evade detection, this may degrade the performance of such algorithms over time. To address this challenge, this paper proposes a multi-view unsupervised learning framework called CADET. CADET utilizes nonlinear autoencoders to learn the feature embedding from multiple views, such as the tweets' content, source, location, and timing information and then projects the embedded features into a common lower-dimensional feature space. Suspicious user accounts are detected based on their reconstruction errors in the shared subspace. Our empirical results show that CADET is better at detecting compromised accounts compared to the leading unsupervised compromised account detection approach when applied to a real-world Twitter dataset.

Abstract: Social media, e.g. Twitter, has become a widely used medium for the exchange of information, but it has also become a valuable tool for hackers to spread misinformation through compromised accounts. To detect compromised accounts, it is necessary to separate normal user behaviors, e.g., via their posts, with anomalous behavior. Detecting compromised accounts faces several challenges. First, social media is inherently noisy where simply selecting post features, e.g., tweet text, may not capture the complexity of compromised accounts. Second, both normal users and hackers tend to change some of their behavior over time, e.g., topic drift and detection evasion respectively. Third, due to the ambiguity of compromised account reporting, e.g., reporting a compromised account on a different platform, identification of compromised accounts is extremely time and effort consuming. To address these challenges, this poster proposes E2EC, an end-to-end compromised account detection framework. E2EC learns a user representation which encodes tweets from multiple viewpoints and considers the temporal evolution of their tweets. E2EC can identify compromised accounts and can effectively cope with limited labeled compromised accounts.

Abstract: In order to deal with complex evolutionary events such as recombination and hybridization, phylogenetic networks are used to represent evolution history instead of phylogenetic trees. The accuracy of inferred phylogenetic networks is influenced by many factors. Estimating a multiple sequence alignment (MSA) is the initial step of almost all genomic analysis, which is also an important factor in downstream phylogenetic network inference. In this simulation study, we quantify the impact of MSA quality on the accuracy of phylogenetic network inference.
**Poster Number:** CSE-50  
**Authors:** Qiqige Wuyun; Pang-Ning Tan; Jiayu Zhou  
**Title:** Generative Clustered Matrix Completion

**Abstract:** Missing data problem is very common in real-world spatial data mining applications. In the study of limnology, for example, some features for the lakes that are far away from research stations will be missing. Such missing data causes significant challenges in subsequent analysis. Many matrix completion models have addressed this problem. However, out-of-the-box matrix completion methods typically do not leverage the important underlying structures of the spatial data. For example, the lakes may be closely connected to each other via similarities in regeneration cycles, and these similarities could lead to patterns in feature variables that are useful for imputation. Discovering and leveraging such underlying patterns could greatly benefit the predictive modeling using the datasets. Moreover, most existing matrix completion methods assume the missing entries are randomly samples, which may not be true for some dataset. For example, the missing reason for limnology dataset is related to the position of the lakes. Also, some missing values may be related to the values of the underlying true data. To address those problems, in this work, we study a novel generative clustered matrix factorization to explore and exploit the underlying cluster structure to improve the missing value estimation. Meanwhile, we learn the probability distribution of the data by borrowing the idea from generative adversarial networks to deal the settings that the missing entries are not randomly sampled. Specifically, the proposed method builds a unified framework to jointly impute the missing value with incorporating the cluster information while learn the probability distribution to adjust the completion process. We conduct extensive experiments on both synthetic dataset and real-world dataset to demonstrate the effectiveness of the proposed framework.

**Poster Number:** CSE-51  
**Authors:** Tyler Wilson; Pang-Ning Tan; Lifeng Luo  
**Title:** A Coupled Weighted Graph Convolutional LSTM Approach to Weather Prediction

**Abstract:** Weather forecasting is an important but challenging problem as one must contend with the inherent non-linearities and spatiotemporal autocorrelation present in the data. This paper presents a novel deep learning approach based on a coupled weighted graph convolutional LSTM (WGC-LSTM) to address these challenges. Specifically, our proposed approach uses an LSTM to capture the inherent temporal autocorrelation of the data and a graph convolution to model its spatial relationships. As the weather condition can be influenced by various spatial factors besides the distance between locations, e.g., topography, prevailing winds and jet streams, imposing a fixed graph structure based on the proximity between locations is insufficient to train a robust deep learning model. Instead, our proposed approach treats the adjacency matrix of the graph as a model parameter that can be learned from the training data. In addition, the algorithm requires a forward pass with time complexity $O(|V|^2)$, where $|V|$ is the number of nodes (locations) in the graph. With large graphs this may lead to slower performance as well as susceptibility to overfitting. We propose a modified version of our approach that can address both of these difficulties.

**Poster Number:** CSE-52  
**Authors:** Qiqige Wuyun; Kevin J Liu  
**Title:** Fast and Accurate Introgression Detection using Statistical Phylogenomic Inference

**Abstract:** Introgression is the movement of genes from one species to the gene pool of another by recurrent backcrossing of hybrid. Introgression is thought to play an important role in genome evolution throughout the Tree of Life, the evolutionary history of all life on Earth. To quantitatively investigate this hypothesis, a variety of state-of-the-art techniques have been developed for detecting introgression from genomic sequence data. However, no existing method is capable of fast and accurate introgression detection on datasets with many dozens of genomic sequences. In this work, we develop an improved introgression detection approach which enables scalable analysis of large-scale datasets. Our approach combines the multi-species network coalescent model with hidden Markov models (HMMs) to tease apart the effects of incomplete lineage sorting (ILS) from those of introgression. Using simulated and empirical data, we perform a large-scale comparative assessment of our new method with other state-of-the-art introgression detection methods such as PhyloNet-HMM and CoalHMM. Our experiments explore a wide range of factors that may influence the performance of introgression detection, including the number of taxa, the number of alleles sampled from each taxa, sequence length, migration probability, and starting time of migration.
**Poster Number:** CSE-53  
**Authors:** Liyang Xie; Kaixiang Lin; Shu Wang; Jiayu Zhou  
**Title:** Differentially Private Generative Adversarial Network  

**Abstract:** Generative Adversarial Net (GAN) and its variants have recently attracted intensive research efforts due to their elegant theoretical foundation and the excellent empirical performance as a generative model. A major concern of GAN when applied to personal and sensitive data such as medical records or financial data is that the density in the learned generative distribution could concentrate on the training data points, and thus may divulge critical privacy information. To address this critical issue, in this work we propose a differential privacy GAN (DPGAN), where we achieve differential privacy in GAN by applying carefully designed noise to gradients during the learning procedure. We provide rigorous proof of the privacy guarantee, as well as comprehensive empirical evidence to support our analysis. In our empirical studies we show that our method can generate high quality data points at a strong privacy level.

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**Poster Number:** CSE-54  
**Authors:** Sorrachai Yingchareonthawornchai; James Daly; Alex X. Liu; Eric Torng  
**Title:** A Sorted Partitioning Approach to High-speed and Fast-update OpenFlow Classification  

**Abstract:** OpenFlow packet classification needs to satisfy two requirements: high speed and fast updates. Although packet classification is a well-studied problem, no existing solution satisfies both requirements. Decision tree methods, such as HyperCuts, EffiCuts, and SmartSplit, can achieve high-speed packet classification but not fast updates. The Tuple Space Search (TSS) algorithm used in Open vSwitch achieves fast updates but not high-speed packet classification. In this paper, we propose a hybrid approach, PartitionSort, that combines the benefits of both TSS and decision trees achieving both high-speed packet classification and fast updates. A key to PartitionSort is a novel notion of rule set sortability that provides two key benefits. First, it results in far fewer partitions than TSS. Second, it allows the use of Multi-dimensional Interval Trees to achieve logarithmic classification and update time for each sortable rule set partition. Our extensive experimental results show that PartitionSort is an order of magnitude faster than TSS in classifying packets while achieving comparable update time. PartitionSort is a few orders of magnitude faster in construction time than SmartSplit, a state-of-the-art decision tree classifier, while maintaining competitive classification time. Finally, PartitionSort is scalable to an arbitrary number of fields.

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**Poster Number:** CSE-55  
**Authors:** Masoud Zarifneshat; Chin-Jung Liu; Li Xiao  
**Title:** A Protocol for Link Blockage Mitigation in mm-Wave Networks  

**Abstract:** mm-Wave is a promising technology to meet the enormous bandwidth demands of the future generation cellular networks. This technology has vast amounts of unused bandwidth, but has problem of human blockage. Blockage mitigation methods for indoor environments cannot be applied to outdoor scenarios effectively. In this paper, we mitigate human blockage of the mm-Wave technology by proposing an algorithm that provides intelligent user association in mm-Wave networks. The proposed algorithm collects the history blockage incidents throughout the network and exploits the history incidents to associate user equipment to the base station with lower blockage possibility. The blockage incidents happened at different locations in the network. When user equipment attempts to find a base station to associate to, the algorithm examines the history blockage incidents near the location of the user equipment. In this way, the user equipment is associated to a base station that has smaller chance of being blocked. The simulation results show that our proposed algorithm is performing better in terms of improving SINR, rate of the links and blockage rate in the network compared to another state-of-the-art user association algorithm designed for mm-Wave networks and common user association algorithms of associating user to closest base station and base station with maximum SINR.
**ELECTRICAL ENGINEERING**

**Poster Number:** ECE-01  
**Authors:** Ibrahim Kagan Aksoyak; Ahmet Cagri Ulusoy  
**Title:** A 94GHz Voltage Controlled Oscillator for Imaging Applications in 130nm BiCMOS SiGe Technology

**Abstract:** Imaging is one of the most used methods to carry information since humans can handle spatial information easily. The frequency range from 30 to 300 GHz is called millimeter wave band which is good for the imaging applications as the radiation wavelength is small enough for the images to be generated with small resolution. The imaging applications greatly benefit from Si-based technologies since they offer highly functional electronics for antenna arrays. The realization of the incoherent transmitters is more energy efficient compared to coherent transmitters since each channel of the coherent transmitters require a synthesizer or frequency translation circuitry to be phase-locked to a common source. Independent voltage controlled oscillators achieve the incoherent radiation by using the internal noise for start-up, which is also useful for generating the noise-like signal as desired for the imaging systems. This research poster discusses the design of a voltage controlled oscillator in SiGe BiCMOS 130nm technology, operating at 94 GHz with the simulated phase noise of -99 dBc/Hz at 1MHz offset. Total power consumption of the VCO is ~41 mW where the fundamental differential output power delivered is around 8 dBm and the 3rd harmonic suppression is around 39dBm.

*This work was supported in part by National Science Foundation*

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**Poster Number:** ECE-02  
**Authors:** Mustaffa Alfatlawi; Vaibhav Srivastava  
**Title:** EEG-Driven Speed Controller for Human-Robot Interaction System

**Abstract:** Human reliability is one of the recognized factors in Human-Robot Interaction (HRI). In this paper, a dynamic model for human reliability is identified using electroencephalography (EEG) measurements of the operator, speed of the mobile robot, its radial distance the nearest obstacle, and the curvature of its trajectory. Six subjects participated in an experiment in which they have to manipulate robotic arm such that the end effector follows predefined trajectories while avoiding obstacles. Two dynamical models were identified for comparison: Auto Regressive Moving Average eXogenous (ARMAX) and Auto Regressive Moving Average (ARMA). ARMAX model shows better accuracy in term of the mean square error. The statistical analysis shows significant positive correlation between the speed and curvature of tracks with the tracking error($p<0.005$), and negative correlation between radial distance from trajectory to the nearest obstacle and the tracking error($p<0.005$). In a second experiment, the estimated human reliability was used to derive a speed controller while the operator is manipulating a robotic arm to track predefined tracks. The results indicates a significant reduction in tracking error($p<0.05$) after activating the speed controller.

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**Poster Number:** ECE-03  
**Authors:** Fares T. Alharbi; Saleh Almasabi; Joydeep Mitra  
**Title:** Enhancing Network Loadability Using Optimal TCSC Placement and Sizing

**Abstract:** Thyristor-controlled series capacitor (TCSC) devices have been utilized for enhancing transmission network loadability. The technical benefit of the TCSC devices comes at the expense of their high investment cost. In this poster, a new approach is presented to provide a profound insight into the compromises between technical and economical aspects of installing TCSC devices in a transmission network. The proposed approach is a multiobjective optimization based algorithm used to maximize the loadability of the network and to minimize the investment cost of installing TCSCs under secured operation conditions. The IEEE 118-bus system is used as a test case to validate the effectiveness of the proposed method.
**Poster Number:** ECE-04  
**Authors:** Saleh Almasabi; Joydeep Mitra  
**Title:** Multi-Stage Optimal PMU Placement Considering Substation Infrastructure

**Abstract:** Phasor measurement units (PMUs) significantly benefit the operation and control of power systems. They offer precise phasor measurements with a high refresh rate. These measurements are utilized for wide area measurement system to improve situational awareness and enhance the control infrastructure. In spite of these advantages, the industry has been slow to adopt PMU technology, largely due to the cost of PMUs and the communication infrastructure. However, judicious selection of PMU locations, through optimal placement of PMUs (OPP) enables the minimization of installation cost. There have been several approaches to solve the OPP problem; most of these approaches assume that the minimum number of PMUs achieves the minimum cost or consider the cost of PMUs without considering the communication infrastructure. This paper presents an OPP approach that considers both the communication infrastructure and the installation cost of PMUs. The proposed approach uses multi-stage installation where each stage is dependent on the cost set by the utility and not the number of PMUs. Higher priority buses can be chosen under the proposed approach. An opposition-based elitist binary genetic algorithm is used to solve the OPP problem. The proposed approach is tested on the IEEE reliability test system, and on the IEEE 14-bus, 30-bus, and 118-bus test systems.

**Poster Number:** ECE-05  
**Authors:** Yasir Al-Nadawi; Xiaobo Tan; Hassan Khalil  
**Title:** Inversion-free Hysteresis Compensation Via Adaptive Conditional Servomechanism for Nanopositioning Systems

**Abstract:** In this work, we consider the problem of hysteresis compensation for piezoelectric nanopositioning systems without using the inverse hysteresis operator. The nanopositioning system model is assumed to be linear dynamics proceeded by a hysteresis nonlinearity modeled with a Modified Prandtl-Ishlinskii (MPI) operator. Without using the inverse operator, the system is non-affine with the hysteresis representing the input nonlinearity. We utilize the properties of the MPI hysteresis model to transform the system into a semi-affine form, where the input nonlinearity is partitioned into two parts. The first partition has the control input appearing linearly, while the second partition represents a hysteresis nonlinearity which is a function of the control input. The second partition by itself can be partitioned into two parts: nominal hysteretic nonlinearity modeled as a PI operator, and the second part representing the hysteretic perturbation. The proposed controller is designed based on the adaptive conditional servocompensator approach, which is basically a continuously-implemented sliding mode control law powered with an adaptive servocompensator. An analytical bound on hysteretic perturbation is derived and used in the design of the continuously-implemented sliding mode control law. The adaptive conditional servomechanism is designed based on the assumption of the knowledge of the number of significant harmonics, where the adaptation manipulates the parameters of the servocompensator to mitigate the effect of those harmonics. Experiments conducted on a commercially available nanopositioner confirms the effectiveness of the proposed method as compared to the case when an inverse model is implemented.

**Poster Number:** ECE-06  
**Authors:** Mohammed Al-Rubaiai; Thassyo Pinto; Xiaobo Tan  
**Title:** Soft Actuators with Stiffness and Shape Modulation Using 3D-printed Conductive PLA Material

**Abstract:** The field of soft robotics has seen an increasing interest in the last few years. In this work we propose a silicone-based soft actuator embedded with a 3D-printed conductive PLA (CPLA) material that is capable of stiffness-tuning. In particular, an applied voltage on the CPLA induces a Joule heating effect, which in turn modulates the material stiffness. The CPLA shows 98.6% reduction of Young’s modulus, from 1 GPa at room temperature to 13.6 MPa at 80 °C, which is fully recovered when cooled down to its initial temperature. Finite-element modeling and computation are conducted to explore the thermal and mechanical behavioral changes of the CPLA under an electrical stimulus, where experimentally identified parameters are used in the simulation. The simulation results are validated with experimental data for a soft actuator with three active CPLA segments. Finally, a gripper composed of two such actuators serving as fingers is fabricated for demonstration of local bending and shape-holding capabilities.

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**Poster Number:** ECE-07  
**Authors:** Abdulrhman Alshaabani; Bingsen Wang.  
**Title:** Modeling The Power Transfer Between Non-Sinusoidal Source and Load Across Impedance Network

**Abstract:** In this paper, the fundamentals of contactless power transformers are presented and discussed. The power transfer between a non-sinusoidal source and a non-sinusoidal load across an inductive network is a new model that can transfer different ranges of power without cables. The main advantage of this new model of transferring power is that the reluctance transformer value is included when it is applied with compensation capacitors. The calculation of the resonant compensated capacitors’ values includes the value of self-inductance with its reluctance. Then, the power transfer system is applied to the high-power wind electric energy system. Consequently, the efficiency of transferring at high level of power is improved by applying the compensation capacitors. The MATHCAD software is used for the analytical modeling while the power transfer system simulation is carried out by the SABER software.

**Poster Number:** ECE-08  
**Authors:** Esraa Al-sharoa; Mahmood Al-khassaweneh; Selin Aviyente.  
**Title:** Tensor Based Temporal and Multi-layer Community Detection for Studying Brain Dynamics During Resting State fMRI

**Abstract:** In recent years, resting state fMRI has been widely utilized to understand the functional organization of the brain for healthy and disease populations. Recent studies show that functional connectivity during resting state is a dynamic process. Studying this temporal dynamics provides a better understanding of the human brain compared to static network analysis. In this research, a new tensor based temporal and multi-layer community detection algorithm is introduced to identify and track the brain network community structure across time and subjects. The framework studies the temporal evolution of communities in fMRI connectivity networks constructed across different regions of interests (ROIs). The proposed approach relies on determining the subspace that best describes the community structure using Tucker decomposition of the tensor. The proposed framework results in summarizing the brain dynamics into a set of functional connectivity states that are repeated across time and subjects. The dynamic behavior of the brain is evaluated in terms of consistency of different sub-networks during resting state. The results illustrate that some of the networks, such as the default mode, cognitive control and bilateral limbic networks, have low consistency over time indicating their dynamic behavior. Consequently, this indicates that the functional connectivity of the brain is dynamic and the detected community structure experiences smooth temporal evolution. Finally, the work in this research provides evidence for temporal brain dynamics during resting state through dynamic multi-layer community detection which enables us to better understand the behavior of different sub-networks.

*This work was supported in part by NSF CCF-1422262 and CCF-1615489 and the Schlumberger Foundation, Faculty for the Future.*

**Poster Number:** ECE-09  
**Authors:** Portia Banerjee; Rajendra Prasath Palanisamy; Mahmood Haq; Lalita Udpa; Yiming Deng  
**Title:** Dynamic Data-driven Prediction of Fatigue-induced Delamination Growth in Composite Joints

**Abstract:** With increasing use of fiber reinforced polymer (FRP) composites in several industries such as aviation, automotive and construction, effective reliability analysis of composites have become an extremely critical task in recent years. Periodic inspection by robust non-destructive evaluation (NDE) techniques and accurate health prognosis is essential for condition-based maintenance (CBM) and overall reliability of the safety-critical components and structures. Prediction of future damage level in composites often becomes challenging due to lack of physics-based damage growth models for complex materials which leaves us to rely solely on the NDE data for prognosis. In this paper, delamination area caused by fatigue loading in Mode I glass fiber reinforced polymer (GFRP) samples is periodically inspected by guided waves (GW) and optical transmission scanning (OTS). The goal of this study is to compare data-driven methods with static and dynamic parameters for estimating growth of delamination area in the composite joints. The dynamic approach utilizes a sequential Monte Carlo method, known as particle filtering technique, to sequentially update model parameters based on available NDE measurements. Results show that even when a simplistic exponential fit is assumed, use of NDE data to estimate function parameters in a probabilistic framework outperforms the static data-driven approaches. Therefore, dynamic approach for estimating damage growth improves overall assessment accuracy leading to bigger impacts in sensor aided reliability analysis.
**Poster Number:** ECE-10  
**Authors:** Yuting Tian; Atri Bera; Mohammed Benidris; Joydeep Mitra  
**Title:** Stacked Revenue and Technical Benefits of a Grid-connected Energy Storage System

**Abstract:** This paper proposes a comprehensive evaluation of stacked revenues generated from grid-connected energy storage systems (ESSs). The stacked revenue from an ESS cannot be calculated by simply aggregating the benefits from each type of application (e.g., energy shifting, frequency regulation, and outage mitigation) due to the fact that the ESS may not be available for use for all types of applications at the same instant—due to technical and operational constraints. In this paper, different types of applications for grid-connected ESSs are identified. Also, a model involving component reliability, power system operation constraints, and storage system operation constraints is developed to evaluate the composite revenue generated from the applications. In this model, different types of applications of ESSs are prioritized according to their intended contributions and system operating conditions. Sequential Monte Carlo simulation and quadratic programming are utilized to solve the problem. The proposed method is demonstrated on the IEEE reliability test system (IEEE-RTS).

*This work was supported in part by Consumers Energy Corporation*

**Poster Number:** ECE-11  
**Authors:** Jennifer Byford; Saranraj Karuppuswami; Premjeet Chahal  
**Title:** Broad-band Dielectric Probes for THz Device Characterization

**Abstract:** There is great interest in terahertz technology and research. As terahertz technology grows in use, especially with a growing number of on-wafer devices moving towards operation in this frequency range, there is a need to easily measure and characterize these on-wafer circuits and systems. Most commercially available THz systems are quasi-optical and thus require some kind of probe to couple the THz waves produced by these systems with the devices under test (DUTs). Although various THz probe designs have been proposed in the literature, many use metal wires which have practical limitations, and other dielectric based probes are designed for commercially available W-Band systems as opposed to THz systems. There are additional parameters to consider for on-wafer applications specifically such as efficient coupling and limiting cross-talk between the probes and nearby devices which are not the DUT. Here, we investigate the design, fabrication, and evaluation of dielectric based probes for coupling THz waves produced from quasi-optical systems into on-wafer applications. Different designs are explored through simulation and the most optimized designs are fabricated and tested. The probes coupling effectiveness and cross-talk susceptibility is also evaluated. In this work, an Emcore PB7200 frequency domain terahertz (0.1 - 2 THz) system is used to evaluation probe performance. The design of the components and different manufacturing process are presented. Simulations were carried out in ANSYS Electronics Desktop using HFSS. On-wafer probing applications are demonstrated with the components and future work is discussed.

**Poster Number:** ECE-12  
**Authors:** Maria Castaño; Xiaobo Tan  
**Title:** Model Predictive Control-based Path Following for Robotic Fish

**Abstract:** Global concern for the integrity of our aquatic ecosystems has led to an increased interest in the use of autonomous aquatic robots to monitor these environments. In particular, underwater robots that propel and maneuver themselves like real fish, often called robotic fish, have emerged as mobile sensing platforms for freshwater and marine environments. To be suitable for these types of sensing applications it is important to attain long operation time. As a result, accurate and energy-saving locomotion in trajectory control is desired. In this work, we present a nonlinear model predictive control (NMPC) approach for tail-actuated robotic fish that accommodates the highly nonlinear dynamics and minimizes control effort while meeting requirements on path-following accuracy. In addition, the proposed approach incorporates a control projection method to deal with the nonlinear control constraints. Furthermore, a parameter estimation approach is proposed for identifying the parameters of the averaged dynamic model that is used for controller design. The proposed approach uses an image processing algorithm for feedback, along with an optimization toolkit for solving the optimal control problem repetitively. Experimental results are presented to validate the proposed approach.

*This work was supported in part by NSF*
**Poster Number:** ECE-13  
**Authors:** Dhrubajit Chowdhury; Hassan K. Khalil  
**Title:** Synchronization in Networks of Multi-Agent Systems with Reduced Information

**Abstract:** Synchronization in networks of agents is widely popular due to its applications in distributed sensor networks, cooperative robotics and formation control. The network is represented by a graph and the synchronizing variable can be the agent's state, output or any another variable associated with the agent. One of the most popular example is synchronization of frequency in power systems network. The controllers designed for synchronization are distributed in nature and do not rely on any central authority this makes the system more flexible and robust in nature. Most of the controllers designed in literature rely on the availability of the local output of the agents which might not be available in applications like deep space, underwater or when installing a sensor to measure local output becomes expensive. Another requirement for the design of controllers is the knowledge about the eigenvalues of the graph Laplacian which is restrictive as it becomes increasingly difficult to estimate the eigenvalues of the Laplacian when the network size increases. A distributed controller for the synchronization of identical linear systems is designed where the only knowledge about the graph that is assumed is that it is connected. The information that is assumed to be available to the agents is its relative output and relative controller states with respect to its neighbors.

*This work was supported in part by NSF*  

**Poster Number:** ECE-14  
**Authors:** Demetris Coleman; Mohammed Al-Rubaiai; Andrew Kim; Xiaobo Tan  
**Title:** 3D-Printed Strain Gauges and Compensation of Their Thermal Dependence

**Abstract:** With the advent of 3D printing and the increasing list of available materials, various functional devices can be printed for low-cost, rapid prototyping. In this work we propose a polymer-based, resistive strain sensor printed with a commercially available filament, conductive PLA (Polylactic Acid). The sensor behavior is characterized for strains up to 0.15% and found to have a gauge factor that lies between 2.8 and 5.5, compared to ~2 for commercial strain gauges. During characterization, the resistance of the material is shown to have a correlation with temperature in addition to strain. Several compensation methods are explored to mitigate this effect and show the material's feasibility as a strain gauge. Future work involves the application of this sensor to structural health monitoring and soft robotics.

*This work was supported in part by MSU Foundation Professorship*  

**Poster Number:** ECE-15  
**Authors:** Michael Craton; Mohd Ifwat Mohd Ghazali; Brian Wright; Kyoung Youl Park; Premjeet Chahal; John Papapolymerou  
**Title:** 3D Printed Microfluidic Cooling for High Power RF Applications

**Abstract:** This paper presents the design and fabrication of microfluidic channel integration in a plastic substrate using 3D printing. The microfluidic channels are integrated along with a copper plate which the coolant is in direct contact with. To demonstrate the design, a diode intended for switched power supplies is integrated onto the copper plate and its performance characterized. 3D printing or additive manufacturing (AM) allows for fast prototyping of such package designs and can be readily adopted in the fabrication of RF circuits. This paper, to the best of our knowledge, for the first time will demonstrate a 3D printed integrated microfluidic channel for the cooling of electronic circuits. Details of design, fabrication and characterization are presented.

*This work was supported in part by MSU Foundation Professorship*  

**Poster Number:** ECE-16  
**Authors:** Osama Ennasr; Xiaobo Tan  
**Title:** Networks of Gliding Robotic Fish: Design and Applications

**Abstract:** Gliding robotic fish is a new and exciting platform for long-term underwater missions. The platform is designed from the ground up to be as energy efficient as possible by utilizing buoyancy-driven gliding to move from one point to another. Over the past few years, the platform has seen numerous electrical and mechanical enhancements that streamlined the manufacturing process and the robot's adaptability to various tasks. Currently, multiple robots are being developed and tested, which offers several advantages over single-robot deployment and will allow for a broader class of applications. In this work, we highlight the advantages that this platform offers and present some of the experimental and theoretical work for sensing applications using networks of gliding robotic fish.

*This work was supported in part by NSF, Great Lakes Fishery Commission, and U.S. Geological Survey*
**Poster Number:** ECE-17  
**Authors:** Vincens Gjokaj; Premjeet Chahal  
**Title:** 3D Printed Hybrid Coaxial-Like Transmission Line

**Abstract:** In this paper a new hybrid technology is introduced which combines flexible Liquid Crystal Polymer (LCP) films with 3D printed metal coated plastic rigid shells to design novel low-loss microwave and millimeter wave components. The process is low-cost and simplifies the manufacturing of these high-end products. Here, a simple coax-like transmission line and a novel low-loss bandpass filter are demonstrated. This work establishes a new way of utilizing 3D printing to create ultra low-loss structures and opens a pathway to manufacture these complex structures with ease using a table top system. In addition, novel structures can be manufactured which would have been difficult, if not impossible, using conventional machining techniques.

**Poster Number:** ECE-18  
**Authors:** Jason Greenberg; Xiaobo Tan  
**Title:** Localization of Mobile Robots Using LEDs

**Abstract:** Achieving Simultaneous Localization And Communication (SLAC) is a great asset to resource-limited robots since it reduces the complexities of capturing the data of two essential sources of information. In this work a method for localizing a mobile robot using the line of sight (LOS) detection of an LED communication system is presented. In particular, in a two-dimensional setting two base nodes use the lines of sight between themselves and the mobile agent to acquire the latter's bearings which are then used to compute its location. The technique used in this work uses a Kalman filter to predict the position of the robot based on past localization results. This allows the base nodes to significantly reduce the search range in establishing LOS with the mobile node and consequently improve the temporal resolution and spatial precision of the localization which would otherwise be limited by extensive scanning. Extensive experimental results are presented to illustrate and support the approach.

*This work was supported in part by National Science Foundation*

**Poster Number:** ECE-19  
**Authors:** Yuxiao He; John Papapolymerou; Collaborators from Gergia Tech: Eric Drew; Wei-ya Chen; Z.J. Zhang  
**Title:** Fabrication and Characterization of Thick (>100 um) CoFe2O4 and MnFe2O4 Nanoparticle Films with the Aid of 3D Printing Technology

**Abstract:** This work presents the fundamental studies on ferromagnetic resonance (FMR) of nanoparticles, the fabrication and the characterization of the magnetic nanoparticle films on the 3D printed testbed. First we explore the FMR profiles of various magnetic nanoparticles and their corresponding magnetic susceptibilities. Then two novel methods, which are the Layer-By-Layer process and the Solution Cast method, are proposed and proven to be effective to fabricate the magnetic films with various thicknesses using CoFe2O4 and MnFe2O4 nanoparticles. Especially the 450 um thick MnFe2O4 film is to the best of the author’s knowledge, the thickest magnetic film that has ever been reported. Next the 3D printed transmission line and fixture are utilized to characterize the magnetic films. By matching the simulated and measured group delay, the relative permeability of the CoFe2O4 film is estimated as 40. The FMR effects are observed when the DC magnetic field bias is applied to the stripline under all five power levels. In particular, the FMR effects appear successively within three frequency bands, namely 4 – 8 GHz, 8 - 14 GHz and 12 - 18 GHz, as the magnetic field strength increases. Moreover, the attenuation also increases under stronger bias and maintains decent performance even at low RF input power. This work presents for the first time a new stripline that is cost effective, easy to assemble and has good frequency selectivity, which paved the way for fabricating RF circuits and components using the magnetic nanoparticles in a wide range of power-sensitive and broadband microwave applications.

*This work was supported in part by National Science Foundation (NSF)*
**Poster Number:** ECE-20  
**Authors:** Rayan Hussein; Proteek Roy; Kalyanmoy Deb  
**Title:** Switching Between Metamodeling Methodologies for an Efficient Multi-Objective Optimization

**Abstract:** Evaluating computationally expensive objective and constraint functions is one of the main challenges faced when solving real-world optimization problems. For handling such problems, it is common to use a metamodeling approach. In its most efficient form, a metamodel is initially formed using a few exact solution evaluations and then optimized the metamodel to find a few in-fill solutions. The in-fill solutions are then evaluated exactly and another metamodel is formed. This procedure is continued in a progressive manner until all allocated budget of solutions are evaluated. In multi-objective optimization, there are several ways to build and utilize metamodeling approaches. Authors have previously proposed a taxonomy of different metamodeling approaches for multi-objective optimization and provided a comparative study highlighting the advantages and disadvantages of them. In this paper, we argue that it is more efficient to use different metamodeling approaches at different stages of the optimization process and then propose several switching strategies between the metamodeling methods. We also introduce a trust region method to achieve a better convergence behavior. We use the well-known Kriging approach as the core metamodeling method in this study. Our results show the efficacy and efficiency of the proposed approaches on challenging multiobjective optimization problems using a limited budget of high-fidelity evaluations.

**Poster Number:** ECE-21  
**Authors:** Ameer Janabi; Bingsen Wang  
**Title:** On-line Selective Harmonic Elimination Method with Seamless Dynamic Performance for VSI Drives

**Abstract:** The mathematical formulation of the selective harmonic elimination (SHE) problem is utilized to produce high performance, on-line implementation approach. First, the transcendental equation of the optimization problem is converted to a set algebraic equations using Chebyshev polynomials. Second, the set of algebraic equations is reduced to a single polynomial using Newton’s identities. The roots of the polynomial hold the unique solution to the optimization problem. Third, the polynomial is implemented using microcontroller to solve for the roots of the polynomial and obtain the optimal PWM switching angles. The proposed implementation method reduces the computational effort required from the microcontroller and exhibits improved transient response during a step change in the modulation index or the switching frequency without being subjected to the transient current spikes of the conventional SHE methods.

**Poster Number:** ECE-22  
**Authors:** William Jensen; Thang Pham; Shanelle Foster  
**Title:** Model-Based Torque Ripple Reduction to Enhance Reliability in PMSMs

**Abstract:** As automotive and aerospace propulsion becomes more electrified, improving the reliability of the electric machines driving these systems is of higher priority. A permanent magnet synchronous machine (PMSM) with single-layer concentrated-windings is an attractive topology for these applications because of its fault tolerance and high torque density; however, the torque pulsations associated with this design can reduce the lifetime of the bearings. Reduction of these torque pulsations can improve reliability. In this work, a priori torque estimation, based on machine geometry and position feedback, is used to compensate for torque pulsations by modifying the current command. PI controllers are replaced with a detailed machine model to calculate voltage commands thus eliminating the tuning and bandwidth limitations associated with PI controllers. Simulation and experimental results validate the effectiveness of the proposed controller.

*This work was supported in part by James Dyson Foundation Fellowship*
Poster Number: ECE-23
Authors: Saranraj Karuppuswami; Jennifer Byford; Premjeet Chahal
Title: Volatile Molecular Sensors Using Terahertz Resonators on Porous Substrates

Abstract: Volatiles emitted from fuels and automobile exhaust, paints, varnishes and sprays, industrial exhaust, etc. pose significant health risk and their detection in the environment is necessary to provide timely warning to public in a local environment. Among the many techniques that can be utilized such as optical, microwave, gas chromatography, colorimetric analysis and mass spectrometry, sensing of volatiles with terahertz (THz) radiation is attractive as it provides an approach to achieve high sensitivity coupled with specificity. Many volatile molecules exhibit unique spectral signatures in the THz spectral range and higher absorption strength than the microwave regime leading to strong interaction with the THz wave. Yet, THz volatile sensing technology has not grown to its full potential due to the need for a controlled low pressure gas environment to be able to measure narrow band absorption or spectral peaks. The lower sensitivity of THz volatile sensors at atmospheric pressure is due to the increased rate of molecular collisions leading to broadening of the spectral peaks, making it impossible to distinguish between different spectral signatures. To overcome this challenge, a practical approach for volatile molecular sensing at atmospheric pressure and room temperature in the THz regime is investigated in this paper by utilizing porous substrates which naturally allows condensing of gas molecules in pores through capillary condensation. Capillary condensation is dictated by pore sizes, density of pores and surface tension. All of these properties are investigated here to achieve high sensitivity. In order to further enhance sensitivity, different types of THz resonators are designed on the porous substrate and are characterized for different molecule sensing (having different boiling point and dielectric properties). Resonators allows easier interrogation of frequency shift due to dielectric loading of porous substrates. For the measurement, the substrate containing THz resonators are placed in the optical beam path of the THz signal and measured as a function of frequency using an Emcore PB7200 frequency domain terahertz measurement system. In order to control the exposure environment, the sensing elements are placed in an enclosed chamber and known volumes of volatile molecules with air mixture are introduced. Both adsorption and desorption rates on the porous surface as a function of time is investigated for specificity of different volatile molecules.

This work was supported in part by The Axia Institute

Poster Number: ECE-24
Authors: Deepak Kumar; Saikat Mondal; Saranraj Karuppuswami; Yiming Deng; Premjeet Chahal
Title: A Wireless PZT Based Harmonic Tag for Remote Vibration Detection

Abstract: Fault detection and monitoring techniques are necessary for continuous and smooth operation of machines in almost every industrial field. In recent years, the focus of the research has turned towards development of low cost and reliable technology for condition-monitoring and predictive maintenance of machines. Vibration analysis plays a vital role in analyzing the structural integrity of machines and provides insights for predictive maintenance. Monitoring of vibration pattern in machines allows detection of anomaly in a timely manner reducing the economic loss associated with a breakdown. There are many techniques developed in literature ranging from acoustics such as piezoelectric and PVDF to vibrometry. Most of the techniques have common limitations such as limited read range, prone to clutter and lower signal to noise ratio. In order to improve sensitivity and overcome these limitations, a piezoelectric based harmonic tag is investigated for vibration detection. The sensor tag consists of a PZT material coupled to a harmonic passive wireless tag. Under vibration, the PZT material generates a time varying voltage, which affect the reflected signal. The RF tag modulates the interrogation RF signal according to the bias voltage and produces a time varying harmonic signal. The design, fabrication and measurement of the proposed sensor tag is presented.

This work was supported in part by DOT

Poster Number: ECE-25
Authors: Mohd Ifwat Mohd Ghazali; Kyoung Youl Park; Premjeet Chahal
Title: 3D Printed Metalized Plastic Waveguides for Microwave Components

Abstract: This paper investigates the design and fabrication of 3D printed waveguide and their application for the design of microwave passive components. This includes a simple waveguide structure, a band pass filter, waveguide power splitter, a leaky wave antenna and a slot antenna array. A Lego-like approach is used to assemble different 3D printed sub-sections after metal coating. Details of modeling, fabrication and measurement are presented, and simulation and measured results match closely.
**Poster Number:** ECE-26  
**Authors:** Saikat Mondal; Mohd Ifwat Mohd Ghazali; Saranraj Karuppuswami; Amanpreet Kaur; Premjeet Chahal  
**Title:** A Nonlinear Transmission Line based Harmonic RF Tag  

**Abstract:** This paper describes the design and development of a nonlinear transmission line (NLTL) based passive RFID tag. When the tag receives a signal from the interrogator, it generates harmonics which are transmitted back to interrogator. The reflected signal is distorted in time domain due to the harmonic contents. Hence, a change in the rise time would be observed in the received signal.

*This work was supported in part by Department of Transportation*

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**Poster Number:** ECE-27  
**Authors:** Saptarshi Mukherjee; Lalita Udpa; Satish Udpa; Yiming Deng; Mahmoodul Haq; Antonello Tamburrino  
**Title:** Design of a Metamaterial Lens for Enhancing the Imaging Resolution for NDE of Composites  

**Abstract:** Metamaterials have been increasingly utilized in the design of novel RF and optical circuits and sensor systems. The unique properties of metamaterials offer several advantages such as super-resolution and compact design which is not found in conventional materials. This research focuses on the feasibility of designing a metamaterial lens in conjunction with a time reversal microwave mirror for NDE of composite materials. The challenges associated with the development and optimization of such a lens for inspection of composite materials is addressed. Specifically, the super resolution capability of the lens for detection of sub wavelength defects inside the composite materials will be studied. The theoretical approach underlying the design, followed by simulation results will be presented to demonstrate the feasibility of using the metamaterial lens for practical NDE applications.

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**Poster Number:** ECE-28  
**Authors:** Marisel Villafane-Delgado; Tamanna Tabassum Khan Munia; Selin Aviyente  
**Title:** Characterization of Functional Connectivity Networks in the Human Brain Through a Graph-to-Signal Transformation  

**Abstract:** In this paper, the functional connectivity of brain networks was characterized by means of a graph to signal transform. We employ a new graph-to-signal transformation based on the resistance distance matrix for transforming weighted functional connectivity networks into signals. Based on the signals obtained, we propose a graph entropy measure and a method for characterizing the network’s small-worldness. Our results illustrate how well-known network structures transform into distinct signals. In addition, the proposed entropy measure reflects changes in the network’s structural complexity. In cognitive control networks, our graph entropy measure is more sensitive to changes during different time intervals and between cognitive states. Through the network characterization method it is possible to estimate the small-world parameters of the functional connectivity networks. Based on our results, the signals obtained from the graph to signal transformation allow for the characterization of functional connectivity networks, and overcome some of the drawbacks of graph theoretic measures. The significance of the study is that the proposed graph to signal transformation provides a more robust way to quantify both the information content of functional connectivity networks and characterize their small-world properties.

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**Poster Number:** ECE-29  
**Authors:** Asad Nawaz; Ahmet Ulusoy  
**Title:** Ka/V Dual-band Phased Array Reconfigurable Transceiver in 0.13um BiCMOS SiGe Technology  

**Abstract:** A fully-integrated Ka/V dual-band reconfigurable phased array transceiver is implemented in 0.13um BiCMOS SiGe technology for multiband radar applications. The transceiver employs tunable matching networks to support impedance matching between antenna and LNA/PA for different beam steering angles. Each RF-front includes wideband single pole double throw switch, a transmitter and a receiver. Receiver comprises of dual-band LNA (with 15dB gain in each band and 3dB noise figure) and dual-band reflection type phase shifter (with 360 degree phase shift range and 45 degree resolution). Transmitter consists of band switchable PA (with 17dBm/16dBm output power and 35%/25% PAE in Ka/V band respectively) and a similar reflection type phase shifter as in receiver. A wideband power combiner is designed to combine powers from each element. Ka/V dual-band phased array radar with hardware reconfigurability is the first demonstration of its kind.

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**Poster Number:** ECE-30  
**Authors:** Haozhi Dong; Gaurab Panda; Kan Xie; Virginia Ayres; Harry Shaw; Deborah Preston; Manohar Deshpande  
**Title:** Flying Qubit Investigations for Heterostructure based Qubit implementations

**Abstract:** The current challenge of providing secure communications may be met through use of quantum communications based on quantum entanglement. Solid-state implementations are highly desirable for onboard spacecraft systems given their space, mass and thermal management restrictions. Initial solid-state implementations, including heterostructure-based and superconducting devices, have shown great promise but currently suffer from non-robust qubit generation and significant active cooling requirements to maintain coherence. Flying qubit designs have emerged as a new approach for adding dynamic control to solid-state qubit implementations including heterostructure-based electron gas implementations. The flying qubit approach utilizes the potential minimum of a SAW wave for the capture and transport of a single or few electron(s) from a reduced dimensionality electron pool. Many details of the interactions between the dynamic potential well induced by propagating SAW wave with the reduced dimensionality electron pool are unknown. In the present work, we investigate the effect of the SAW wave longitudinal component modelled as perturbation to the k-space momentum in the transport direction for a heterostructure based finite width 1D channel. A new quadratic expression for the k-space momentum and a new expression for the number density are reported for the first time in Ref. [1]. A major effect of positive or negative longitudinal perturbations on electron transport is the introduction of shifts that can affect both quantum channel accessibility and number density allowed occupations.

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**Poster Number:** ECE-31  
**Authors:** Thassyo Pinto; Mohammed Al-Rubaiai; Hongyang Shi; Chuan Wang; Xiaobo Tan  
**Title:** Stiffness-controlled Soft Robotic Catheter with Nanomaterial-based Pressure Sensors for Measuring Tissue Hardness

**Abstract:** In this work, we present a new class of soft catheters with stiffness-changing and pressure-sensing capabilities. The catheter is composed of a soft pneumatic actuator (SPA) combined with an electrically conductive polylactic acid (PLA) sheet and carbon nanotube (CNT) screen printed sensors. Silicone molding is used to fabricate the SPA, whereas the conductive PLA layer is created through 3D printing. The sensor is bonded to the catheter end tip. Different bending angles can be achieved depending on the number of indentations in the conductive PLA for modular rigidity. This allows the application of high forces against biological tissues for probing the hardness spatially.

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**Poster Number:** ECE-32  
**Authors:** Jubaid Qayyum; John Papapolymerou; Ahmet Cagri Ulusoy  
**Title:** A 94-GHz Five-Port Reflectometer Integrated Permittivity Sensor using 0.13-µm SiGe Process and Aerosol Jet Printing

**Abstract:** In this report, the author proposes an on-chip dielectric sensor based on multi-port architecture. The designed sensor, integrated on-chip with the five-port reflectometer (FPR), is being fabricated in a 0.13-µm 300GHz-fT/450GHz-fmax SiGe process technology. The heterojunction bipolar transistors (HBTs), implemented as power detectors for the FPR, yield a responsivity of 17 kV/W at 94 GHz. A 450-µm long shorted coplanar-waveguide (CPW) line was designed as the sensor to detect the phase variation in the reflection coefficient when the dielectric constant above the CPW changes. The chip occupies an area of 1164-µm x 410-µm and the reflectometer itself consumes 6.28 mW from a 1.5 V power supply. The system will be packaged using 3D printed interconnects using aerosol jet printing (AJP) technology. As a proof of concept, a trapezoidal structure was 3D printed on Liquid Crystal Polymer (LCP) and CPWs were printed on top of them to imitate mm-wave packaging. The printing was done using silver nanoparticle ink that acquired 40% conductivity of the bulk silver after sintering at 200 °C for one hour. The CPW interconnects yielded insertion loss of as low as 0.49 dB/mm including the trapezoid, and with a loss of 0.38 dB/mm on LCP substrate at 110 GHz. This work also represents AJP as a solution for cost-effective system-on-package (SoP)/ millimeter-wave (mm-wave) systems.
**Poster Number:** ECE-33  
**Authors:** Mohammad R. Rawashdeh; Andres Rosell; Lalita Udpa; Yiming Deng  
**Title:** Experimental Two-Dimensional Defect Detection and Characterization Using TMR Sensors and Excitation Coil in Fixed Position  
**Abstract:** An experimental setup is developed to detect and characterize subsurface defects in T6061 aluminum alloy which is widely used in aircraft structures and automotive parts. (Tunnel Magnetoresistance) TMR sensors are used to measure the perturbation of magnetic flux density fields and form C-scan images. Validation using both commercial COMSOL and in-house Subregion FEM solver is conducted.

**Poster Number:** ECE-34  
**Authors:** Mohammad R. Rawashdeh; Ma’moun S. Altantawi; Nihad Dib; Yiming Deng  
**Title:** Parameters of Microstrip and Coupled Microstrip Lines Mounted on Anisotropic Multilayer Substrate Using Conformal Mapping  
**Abstract:** It is known that it is mathematically difficult to find the different characteristics and properties of multilayer anisotropic microstrip and coupled microstrip lines. In this project, closed form expressions are presented to the per unit length line coupling parameters of coupled on-chip microstrip interconnect on anisotropic multilayered substrate. The Single Layer Reduction (SLR) formulation is presented to reduce the multi-layer structure into an equivalent single layer structure. Transformation from anisotropic to isotropic media is evaluated based on the Modified Wolff Model (MWM) formulation; the rest of calculations are mainly based on Schwartz-Christoffel transformation which is a special case of conformal mapping.

**Poster Number:** ECE-35  
**Authors:** Mohammad R. Rawashdeh; Nihad Dib; Yiming Deng  
**Title:** Full-Wave Analysis of Circular Structures Loaded with Longitudinal and Azimuthal Magnetized Ferrite Substrates Using the Finite Difference Frequency Domain Method  
**Abstract:** Full-wave analysis of circular guiding structures completely filled with ferrite by using the finite difference frequency domain method is presented. The ferrite is assumed to be azimuthally and longitudally magnetized to remanence. Emphasis is placed on the TE0m modes that are rotationally symmetric. These modes exhibit nonreciprocal behavior that could be exploited to build phase shifters and microwave isolators. Dispersion diagrams for these modes are given for both forward and reverse waves, and the effect of various ferrite parameters is studied. It is shown that the dispersion diagram may exhibit a region of negative slope, which gives rise to backward wave.

**Poster Number:** ECE-36  
**Authors:** Montassar Sharif; Xiaobo Tan  
**Title:** IPMC Flow Sensor Exploiting Self-Generated Vortices  
**Abstract:** Ionic polymer-metal composites (IPMCs) have inherent sensing properties, one application of which is flow sensing. However, the transduction physics and mechanics of IPMC pose challenges in deciphering the sensor output for DC flows. In this work we propose a novel IPMC flow sensor that exploits self-generated von Karman vortices to produce vibration of the sensor, the frequency and amplitude of which are correlated with the stream flow. The sensor consists of a 3D-printed soft cylindrical sheath housing an IPMC beam, and one end of the sheath takes the shape of a sphere. In the sensing configuration, the sheath is placed parallel to the stream flow direction, with the sphere end fixed. Experiments are conducted in a flow channel to measure the IPMC sensor output and free-end displacement of the sheath under different flow speeds. The results indicate that the proposed sensor structure can produce significant oscillatory signals for effectively decoding the flow speed.  

*This work was supported in part by Office of Naval Research (Grant N000141512246), and the Higher Committee for Educational Development in Iraq (HCED)*
Poster Number: ECE-37
Authors: Hongyang Shi; Thassyo Pinto; Yiheng Zhang; Chuan Wang; Xiaobo Tan
Title: Soft Capacitive Sensors for Measurement of Both Positive and Negative Pressures

Abstract: Soft pressure sensors have a wide range of applications, such as aerodynamic control of cars and unmanned aerial vehicles, navigation of underwater vehicles, and wearable electronics. Existing soft pressure sensors are typically based on capacitive or resistive principles. However, these sensors, made of multiple layers of different materials, tend to delaminate under negative pressures and thus cause sensor failure. In this work, we present the fabrication method for soft capacitive pressure sensors that can reliably detect both positive and negative pressures. The pressure sensor is comprised of one layer of Ecoflex-0030 substrate with cavity channels embedded inside, and two layers of polydimethylsiloxane (PDMS), with two layers of patterned PEDOT:PSS films serving as the electrodes of the sensor. The PEDOT:PSS films are screen-printed orthogonally on both sides of the Ecoflex-0030 substrate, and each side is encapsulated by another PDMS layer, which is much stiffer than the Ecoflex-0030 substrate. More importantly, the cavity channels in the Ecoflex-0030 substrate greatly enhance the substrate deformation, hence the capacitive sensor would exhibit remarkable relative change in capacitance when a pressure is applied. Secondly, the encapsulation of PDMS on the Ecoflex substrate protects the electrodes and effectively avoids the delamination problem under negative pressure. In particular, we report the detailed characterization of sensitivity and repeatability of the fabricated pressure sensor for positive and negative pressures of up to 50 kPa. Furthermore, a 12-by-12 pressure sensor array is fabricated to demonstrate the capability of mapping pressure distributions created by both compressive loads and vacuum suction.

This work was supported in part by Office of Naval Research (Grant N000141512246) and MSU Strategic Partnership Grant (16-SPG-Full-3236)

Poster Number: ECE-38
Authors: Seyyid Emre Sofuoglu; Selin Aviyente
Title: A Two-Stage Approach to Robust Tensor Decomposition

Abstract: The rapid advance in sensor technology and computing systems has lead to the increase in the availability of multidimensional (tensor) data. Tensor data analysis have witnessed increasing applications in machine learning, data mining and computer vision. Traditional tensor decomposition methods such as Tucker decomposition and PARAFAC/CP decomposition aim to factorize the input tensor into a number of low-rank factors. However, they are prone to gross error that may occur due to illumination, occlusion or salt and pepper noise encountered in practical applications. For this purpose, higher order robust PCA (HoRPCA) and other robust tensor decomposition (RTD) methods have been proposed. These methods still have some limitations including sensitivity to non-sparse noise and high computational complexity. In this paper, we introduce a two-stage approach that combines HoRPCA with Higher Order SVD (HoSVD) to address these challenges.

This work was supported in part by NSF CCF-1615489.

Poster Number: ECE-39
Authors: Pratap Bhanu Solanki; Xiaobo Tan
Title: Extended Kalman Filter-based 3D Active Alignment Control for LED Communication

Abstract: LED-based optical communication is emerging as a low-cost, high-data-rate alternative to the traditional acoustics mode of underwater communication. However, it is challenging to establish and maintain Line-Of-Sight (LOS) between the receiver and the transmitter, especially when such systems are used by mobile robots due to the robot movement. Hence, there is a need for an active alignment system that enables the receiver to constantly align itself towards the direction of the transmitting device. We propose and implement an active alignment control system capable of tracking a transmitting source moving in the three-dimensional (3D) space. An extended Kalman filter is used to estimate the components of the angle between the receiver orientation and the receiver-transmitter line. Using the estimate, a proportional-integral (PI) controller is implemented to adjust the receiver orientation. The algorithm uses one measurement of the light intensity from a single photodiode, where successive measurements are obtained via a circular scanning technique. The amplitude of the scanning is adapted to the alignment performance, to achieve a sound trade-off between estimation accuracy and signal strength along with energy consumption. Simulation and experimental results are presented to illustrate the effectiveness of the proposed approach.

This work was supported in part by National Science Foundation
Abstract: Carbon fiber reinforced polymers (CFRP) are extensively used in modern automotive industry because of its extremely strength and light-weight property. Large-scale manufacturing of CFRP components has resulted in a demand for low-cost, rapid and automated non-destructive techniques (NDT) for ensuring part integrity. Many NDT methods, e.g. X-ray, ultrasonic, thermographic, optical and electromagnetic methods have been proposed and applied to this problem. This presentation focuses on the detection and measurement of disbond between carbon fiber based materials using low frequency electromagnetic methods. Specifically, eddy current methods and capacitive methods are applied to two-layer bonded CFRP samples for measuring potential disbands. In this contribution, we present a comprehensive study on evaluating the performance and capabilities of these two probes and the interpretation of experimental results.

Poster Number: ECE-41
Authors: Zhiyi Su; Antonello Tamburrino; Chaofeng Ye; Gaspare Giovinco; Salvatore Ventre; Lalita Udpa
Title: Evaluation of Electrical Conductivity of Metals via Monotonicity of Time Constants

Abstract: This manuscript addresses the problem of evaluating the “classical” problem of estimating electrical conductivity of metals. The novel contribution of this work is the use of time constants of the source-free response in a pulsed eddy current testing (PECT) experiment. Time constants characterize the source-free response and increase monotonically with the electrical conductivity of the specimen. Source-free time constants are particularly important set of features because they do not depend upon the probing system and hence they are not sensitive to probe lift-off and tilts that are responsible for significant experimental errors.

Poster Number: ECE-42
Authors: Min Yu; Le Cai; Haocuhan Wan; Jinshui Miao; Suoming Zhang; Chuan Wang
Title: Printed Dual Gate Structure Ambipolar Carbon Nanotube Thin Film Transistor and Application in Complementary-Like Inverter

Abstract: Printing electronics based on single wall semiconductor carbon nanotubes (sSWCNTs) has broad application prospect. A new method of printing inverter and ambipolar sSWCNT TFT is demonstrated. The ambipolar sSWCNT TFT was realized by printing a cover layer on the sSWCNT film with a hybrid dielectric ink comprised of barium titanate BaTiO3 (BTO) nanoparticles and poly (methyl methacrylate) (PMMA). The threshold voltage, i.e. minimum drain current point, of the ambipolar TFT mainly ranges from -10 V to 10 V. The width-normalized ON-current (ION/W) reaches 10.7 μA/mm and the peak transconductance reaches 1.02×10^-6 S. With the covering BTO/PMMA layer, the TFT is stable after long time storage. With the control gate voltage increases from -60V to 60V, a threshold voltage tuning range of 18V is achieved. Almost hysteresis free transfer characters for top gate structure is achieved. With the dual gate ambipolar TFT, the complementary-like inverter is set up. The peak output voltage of 9.9 V for VDD = 10 V is achieved. This work shows a new possibility of printing complementary logics circuits with a sole kind of sSWCNT channel materials.

Poster Number: ECE-43
Authors: Weiyang Yang; Allison Broski; Jiajia Wu; Qi Hua Fan; Wen Li
Title: Characteristics of Transparent, PEDOT:PSS Coated Indium-Tin-Oxide (ITO) Microelectrodes

Abstract: This paper reports on electrochemical and optical characteristics of flexible, transparent microelectrodes, which consist of thin poly-(3, 4-ethylenedioxythiophene)/poly(styrenesulfonate) (PEDOT:PSS) spun onto indium-tin-oxide (ITO) electrodes for potential applications in biomedical optoelectronic devices. Although PEDOT:PSS/ITO combined films have been extensively investigated for applications in optical devices, such as solar cells and LEDs, PEDOT:PSS/ITO films for use in electrophysiological recording have not been well-characterized yet. In this work, PEDOT:PSS coated ITO microelectrodes with various diameters of 10 μm, 37 μm, 50 μm and 80 μm were microfabricated and characterized, and their properties were compared with plain ITO microelectrodes. Experimental results demonstrate that PEDOT:PSS coated ITO electrodes exhibit decreased electrochemical impedance, well-performed stability in saline, and increased charge storage capacity while preserving excellent optical transparency and mechanical flexibility. Equivalent circuit models were fitted to the experimental results to analytically extract interface capacitance, charge transfer resistance and solution resistance at the electrode-electrolyte interface.

This work was supported in part by National Institutes of Health under Award NIH R21NS096637-02 and Michigan State University Strategic Partnership Grants.

Abstracts of the 2018 Engineering Graduate Research Symposium, Michigan State University
Poster Number: ECE-44
Authors: Yiheng Zhang; Suoming Zhang; Chuan Wang
Title: Printed Stretchable Pressure Sensor

Abstract: In this work, a micro-crack enabled pressure sensor with tunable sensitivity has been demonstrated. The devices are made by conductive patterns composed of silver nanoparticles with structure-dependent electrical characteristics. Silver nanoinks are printed on an elastomeric polyurethane acrylate substrate in the form of planar serpentine structures and the relative changes in resistance (\(\Delta R/R_0\)) and sensitivity are found to strongly depend on the serpentine radius (\(r\)) that determines the strain relieving efficiency. Additionally, an application of monitoring the blood pressure in real time using the pressure sensor has been demonstrated. Instead of using the conventional measurement setup or the Photoplethysmography (PPG) technology, the real-time blood pressure could be achieved by the fabricated pressure sensor, which has been mounted by a rubber band around the wrist tightly. The results demonstrate the versatile functionalities that can be acquired from conventional materials by judicious structural designs.
ENVIRONMENTAL ENGINEERING

Poster Number: ENE-01
Authors: Jennifer M. Collier; Benli Chai; James R. Cole; Alison M. Cupples
Title: High Throughput Quantification of the Functional Genes Associated with RDX Degradation using the SmartChip Platform

Abstract: Many military sites have been contaminated with the explosive hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and biological degradation is considered a viable remediation method for these sites. While many microorganisms have been linked to RDX degradation, their occurrence across contaminated sites is still largely unknown. To address this, methods have been developed to detect the functional genes associated with RDX degradation. However, published PCR primers do not fully capture the known genetic diversity associated with these genes. Therefore, the goal of this work was to design a suite of primers for each functional gene that together would have high coverage of all currently known gene sequences. Sequences of functional genes were collected from the NCBI non-redundant protein database using the Michigan State University Ribosomal Database Project’s (RDP) Functional Gene Pipeline & Repository (FunGene). These sequence sets were used to evaluate the published primers and to design new primers using RDP’s PrimerDesign tool. The SmartChip Real-Time PCR system, a massive-parallel single-plex PCR platform, will be used to quantify RDX functional genes on samples from RDX-contaminated sites. The current work is ongoing and completed tasks involve the development of a suite of primers for xplA, xenA and xenB. The newly designed primers have greatly increased the coverage for the target genes. For example, the coverage for published primers for xenA was less than 15% and the new primers have a theoretical coverage of >80%. Preliminary tests include testing a subset of these primers using qPCR with the CFX96 Bio-Rad real time platform.

Poster Number: ENE-02
Authors: Zachary Curtis; Hua-sheng Liao; Shu-Guang Li
Title: Natural and Anthropogenic Controls of Groundwater Salinity in Michigan - A Statewide Multiscale Assessment

Abstract: The State of Michigan - although surrounded by Great Lakes - relies heavily on groundwater to support its different water-use sectors. There is, however, growing concern over the sustainability Michigan’s groundwater resources due to reports of elevated salinity in shallow aquifers across the state. To better understand the sources, controls, and dynamics of groundwater salinity in Michigan, we performed a systematic, statewide investigation of near-surface conditions across multiple scales (both in space and time). In particular, we combined 1) data-driven modeling of massive amounts of statewide groundwater/geologic information across multiple spatial scales with 2) detailed field sampling, historical data mining, and process-based groundwater modeling for important local groundwater systems. The results show that a large-scale natural process is primarily responsible for the salinization, namely, the upwelling of deep brines into low-lying groundwater discharge areas. At local scales, the relative impact of upwelling is controlled by: i) streams and rivers - which act as ‘natural pumps’ that bring deeper groundwater to the surface; ii) the occurrence of nearly impervious geologic material at the surface – which restricts freshwater flushing of deeper groundwater; and iii) the spacetime evolution of water well withdrawals – which, over time, induces migration of saline groundwater from its natural course. These findings triggered an urgent response from local government officials to reduce/minimize the negative impacts on the groundwater system in coming years of growth. Using carefully planned projections of climate change, groundwater use, and land use, our calibrated model is being applied to explore groundwater conditions for the next 20 years.

This work was supported in part by This research was funded by the Michigan Department of Agriculture and Rural Development (MDARD) and the Ottawa County Planning Commission.
Abstract: Bioremediation is becoming an increasing common approach to clean up sites contaminated with the chlorinated ethenes. The determination of dichlorination Dechlorination activity is typically determined by using quantitative PCR (qPCR) targeting on the Dehalococcoides mccartyi reductive dehalogenase (RDase) genes. However, this approach provides no information on other chlorinated solvent degraders that might also be present and contributing to contaminant biodegradation. In this study, nucleic acids were extracted from SDC-9, which is a commercial bioaugmentation mixed culture, and eighteen groundwater samples (injection and extraction wells) from five chlorinated solvent contaminated sites (TX, OK, NJ, VA, and MD) bioaugmented by SDC-9. Extracted DNA were sequenced by Illumina HiSeq 4000 (2x150bp paired end format). Meta Genome Rapid Annotation using Subsystem Technology (MG-RAST) and double index alignment of next-generation sequencing data (DIAMOND) were used for the taxonomic and RDase analysis, respectively. The results showed that: SDC-9 was primarily composed of the genera Dehalococcoides, Methanocorpusculum, Parabacteroides, Bacteroides, Desulfotobacterium, Desulfovibrio and Clostridium. In the groundwater samples, potentially important chlorinated solvent degraders included Dehalococcoides, Desulfotobacterium, Geobacter, Polaromonas and Methylcococcus. Characterized RDase (pceA, tceA, bvcA, vcrA, tdrA) and uncharacterized putative RDase from Dehalococcoides mccartyi (30 strains), Dehalogenimonas (4 strains), Dehalobacter (4 strains) had been found in both SDC-9 and groundwater samples. Besides, functional genes accounted for metabolizing dioxane or degrading it cometabolically were also presented in those samples. These results should enable more comprehensive detection approaches towards in situ degraders following bioaugmentation with SDC-9 and thus contribute to the improved prediction of chlorinated solvent removal rates.

Poster Number: ENE-04
Authors: Farshid Felfelani; Yadu N. Pokhrel
Title: Improving Irrigation Parameterizations in the Community Land Model (CLM) using SMAP Soil Moisture Data

Abstract: In this study, we use in-situ observations and satellite data of soil moisture (SM) to improve irrigation parameterizations in version 4.5 of the Community Land Model (CLM). The irrigation application trigger, which is based on SM deficit mechanism, is enhanced by integrating SM observations and data from the Soil Moisture Active Passive (SMAP) mission which is available since 2015. We conduct three sets of offline simulations (no irrigation, control setting with default irrigation module of CLM, and SMAP simulation) at 3 arcminute resolution forced by the North America Land Data Assimilation System phase II (NLDAS2) meteorological data for 2000-2016. The central US (that encompasses highly irrigated regions such as the High Plains Aquifer) is selected as the study area for where model results are evaluated with available irrigation water use data at county-scale and also in-situ and satellite observations of SM content. We quantify spatial and temporal irrigation-induced changes in water and energy cycle components e.g., SM, irrigation total water withdrawal, surface temperature, and latent heat flux. Our results show that the SMAP simulation shows up to 0.1 mm^3/mm^3 drier estimation of SM (particularly across irrigated cells) compared to control simulation which suggests better agreement with both of SMAP and in-situ data. Further, the results suggest that alteration of SM magnitude and patterns significantly affect the surface energy and water balances. Lower SM content of SMAP simulation results in up to 2°C warmer surface temperature and up to 120 W/m^2 decrease in latent heat flux compared to the control simulation.

Poster Number: ENE-05
Authors: Shardula Gawankar; Rebecca H. Lahr
Title: Real-Time Monitoring of Phosphorus in Lake Erie using the Coffee-Ring Effect

Abstract: Agricultural runoff through Maumee River into Lake Erie plays a significant role in the formation of harmful algal blooms in the lake. Phosphorus is generally the limiting nutrient in freshwater systems like Lake Erie. Automated phosphorus monitoring in the field is preferred to lab based methods due to its advantage of providing faster and real-time results. Generally, these monitoring devices are expensive and are not capable of detecting low concentrations of phosphate (<0.02 uM); thus, there is a need for an accurate, highly sensitive and easy to use monitoring system of these nutrients. We are conducting proof of concept experiments to harness the coffee ring effect for orthophosphate quantification in surface water samples. The coffee-ring effect is the phenomenon by which a water droplet, once dried, leaves ring patterns such that the particles within the droplets are systematically concentrated around the edge of the droplet, separated by size. The new detection method will harness the low solubility of phosphate salts; dissolved phosphorus will be precipitated with an additive such as copper to form distinctly shaped and colored copper phosphate crystals that are expected to deposit at the edge of the residue pattern. A field autosampler capable of wirelessly transmitting photographs of the residue patterns will be designed and tested to create an online monitoring system for phosphorus.
Abstract: Fullerene is a form of pure carbon. It is used in cancer therapy and MRI, drug delivery, Nano-sensor, and organic photovoltaic devices. The challenge in large scale production of fullerene is to reduce the cost of purification from the fullerene mix to >99% C60 and C70 which is required for all applications. The current purification processes are expensive and have negative impacts on the environment due to the use of large amounts of toxic solvents and repetitive process. In this study, the environmental and cost impact of three purification techniques: liquid chromatography, selective complexation, and crystallization are compared based on life cycle assessment metrics (cumulative energy demand and global warming potential). In addition to the LCA metric, the E-factor which measure the amount of waste materials in the purification process is calculated. Finally, on the basis of results from LCA and green chemistry metrics, an alternative purification method with lowest environmental impacts and highest purification yield is proposed.

This work was supported in part by The Project is funded by Discretionary Funding Initiative (DFI).

Title: Sustainable Approach for Fullerene Purification

Authors: Seyed Mohammadreza Heidari; Eunsang Lee; Annick Anctil

Abstract: Fullerene (C60, C70, and higher fullerenes) are allotropes of carbon that are used in cancer therapy, MRI, drug delivery, Nano-sensors, and organic photovoltaic (OPV) devices. The challenge in large scale production of fullerene is to reduce the cost of purification from the fullerene mix to >99% C60 and C70 which is required for all applications. The current purification processes are expensive and have negative impacts on the environment due to the use of large amounts of toxic solvents and repetitive process. In this study, the environmental and cost impact of three purification techniques: liquid chromatography, selective complexation, and crystallization are compared based on life cycle assessment metrics (cumulative energy demand and global warming potential). In addition to the LCA metric, the E-factor which measure the amount of waste materials in the purification process is calculated. Finally, on the basis of results from LCA and green chemistry metrics, an alternative purification method with lowest environmental impacts and highest purification yield is proposed.

This work was supported in part by NSF PIRE (Partnerships for International Research and Education) program

Title: Mechanistic Understanding of Oil Droplet Adhesion to Charged Surfaces under Conditions of Hydrodynamic Shear

Authors: C. A. Hejase; E. N. Tummons; J. W. Chew; A. G. Fane; V. V. Tarabara

Abstract: Large volumes of oily wastewater are produced during hydraulic fracturing and in various industrial operations at petroleum refineries and petrochemical plants. If not properly treated, these wastewater streams can pose significant environmental risks. Removal of emulsified fraction of oil (i.e., oil droplets smaller than 10 micron) is often a prerequisite for meeting environmental regulations. Interaction of oil droplets with various surfaces (coalescers, membranes, media filters) is a key process in many treatment operations. Yet, mechanisms of oil droplet adhesion when emulsions are flown along or through such surfaces under conditions of high salinity and hydrodynamic drag remain poorly understood. Specifically, conditions that lead to oil accumulation into compressible surface cakes or formation of contiguous films are unclear. Previous work by our team demonstrated the feasibility of a direct real-time visualization of surfaces being coated by emulsified oil in the presence of hydrodynamic shear [2, 3].

In the present study, we investigated the impacts of salinity and stability of hexadecane-in-water emulsions, and of the surface charge on oil droplet adhesion to such surfaces. Direct Observation Through the Membrane (DOTM) technique was employed to visualize the droplets in real time on the surface of two optically transparent polyelectrolyte-coated surfaces of opposite charge. Visualization by DOTM was complemented by a force balance analysis to estimate the hydrodynamic and surface forces governing oil droplet behavior at the surface. Quartz crystal microbalance with dissipation (QCM-D) and reflectance Fourier transform infrared (FTIR) spectroscopy experiments were conducted to examine the assembly and potential disassembly of polyelectrolyte coatings upon exposure to sodium dodecyl sulfate (SDS) used to stabilized emulsions. The addition of salt had two main effects on emulsion stability: decreased interfacial tension and decreased zeta potential of oil droplets. DOTM tests conducted with the positively charged surfaces revealed contiguous oil film formation due to the high droplet-droplet and droplet-surface interactions. Tests with negatively charged surfaces showed distinct adhesion behaviors that depended on the type of salt added. Addition of divalent cations stimulated oil droplets coalescence which later led to oil film formation. Coalescence was observed under conditions of moderate membrane wettability by oil and moderate droplet-droplet interaction where oil droplets reach a critical size and then are swept off the surface by the crossflow shear. The results indicate that oil droplet adhesion to a surface is governed by interfacial tension, electrostatic droplet-droplet and droplet-surface interactions, oleophilicity of the surface, and salinity of the dispersion phase. The accumulation of oil on the surface can be mitigated by promoting droplet coalescence where oil droplets reach a critical size and then are swept off the surface by the crossflow shear.

REFERENCES

This work was supported in part by NSF PIRE (Partnerships for International Research and Education) program
**Poster Number:** ENE-08  
**Authors:** Dipti Kamath; Siddharth Shukla; Annick Anctil  
**Title:** Home Charging Electric Vehicles with Second Life EV Batteries: Getting Every Lithium-ion out!

**Abstract:** Lithium-ion batteries (LIBs) are suitable for vehicle application until their capacity fades by 20%, after which they are considered to have reached end-of-life (EOL) and are discarded. Considering the rapid growth in electric vehicles (EVs), LIB disposal could create an important waste management problem. However, even with this capacity fade, EOL LIBs could be used for other applications, especially stationary storage applications which require less rigorous charge-discharge cycling. Second Life Batteries (SLB) are EOL batteries that have been remanufactured and have undergone quality checks, according to Original Equipment Manufacturer specifications. This work aims at assessing environmental and cost-benefit of SLBs. SLBs can be used to store and when necessary, use energy, either from intermittent renewable energy sources or from the grid at low cost and high net environmental benefit. This work evaluates using SLBs as an Energy Storage System (ESS) at household-level for residential electricity demand as well as EV charging while taking advantage of time-of-use rates. A variation of the scenario considered an additional rooftop photovoltaic panel to supplement the electricity demand. The optimal battery and solar system size were modeled using HOMER Pro software. The environmental and cost impact for the second life application system was compared to actual grid scenario using levelized cost of electricity, greenhouse gas emissions and energy demands for five locations in the US.

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**Poster Number:** ENE-09  
**Authors:** S. Kucuk; C. A. Hejase; I. Kolesnik; V. V. Tarabara  
**Title:** Filterability of Saline Crude Oil Emulsions Stabilized by Corexit 9500A

**Abstract:** During the 2010 Deepwater Horizon oil spill, nearly 800 million liters of oil was released into the Gulf of Mexico polluting deep ocean and more than 1600 km of the Gulf's shoreline [1]. A large amount (1.84 million US gallons) of dispersant, Corexit 9500A, was applied to the spill; as a result, the oil was emulsified into microdroplets that remained suspended in the water column. Even though small droplets facilitate biodegradation, they can pose high environmental risks. Microfiltration is one of the most cost-effective remediation technologies that can remove emulsified oil. In this study, the effect of salinity on the stability of model and complex oil-in-water emulsions was investigated during dead-end microfiltration. A hydrophilic polycarbonate track-etch (PCTE) membrane with a nominal pore size of 0.40 μm was used. Crude oil-in-water emulsion (0.1% v/v) was stabilized by Corexit 9500A. A hexadecane-in-water emulsion (0.1% v/v) stabilized by sodium dodecyl sulfate (SDS; 0.1mM) was used as a comparative basis. Salinity of the crude oil and hexadecane emulsions was varied using by adding MgSO4, NaCl, or instant sea salt mixture in various amounts. Emulsions were characterized in terms of their droplet size distribution, interfacial tension, and zeta potential. In addition, contact angles of the oil droplets on the membranes for different surfactant contents and ionic compositions of the dispersion medium were determined. Increasing salt concentration didn’t affect the crude oil droplet size distribution whereas hexadecane droplet size distribution shifted to larger droplet sizes. For both emulsions, increasing salt concentration decreased the interfacial tension. Constant pressure tests with non-saline crude oil emulsions showed rapid membrane fouling whereas addition of instant sea salt mixture resulted in a higher pseudo-steady-state flux. For hexadecane emulsions, permeate flux was a strong function of salinity. Increasing MgSO4 concentration from 6.7 to 54.3 mM caused an increase in the pseudo-steady-state constant flux 1 to 10 L/(m2·h).

Poster Number: ENE-10
Authors: Eunsang Lee; Christopher Traverse; Richard R. Lunt; Annick Anctil
Title: Environmental Benefit of Transparent Organic Photovoltaic in Window Application for Urban Area

Abstract: Transparent organic photovoltaics (TPV) harvest energy in the near-infrared (NIR) of the solar spectrum and therefore can be used in window applications. TPV in window application for an efficient landuse in urban areas where available land is limited. Our previous work showed that TPV in window applications reduces the energy consumption of building operation. TPV absorbs heat from NIR of solar radiation, and thus less energy is required for air conditioning while the back reflection of TPV conserves heat generated within the building. This effect could also reduce ambient temperature in urban areas since more heat energy will be absorbed and retained by TPV. Therefore, TPV application can potentially mitigate the urban heat island effect, urban regions to become warmer than rural surroundings. As a result, the reduced ambient temperature will also affect the energy demand of the building. This study includes the simulation of microclimate and building energy demand in Lansing area as a case study. ENVI-met is used to simulate the change of ambient temperature by TPV, and EnergyPlus is simultaneously used to compute required building energy demand by changed ambient temperature. Our preliminary results show that the temperature surrounding TPV is reduced ~ 0.2 °C and increased ~ 0.1°C based on each hour of simulation period for the lowest and highest temperature in summer. The final data will include continuous simulation over several days to assess the cumulative change of atmospheric temperature and analyze the benefits of TPV application in an urban area.

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Poster Number: ENE-11
Authors: Xiaoyan Li; Alyssa Sanderson; Rebecca Lahr
Title: Imaging the Coffee Ring Effect for Low Cost, Open Access Tap Water Fingerprinting

Abstract: As water infrastructure ages and public funds to monitor tap water decrease, new methods for household testing that are fast, cost-efficient, user-friendly, low tech, and reliable will become increasingly valuable. A new water analysis method is currently under development to harness the separation of solutes from aqueous solutions via the coffee ring effect using an aluminum slide ($0.24), jeweler loupe ($18), and cell phone camera. The coffee ring effect is the phenomenon by which water droplets leave distinguishable fingerprint residue patterns after water evaporates, where residues display ring-like deposits of solute particles separated by size and solubility along the perimeter of the residue. Tap water was collected from MSU and the surrounding communities. Water chemistry was measured ICP-OES, IC and pH meter. Synthetic waters were prepared following EPA protocols to represent five levels of hardness water components. Two microliter droplets of each water sample were dried on an aluminum substrate (aluminum 6061 with a mirror-like finish) and imaged through a jeweler loupe (Fancil 30x triplet loupe with an LED light) with a cell phone camera (Samsung Galaxy 6). Similar tap water chemistries were grouped through cluster analysis. Water samples with similar compositions that clustered in same group also displayed similar residue patterns after drying. Synthetic waters with higher hardness level show larger particles sizes and wider width of the coffee-ring in the residue patterns than synthetic waters with lower hardness levels. Water samples with above 6 mM bicarbonate and about 0.1 mM chloride form small, evenly distributed particles that are found across the entire residue area. Water samples with high sodium concentration (as high as 15 mM compared to about 0.2 to 3 mM), form large crystals in addition to the small particles. Water samples with about 5 mM bicarbonate, 0.5 mM sodium and lower, and about 2 mM calcium form tree leaf shaped patterns. Furthermore, the residue patterns for a given water chemistry are reproducible due to the physics of the coffee ring effect and particle formation in solutions with high concentrations of dissolved ions. Few water testing methods can be conducted cheaply and without specialized equipment to determine overall water composition in a single snapshot; thus, with further development this method may be valuable for low cost tap water analysis.
**Poster Number:** ENE-12  
**Authors:** Camille McCall; Irene Xagoraraki  
**Title:** Proposed Wastewater-based Method for Early Detection of Water-related Viral Disease Outbreaks in Urban Communities

**Abstract:** Water-related disease burden has been an increasing area of concern worldwide. The Centers for Disease Control and Prevention (CDC) estimates that 4-32 million cases of gastroenteritis occur per year in the U.S as a result of public drinking water systems. According to the World Health Organization (WHO), waterborne gastrointestinal diseases are responsible for 2 million deaths per year, most are young children. Moreover, it is estimated that the leading cause of water-related diarrheal illnesses worldwide is of viral origin. Viruses pose a major threat to human health due to their high mutation rates, low infectivity dose, and lack of medications to treat viral infections. These agents can be particularly difficult to manage in urban settings since high population density promotes the rapid spread of communicable diseases. Therefore, methods for early detection of disease outbreaks are needed to protect public health. Methods traditionally used for detection of disease agents rely on diagnostic tests of clinical isolates and are ineffective at detecting early signs of an outbreak. Gastrointestinal water-related viruses are excreted in human feces and persist in wastewater systems. Thus, we propose wastewater as an ideal tool for early detection and surveillance of water-related viral outbreaks in urban communities. Here, we present the diversity and concentrations of predominant water-related viral pathogens in wastewater collected from the Detroit Water and Sewage Department wastewater treatment plant. Furthermore, we assess correlations between viral signals obtained in wastewater and the occurrence of water-related viral diseases in clinical data for communities serviced by Detroit's WWTP.

*This work was supported in part by National Science Foundation*

**Poster Number:** ENE-13  
**Authors:** Evan O'Brien; Irene Xagoraraki  
**Title:** One-Health Approach to Detect and Prevent Water-Related Viral Outbreaks

**Abstract:** One-Health is a relatively new approach to the solving of global health challenges. A key component to the One-Health approach is the notion that human health, animal health, and environmental health are all innately interrelated. This approach is an ideal perspective from which to manage and prevent viral outbreaks. Viruses are small compared to other pathogens, facilitating transport in the environment, and possess resistance to disinfection and the ability to survive for prolonged periods in water and solids. Exposure pathways also exist directly from animals to humans and vice-versa; some viruses are able to be transmitted from animal hosts directly to human hosts. Additionally, viruses are often excreted in waste products, and can thus reenter the environment in these waste pathways. With regards to One-Health, two primary types of viruses can be considered: zoonotic viruses (those that can be transmitted directly from animals to humans) and water-related viruses. Because viruses can be transmitted in this variety of exposure pathways, they must be considered in their totality when engineering solutions to viral outbreaks. This review analyzes previous viral outbreaks in the United States and abroad, examines the exposure pathways that led to these outbreaks, identifies interventions that succeeded in mitigating viral outbreaks, and proposes a greater framework to implement long-term solutions to these health problems.

**Poster Number:** ENE-14  
**Authors:** Han Qiu; Phillip Blaen; David Hannah; Stefan Krause; Mantha S. Phanikumar  
**Title:** Modeling the Spatiotemporal Dynamics of Stream Temperature in a Mixed-Use Farmland Catchment

**Abstract:** Temperature is an important variable that controls biogeochemical processes in aquatic systems. Complex interactions between land surface - subsurface processes make accurate simulation of stream temperature dynamics a challenging task. This work provides a watershed-scale framework to model stream, soil, streamed and groundwater temperatures coupled with hydrologic and vegetation processes in a mixed land use catchment at the BIFOR facility. The availability of high-resolution stream flow, temperature, and nutrient data at the BIFOR site provides the motivation for this work.
Abstract: It is now well recognized that there is a critical need to develop management strategies for the emerging contaminant, 1,4-dioxane, due to its widespread occurrence. Given the limitations associated with traditional remediation methods, interest has turned to the use of microorganisms to degrade 1,4-dioxane. The majority of research on 1,4-dioxane biodegradation has centered on the transformation of this chemical under aerobic conditions. However, it is questionable if aerobic 1,4-dioxane degraders will be effective at chlorinated solvent sites that use reductive dechlorination as a remediation approach, as these sites are typically highly reducing. To address this, the current project aims to develop enrichment cultures capable of anaerobic 1,4-dioxane biodegradation. To date, experiments have involved the establishment of microcosms using agricultural soils, lake sediments and sediments from 1,4-dioxane contaminated sites (California and Maine) under a range of reducing conditions (nitrate, iron, sulfate reducing and methanogenic). 1,4-Dioxane concentrations over time are being determined using a GC/MS combined with Solid Phase Micro Extraction. The agricultural soils along with a river sediment sample illustrated a significant difference in concentration between the controls and the live microcosms under methanogenic conditions. Further data will be collected over next few months to confirm these results. Additional plans include the use of high throughput sequencing to identify the dominant microorganisms in the 1,4-dioxane degrading enrichments.

This work was supported in part by Strategic Environmental Research and Development Program (SERDP)

Poster Number: ENE-17
Authors: Jean-Rene Thelusmond; Emily Kawka; Timothy J. Strathmann; Alison M. Cupples
Title: Determining the Potential of Soil Communities to Metabolize Emerging Environmental Contaminants using Metagenomics

Abstract: Pharmaceuticals and personal care products (PPCPs) are released into the environment as a result of their incomplete elimination during the wastewater treatment process. Soil constitutes a major sink for such releases through irrigation with wastewater effluent and biosolids application. The presence of PPCPs in soils is quite concerning giving the risk of the underlying groundwater contamination and the uptake into plants leading to their unintended consumption by humans. This study investigated the biodegradability of two common wastewater and biosolids pharmaceuticals i.e. diclofenac (DCF) and carbamazepine (CBZ) alongside the antimicrobial triclocarban (TCC) in soil microcosms under different terminal electron accepting conditions (aerobic, nitrate-reducing, sulfate-reducing, and methanogenic). The objectives were to determine the microorganisms and pathways associated with DCF, CBZ, and TCC biodegradation in four agricultural soils at environmentally relevant concentration (50ng/g). The results demonstrated that DCF was rapidly biodegraded in all the soils under aerobic conditions. DCF was rather persistent under anaerobic conditions with only a small but significant decrease (p<0.05) in concentration under nitrate reducing and methanogenic conditions on day 50 and day 7, respectively. No DCF removal occurred under sulfate-reducing conditions. Separate experiments were performed for CBZ and TCC only under aerobic conditions. CBZ and TCC were found to be recalcitrant in soils with concentrations decreasing only by 20% (day 40) and 30% (day 50), respectively. At day 3, four pathways contained genes that were significantly enriched in the samples compared to the controls for DCF (propionate metabolism, lysine degradation, fatty acid metabolism and benzoate metabolism). These genes are likely very common in soils and perhaps explain the rapid removal of DCF in all four soils. In contrast, there was a limited impact of CBZ on the metabolic pathways in all four soils. TCC removal was associated with an increase in genes associated with the degradation of simple substrates as well as complex substrates.

This work was supported in part by USDA
**Poster Number:** ENE-18  
**Authors:** Xiaoyu Wang; Simon Davies; Susan Masten  
**Title:** Comparison of Zinc Ferrite Oxide, Nickel Ferrite Oxide and Cadmium Sulfide in Photocatalytic Degradation of Organic Pollutants

**Abstract:** The application of photocatalysis to utilize solar light energy for the photodegradation of organic compounds present in water and wastewaters is of significant interest. More than 50 organic compounds or waste products that potentially could be photodegraded, including sugars, alcohols, aldehydes, ketones and organic acids, are commonly found in wastes derived from biomass. In this study, the efficacy and kinetics of several photocatalysts to degrade organic contaminants have been evaluated. The impact of the concentrations of competing organic contaminants concentrations on removal efficacies has also been examined. The results showed that the methylene blue removal efficacy decreased as methylene blue concentration went up. Methylene blue concentrations fast decreased at the beginning of illumination then decreasing got slower after 100 min, especially obvious shown when CdS and nickel ferrite oxide working as catalysts.

**Poster Number:** ENE-19  
**Authors:** Hassan Waseem; Maggie R. Williams; Robert D. Stedtfel; Tiffany M. Stedtfeld; Syed A. Hashsham  
**Title:** AMR Analyzer: A Simplified PSR Amplification Based Platform for Antimicrobial Resistance Gene Measurements in Limited Resource Settings

**Abstract:** Measurement of antimicrobial resistance (AMR) genes in limited resource settings is a major challenge due to limited availability of tools capable of measuring molecular markers. We have developed an integrated low cost platform named AMR Analyzer that employs an android camera and a 96-384 well microfluidic chip for screening of AMR genes. The microfluidic chip contains PSR (Polymerase Spiral Reaction) primers for cost effective isothermal amplification eliminating the need for costly thermocycler platforms and simplifying the process. The microfluidic chip is fabricated from 3 mm acrylic sheets using CO2 laser and specially designed network of channels and wells allowing a single channel pipette or syringe to dispense the sample, greatly simplifying the process. Custom PSR primer sets can be dispensed after fabrication by the user. Up to 128 primer sets are possible with 3 replicates of each set. The platform uses an android based camera that captures the images at regular intervals. The images are then analyzed in image J software for the signal intensities to extract signal to noise ratio for each well. In this presentation, validation data related to the PSR based AMR chip, will be presented for clinical isolates, bioreactor, and environmental samples and compared with qPCR data for the same.

**Poster Number:** ENE-20  
**Authors:** Ammar Safaie; Tuan Nguyen; Chelsea Weiskerger; Meredith Nevers; Mantha Phanikumar  
**Title:** Relative Contributions of Sand, Sediments, and Birds to E. coli Concentrations at Lake Michigan Beaches

**Abstract:** As some of the most polluted beach areas in the United States, the Jeorse Park beaches in southern Lake Michigan are subject to microbial contamination from many and varied sources. To understand the relative influence of many of these contamination sources at the beaches, we developed an E. coli fate and transport model for Jeorse Park beaches. The model accounted for inputs from nearby rivers, resuspension of contaminated sediments, beach sand along the shoreline, and shorebirds in the presence of wave-current interactions, sediment transport and sediment – bacteria interactions. The models were tested against high-resolution field data collected in the summer of 2016, including E. coli concentrations in water, sand and sediment, total suspended sediment concentrations, and the number of gulls on the beaches. Results suggest that resuspension of sediments under the water is an important for accurately modeling the observed E. coli data, as is sand from along the beach. For Jeorse Park, the impact of river inputs was insignificant. Bird inputs to the beaches, however, were found to be critical to correctly modeling local E. coli concentrations. Because bird impacts are the only source factor that changes considerably between beaches, we conclude that birds are the major driver of elevated E. coli levels at the Jeorse Park beaches, contributing directly to water or indirectly through sand and sediment resuspension in the water. No additional sources, beyond those associated with birds, are necessary to explain variations in E. coli concentrations at Jeorse Park beaches.

*This work was supported in part by Army Corps of Engineers*
**Poster Number:** ENE-21  
**Authors:** Maggie Williams; Hassan Waseem; Robert Stedtfeld; Tiffany Stedtfeld; Sana Jameel; Syed Hashsham  
**Title:** Development and Validation of Polymerase Spiral Reaction (PSR) – A Two-Primer Isothermal Amplification Approach for Detection of Dehalogenase, Antimicrobial Resistance, and other Genes Relevant to the Environment

**Abstract:** The use of nucleic acid-based approaches for quantification of molecular targets in biology allows for rapid responses and potentially improved outcomes for protection of the environment and human health. However, these approaches are often complex, requiring centralized laboratory facilities and skilled personnel. The use of isothermal approaches could allow these tests to be conducted in the field. Polymerase spiral reaction (PSR) is an isothermal amplification approach that utilizes two primers that fold over each other, resulting in circular templates. Through the use of Bst polymerase and Betaine solution, temperature cycling is not needed, as both promote strand displacement. Use of two primers (opposed to the 4-6 primers typically used in isothermal experiments) allows for better allelic coverage and simultaneous detection of multiple strains. This is particularly important for dehalogenase genes, which can be diverse, making it difficult to obtain a consensus sequence. In this study, PSR primers were designed for detection of dehalogenase, antimicrobial resistance, and several other genes relevant to the environment. As PSR primers also require an exogenous sequence on the 5’ of both primers, these were ligated to the species-specific primers via T4 RNA ligase to create a panel of assays to be used on field-based platforms (such as Gene-Z) and in high-throughput centralized laboratory-based platforms. Overall the use of PSR and the development of these primers through the ligation of sequences could allow for more rapid, field-based detection of genes relevant to the environment while providing better sequence coverage. Future work includes the development of high-throughput simple quantitative platform that utilize these assays.

**Poster Number:** ENE-22  
**Authors:** Huiyun Wu; Amira Oun; Ruth Kline-Robach; Irene Xagoraraki  
**Title:** Microbial diversity analysis for pollution source tracking of a Michigan sub-watershed

**Abstract:** Communities throughout the Great Lakes basin are developing and implementing watershed management plans to address non-point sources of pollution and meet Total Maximum Daily Load (TMDL) requirements. Investigating sources of microbial contamination in key streams and creeks is critical for the development of effective watershed management plans. Our specific goal is to characterize microbial pollution in the Sloan Creek sub-watershed in Ingham County MI, one of the impaired areas located in the Great Lakes Basin. This work presented an approach that will facilitate source identification. To identify pollution sources (human or animal) and major sites of origin (tributaries with highest pollution loads) water samples were collected from three locations in the sub-watershed representing the main creek upstream, main creek downstream, and tributary. Whole genome shotgun sequencing was performed in three samples to unveil the microbial community diversity. Fecal and sewer signatures, wastewater metagenome, human gut metagenome, rumen gut metagenome presented in the water samples. The conventional indicator E. coli and host-specific markers human and bovine Bacteroides genetic markers were quantified in water samples. 54% of the E. coli samples from the sampling locations exceeded the recreational water quality guidelines. High concentrations of Bacteroides indicated influence of multiple sources of fecal contamination, and confirmed that the studied watershed was affected by human and animal fecal contamination. The probable source of contamination were leakage from septic systems, and runoff from agriculture activities nearby Sloan Creek.
MATERIALS SCIENCE

Poster Number: MSE-01
Authors: Aida Amroussia; Mikhail Avilov; Carl J. Boehlert; Florent Durante; Clara Grygiel; Wolfgang Mittig; Isabelle Monnet; Frederique Pellemeoine
Title: Ex-Situ and In-Situ Investigation of Heavy Ion Irradiation Damage in Ti-6Al-4V

Abstract: Due to its high specific strength, good mechanical properties and corrosion resistance Ti-6Al-4V is considered as a structural material for the beam dump drum for the Facility for Rare Isotope Beams. Ti-6Al-4V samples were irradiated at the CIIMAP-GANIL Facility (1 MeV/u) and Notre Dame University (0.1 MeV/u) to investigate the changes in microstructure and mechanical properties at 350ºC and 25 ºC. Nano-indentation results for samples at lower doses (~1 dpa), indicated a low sensitivity to high electronic excitation (~7.5 keV/nm) and that the radiation damage was affected mainly by a dual dose and temperature dependence. Dose rate effect was also investigated (13 dpa/h and 0.8 dpa/h). In addition, an in-situ TEM investigation of irradiation damage was performed at the IVEM-Tandem Facility at Argonne National Laboratory. Three different Ti-6Al-4V TEM samples, with different processed microstructures, were irradiated with 1 MeV Kr2+ at 350ºC up to a dose of 24 dpa.

This work was supported in part by This work was partially supported by the U.S. Department of Energy Office of Science under Cooperative Agreement DE-SC0000661, the State of Michigan and Michigan State University. Michigan State University designs and establishes FRIB as a DOE Office of S

Poster Number: MSE-02
Authors: JoAnn Ballor; Vahid Khademi; Carl J. Boehlert; Masahiko Ikeda
Title: The Mechanical Behavior and Microstructure of Fe and Al modified Ti-Cr alloys

Abstract: To achieve desired mechanical properties of titanium (Ti), alloying elements are added to promote the formation of different microstructures. Ti alloys containing the omega-phase, which forms in beta-Ti alloys through quenching, heat treatment, or deformation, can exhibit significantly higher strengths and hardness than other Ti alloy microstructures. For example, Titanium-Chromium-Iron-Aluminum (TCFA) alloys have exhibited exceptional high-temperature strengths after undergoing heat treatments which induce the omega-phase. Further investigation into the processing-microstructure-property relationships for TCFA alloys has been conducted. Hardness, tensile, and fatigue testing was performed to investigate the mechanical properties of such alloys. Scanning Electron Microscopy, optical microscopy, Electron Backscatter Diffraction, and X-ray Diffraction techniques have been used to investigate the microstructure.

This work was supported in part by This research was supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy sciences through grant DE-FG02-09ER46637.

Poster Number: MSE-03
Authors: David Hernandez Escobar; Hakan Yilmazer; Carl Boehlert
Title: Characterization of HPT-Processed Zn-Mg Disks as a Potential Biodegradable Implant Material

Abstract: High-pressure torsion (HPT) is a severe plastic deformation process in which a disk-like sample is subjected to torsional shear strain under a high hydrostatic pressure. HPT has recently gained popularity in the biomaterials field as it provides the potential for achieving nanograin microstructures that can significantly improve mechanical properties, such as tensile strength and microhardness. In the last years, mainly Fe and Mg alloys have been studied as potential biodegradable metals, but neither of them has shown a satisfactory enough combination of mechanical performance, biodegradation and biocompatibility. Consequently, Zn-based alloys have been proposed due to numerous reasons as an alternative way to satisfy these requirements. Zn is naturally present as an essential element for basic biological functions and shows ideal physiological corrosion behavior. However, in order to overcome its poor tensile strength, pure Zn needs to be alloyed without compromising its good elongation-to-failure and corrosion resistance. In this work, a set of Zn-3Mg samples processed by HPT at 1, 5, 15 and 30 turns under 6 GPa at a rotational speed of 1 rpm were chosen. Scanning electron microscopy (SEM) was used to analyze the distribution of Zn and Mg phases across the disks at different number of turns. The microhardness evolution along the disk diameter was also recorded. Electron backscattered diffraction (EBSD) combined with SEM was used to analyze the grain size, crystal orientation distribution, as well as the formation of high-angle grain boundaries at increasing plastic strain. X-ray diffraction was performed to detect the formation of Zn-Mg strengthening phases during HPT processing.

This work was supported in part by National Science Foundation
**Poster Number:** MSE-04  
**Authors:** Matthew Klenk; Sydney Boeberitz; Jin Dai; Niina Jalarvo; Vanessa Peterson; Wei Lai  
**Title:** Modeling Lithium Diffusion Using Quasi-Elastic Neutron Scattering

**Abstract:** Next generation lithium ion batteries will require safer and more conductive materials to meet future energy needs. Here the solid electrolyte lithium garnet, is evaluated using Quasi-elastic neutron scattering to better understand the diffusion properties of lithium within the crystal. We show that lithium moves through the lattice via a jump type mechanism with a distribution of jump lengths around a mean residence time. Consistent with the known spacing between neighboring lattice sites. We hope to show that by better understanding the diffusion mechanism of the garnet system, we will be able to engineer higher conductivity solid electrolytes.

*This work was supported in part by National Science Foundation (DMR-1206356)*

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**Poster Number:** MSE-05  
**Authors:** Junchao Li; Wei Lai; Dan P. Weller; Donald T. Morelli.  
**Title:** Effect of Cell Size and Basis Set on the Simulation of Atomic Dynamics in Tetrature Thermoelectrics

**Abstract:** Cu12Sb4S13-based tetrahedrites recently attract scientific focus as thermoelectrics due to their high performance and low expense. Molecular dynamic simulation is a useful tool to study the mechanism behind their low thermal conductivity (< 1 W m−1 K−1 at 300 K). The present work applies molecular dynamic simulation in Cu10Zn2Sb4S13 with two different cell sizes to investigate the size effect upon the structural and dynamical properties. In addition, two different basis sets, atomic orbital and plane wave basis, are performed on our structure as well, to examine the influence on the results.

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**Poster Number:** MSE-06  
**Authors:** Yuxiao Lin; Yue Qi  
**Title:** Origin of the Two-Plateaued or One-Plateaued Open Circuit Voltage in Li/S Batteries from First Principle Calculation

**Abstract:** Li/S battery is widely considered as one of the next generation energy storage devices because of its high specific energy density. Most of the discharging curves for Li/S batteries can be categorized into two types: with two-plateaus or one-plateau. Two-plateaued discharging curves are typically observed in Li/S batteries with a liquid electrolyte, and they are signatures for the generation of soluble polysulfide (PS). One-plateaued discharging curves have been observed in Li-S batteries with solid electrolytes, indicating direct transformation from S to solid state Li2S2 and Li2S, without the formation of PS. More interestingly, some Li/S batteries with liquid electrolyte also displayed one-plateaued discharging curves, which seems related to the nanopores in cathode materials or the limited solubility of PS in the electrolyte. The fundamental understanding of the mechanism and the conditions for the one-plateaued discharging curve will provide guidelines for Li/S battery design in order to improve its cycle life by preventing the PS dissolution.

In this article, we systematically investigated the influence of temperature and solvation on the predicted free energy and the open circuit voltage (OCV) curves for Li/S batteries. First, we confirmed that S, Li2S and Li should be modeled as crystal structures; while PS, such as Li2S4 should be modeled as monomer under solvation. Secondly, it was shown that the effect of temperature is negligible for predicting OCV curves associated only with solid-phase transformation, but plays a deterministic role in the free energy of dissolved molecules, such as PS. Thirdly, the solvation energy calculations are deemed to be the most accurate with a combined implicit and explicit model, which means the first solvation shell is modeled explicitly with an implicit dielectric continuum media.

With the appropriate treatment of temperature and solvation effect, we demonstrated that the two-plateaued discharging curves occur when the PS is fully solvated (by DOL in our model) and one-plateaued discharging curve occurs when PS is not solvated, in agreement with experimental observation in typical Li/S battery with liquid or solid electrolytes. Furthermore, if PS is only partially solvated, its formation energy increases, leading to a transition from the two-plateaued to the one-plateaued discharging curves, as the PS changes from fully solvation to partial or no-solvation. Partial solvation can be created with a highly-concentrated solution or by varying pore size and volume in the carbon matrix to confine S and limit the number of solvents transported into the pores, as practical methods to mitigate the PS shuttle problem from its root cause.
Abstract: By utilizing sequential catalytic active sites, cascade catalysis can fully extract the energy stored in chemical bonds, enabling biofuel cells with higher energy density and biosensors with stronger signal. A key limitation of this process is the transport of reaction intermediates, which is found to be naturally facilitated by substrate channeling, where intermediate molecules are shuttled directly to the downstream active site instead of equilibrating into bulk environment. [1] Electrostatic bound diffusion represents such mechanism that charged intermediate molecules are transferred along oppositely charged pathways. In past decades, significant work has been done on natural cascade. However, the gap between molecular-level interaction and phenomenal kinetics is not well built, because of the absent of surface diffusion via hydrogen bonds. Our group reported in early 2017 the first synthetic cascade, where poly-lysine peptide was found to be an effective bridge to facilitate the channeling of glucose 6-phosphate through a surface hopping mechanism. [2] Here, we are going to further explore the kinetic quantification by multi-scale models including Molecular Dynamics (MD) and Kinetic Monte Carlo (KMC). Using MD simulation, the energy barriers for surface hopping and desorption were quantified. Then, KMC model integrates the rate constants from MD simulation and experimental results, enabling a direct comparison to experimental kinetics and identifying potential limitation.

Reference

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Poster Number: MSE-08
Authors: Jialin Liu; Ilias Magoulas; Yue Qi; Piotr Piecuch
Title: Cluster Approach for Predicting the Open Circuit Voltage in Energy Storage Materials Using High-Accuracy Quantum Chemistry Calculations

Abstract: The redox reactions in energy storage materials are based on charge-transfer processes that involve transition metals. Most computational investigations of charge-transfer-related properties in batteries, such as the open circuit voltage (OCV), are based on density functional theory (DFT). However, DFT methods have problems with providing accurate and systematic results, mainly due to the self-interaction error, the delocalized nature of d-electrons originating from transition metal atoms, and difficulties the DFT approaches have with charge-transfer phenomena. Typical errors for OCV resulting from DFT calculations are on the order of 1 eV, i.e., they can be as large as ~30% for some cathode materials in Li-ion batteries. Furthermore, when one tries to determine OCV values for a number of materials, the errors obtained with DFT are far from being systematic and vary in a wide range. For example, if one tries to use the DFT GGA methodology to predict OCV in a series of lithium-based LiMxSxt materials, where M = Ti, Mn, Fe, Co, Ni and X = O, S, PO4, the calculated errors vary from 0.2 to 1.2 eV, without any obvious accuracy pattern. One could try to remedy this situation by adopting a GGA+U approach, which incorporates an empirical parameter U to correct for the self-interaction error and improve the calculated OCV values in some cases, but this hinders the transferability of the results and does not eliminate the problem of non-systematic error values when going from one material to another. To accurately predict the changes in energetics during charge-transfer processes that define OCV, we have decided to explore the usefulness of ab initio coupled-cluster (CC) methods, which are the de facto standard for high-accuracy molecular applications. The CC approaches offer a number of advantages relevant to OCV determination, including fast convergence toward an exact description in a basis set, size extensivity, and the ability to handle changes in oxidation states during charge-transfer processes. Unfortunately, the desired high-level CC calculations for crystalline structures with periodic boundary conditions are not feasible at the moment. We have, therefore, devised a protocol for designing polyatomic clusters that are large enough to resemble key properties of the bulk materials of interest, such as the structure and the formal oxidation states of transition metal centers, and yet small enough to allow high-level CC computations. We then employ an incremental approach where we perform CC calculations with singles and doubles, which can further be corrected for the connected triples, while examining the effect of the basis set at the appropriate second-order Møller–Plesset perturbation theory levels, to obtain the CC-level OCV values. The details of the above computational protocol and the results of the initial OCV calculations for the lithium-based energy storage materials, including LiCoO2 and, possibly, LiTiS2 will be presented.
Poster Number: MSE-09  
Authors: Yang Lu; Andre Lee  
Title: High Performance Cast Aluminum Alloys for Automobile Applications  

Abstract: Depending on Si content, minor element such as Sr was used with hypoeutectic Al-Si to modify the solidified microstructure leading to performance improvement of cast aluminum alloys. However, poisoning and recyclability issues due to the addition of minor elements into Al-Si melt, become major concerns for aluminum foundries and researchers. Therefore, there is a need for a universal modifier that can be used over a larger range of Si content. Previously, microstructure modification and ductility enhancement were obtained in nearly eutectic, A4047, alloy when treated with nanostructured chemical based on trisilanol phenyl polyhedral oligomeric silsesquioxane. It was postulated that silanols react with the active aluminum surface to form stable Si-O-Al bonds, while cage-like silsesquioxane core controls the subsequent solidification process. Similar approach was used in hypoeutectic (A356) casting alloys. Using standard casting approach, highly refined eutectic Si in A356 was observed, which lead to improve ductility while maintain their tensile strength.  

This work was supported in part by Ford Motor Company

Poster Number: MSE-10  
Authors: Xing Lu; Krishnamurthy Jayaraman  
Title: Biaxially Oriented Barrier Film (BOPP) with Nanostructured Additives  

Abstract: Biaxially oriented polypropylene (BOPP) has been developed as a commercial product in flexible packaging and dielectric capacitors. The biaxial orientation process improves the barrier to both oxygen and water vapor but the barrier still falls short of specifications in many cases and then a variety of coatings - organic, inorganic or metal, must be used to meet product specifications. An alternative route of adding nanoclay as a filler in the polypropylene, typically cut down on the stretch ratio of the polymer during biaxial stretching, by some reports in the literature. A new formulation (BOPP-NC) developed in our laboratory has not only achieved comparable stretch ratios but also resulted in nearly 50 % enhancement of barrier in the BOPP. Transmission electron micrographs (TEM) showed that the dispersion of nanoclay was maintained after the biaxial stretching while X-Ray diffraction studies revealed that the mean crystalline lamellar size in the nanocomposite BOPP film, BOPP-NC, was larger than in BOPP. Mechanical tests and optical tests showed that a nanocomposite BOPP film with significantly enhanced stiffness and barrier to both water vapor and oxygen was achieved without sacrificing clarity.

Poster Number: MSE-11  
Authors: Yuxi Ma; Jason Nicholas  
Title: The High Temperature Mechanical Properties, Defect Chemistry, and Electrochemical Performance of Praseodymium Doped Ceria Thin Films Determined Via In Situ Wafer Curvature Measurements  

Abstract: This work demonstrated for the first time that a wafer curvature measurement platform could be used to measure a variety of physicochemical properties (i.e. the oxygen surface exchange coefficient, biaxial modulus, thermo-chemical expansion coefficient, and thermal expansion coefficient) of oxygen exchange materials under well-characterized film stress states in situ under well-controlled temperature and atmospheric conditions. In addition, by combining the measured biaxial modulus and thermo-chemical expansion coefficients with independently-obtained values of the Poisson’s ratio and chemical expansion coefficient, respectively, the Young’s modulus and oxygen nonstoichiometry were determined. Lastly, from the oxygen surface exchange coefficient and the oxygen nonstoihcioity the oxygen surface exchange resistance was determined. Application of this analysis to the model Solid Oxide Fuel Cell cathode material Pr0.1Ce0.9O1.95-x (10PCO) showed that 1) the oxygen surface exchange coefficients of pulse laser deposited 10PCO thin films produced in different laboratories and analyzed with different electrode-free kchem measurement techniques were similar in magnitude but more than 1000 times lower than other 10PCO films in the literature, 2) that 230 nm thick (100)-oriented 10PCO films subjected to small (i.e. < 650 MPa) biaxial stresses have point defect concentrations and mechanical properties similar to those of bulk 10PCO samples, and 3) that on its own (i.e without catalytically active metal electrodes) 10PCO performs much worse than conventional Solid Oxide Fuel Cell cathode materials.

This work was supported in part by Department of Energy under Award Number DE-FE0023315
**Poster Number:** MSE-12  
**Authors:** Adam C. Marsh; Nathan P. Mellott; Natalia Pajares Chamorro; Neal Hammer; Xanthippi Chatzistavrou  
**Title:** Characterization of 3D Silver-Doped Bioactive Glass-Ceramic Scaffolds

**Abstract:** There is a significant need for the development of novel bioactive and antibacterial 3D scaffolds that can be used in orthopedic applications aiming to heal and regenerate lost, damaged, or diseased tissue. The aim of this work was to develop a novel 3D bioactive glass-ceramic scaffold with bioactive and antibacterial properties against resistant bacteria. The sol-gel (solution-gelation) technique was applied for the fabrication of this glass and the sacrificial template method was used for the formation of the 3D scaffolds. The homogeneity, morphological, and microstructural characteristics of the new 3D scaffolds were studied by SEM-EDS, XRD, XPS, and FTIR-ATR methods respectively. The bioactive properties were studied by immersing the scaffolds in Simulated Body Fluid (SBF). The formation of a hydroxyapatite phase on the surface of the scaffolds after two weeks of immersion in SBF confirms the bioactive behavior of the scaffolds. The antibacterial activity of these scaffolds were observed against Methicillin-resistant Staphylococcus aureus (MRSA) strain. An inhibition in the bacteria growth was observed when bacteria were cocultured with 15 days extracts of the scaffolds. A new 3D scaffold with potential applications in orthopedics and advanced bioactive and antibacterial properties has been developed. Future work will focus on improving the mechanical properties of this structure.

**Poster Number:** MSE-13  
**Authors:** Eureka Pai Kulyadi; Philip Eisenlohr  
**Title:** Development of a Constitutive Model to Describe Plastic Deformation in Single Crystal Niobium

**Abstract:** Non-Schmid effects influence the orientation dependence and tension-compression asymmetry of the yield stress in body-centered cubic (bcc) metals such as Nb. A constitutive model for plastic deformation in Nb that captures non-Schmid behavior is formulated by incorporating material specific dislocation strengthening coefficients that depend on the dislocation interaction mechanisms in play, and the deviation of the screw dislocation trajectory from the average glide plane, which modifies the Peierls stress for dislocation motion. The results from the adopted model are compared to those from compression and tension experiments.

This work was supported in part by U.S Department of Energy, Office of High Energy Physics, grant number DE-SC0009962

**Poster Number:** MSE-14  
**Authors:** Natalia Pajares Chamorro; Neal Hammer; Xanthippi Chatzistavrou  
**Title:** Reactivation of Antibiotics Against MRSA by Using Silver-Doped Bioactive Glass

**Abstract:** Regeneration of infected tissue is a global challenge worldwide. Clinical therapies normally involve prolonged administration of antibiotics aiming to combat bacteria by targeting at the cell-wall, DNA, RNA and other proteins synthesis mechanisms. The extensive use of antibiotics may lead to the development of antibiotic resistant pathogens like Methillin Resistant Staphylococcus aureus (MRSA). MRSA is a strain that has been isolated in many degenerative diseases in human body such as osteomyelitis and endocarditis. Over the years, different attempts have been explored to expand the action of the known antibiotics such as the combined delivery of different antibiotics or the addition of enzymes and antibodies. However, these approaches cannot prohibit the development of resistant bacteria. There is increasing interest around the use of heavy metal ions such as silver that can combat bacteria through various mechanism unlike antibiotics. In fact, the lack of resistance development is attributed to those multiple mechanisms of action. Combined delivery of heavy metals and antibiotics have shown to improve their spectrum of action. In this work, we combine new silver-doped bioactive glass particles (<20μm) with different antibiotics and we study the synergistic effects and the enhancement of the antibacterial capability of the agents alone. 

This work was supported in part by MSU
**Poster Number:** MSE-15  
**Authors:** Wanyue Peng; Guido Petretto; Alexandra Zevalkink  
**Title:** Ultra-low Lattice Thermal Conductivity in MgMg2Sb2 Compound

**Abstract:** Thermoelectric materials have a wide range of applications ranging from waste heat recovery to powering space explorations, among which Zintl phases are a subset of complex thermoelectric materials. MgMg2Sb2 belongs to the category of AM2X2 Zintl compounds with CaAl2Si2 structure type. n-type MgMg2Sb2 have the highest figure of merit zT of 1.6 which is the highest in this structure type. The origin of high zT is originated from the low thermal conductivity. Umklapp scattering plays a critical role in lattice thermal conductivity of a material. The phonon relaxation time, a concept originated from phonon-phonon scattering, depends on the anharmonicity of the phonon mode, which is known as mode Gruneisen parameter. The Gruneisen parameter describes the dependence of the mode's frequency and volume, which is related to the bonding nature of a material. Weaker bonds usually result in higher thermal expansion, lower speed of sound and low thermal conductivity. However, MgMg2Sb2 is an out-liner. Comparing to other AM2X2 type of compounds with the same structure type, it has the highest thermal expansion and lowest lattice thermal conductivity, but a rather high speed of sound. Our preliminary results shows that the ultra-low thermal conductivity is originated from the high mode Gruneisen parameter. Besides, unusual dips with negative mode Gruneisen on the edge of the Brillouin zone can be observed from the phonon-dispersion of MgMg2Sb2 compounds, which could imply the distortion of a certain bonds that contributes to the overall anharmonicity. In this work, the relationship between bond strength, Gruneisen parameter, thermal expansion, and phonon mean free path is discussed via a combination of experimental and calculated results.

**Poster Number:** MSE-16  
**Authors:** Mariana D. Reale Batista; Lawrence T. Drzaí; Aįper Kiziltas; Deborah Mielewski  
**Title:** Hybrid Cellulose-Inorganic Reinforcement Polypropylene Composites: Lightweight Materials for Automotive Applications

**Abstract:** Cellulose fibers are attracting considerable attention within the transportation industry as a class of reinforcing agents for polymer composites owing to their low cost, low density, high mechanical properties, and considerable environmental benefits. The objective of this study was to develop hybrid composites combining cellulose fiber with long glass fiber, short glass fiber or talc in a polypropylene (PP) matrix to optimize the overall composite properties. Tensile, flexural and notched Izod impact tests revealed that in general the mechanical properties decreased with increasing cellulose content, however, adding an optimum concentration of the cellulose fiber is a promising alternative to reduce or replace the utilization of inorganic fibers. For applications in automotive “under-the-hood” and body interior components, the hybrid cellulose-inorganic reinforcement composite approach not only leads to superior weight and cost savings, but also environment benefits over the inorganic reinforced composites.

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**Poster Number:** MSE-17  
**Authors:** L. B. Ren; G. F. Quan; C. J. Boehlert; D.D. Yin  
**Title:** Mechanical Asymmetry and Anisotropy Improvement Resulting from the Yttrium Micro-Alloying in AZ80 Mg Alloys

**Abstract:** Tension/compression tests were conducted for as-cast AZ80·xY (x=0.0, 0.2, 0.8 wt.%) Mg alloys. In addition, tension experiments were performed in the extrusion direction (ED), diagonal direction (DD), and transverse direction (TD) on the subsequently as-extruded Mg alloy sheets. For the as-cast alloys, the yield strength (YS) decreased with increasing yttrium (Y) content, while the elongation-to-failure exhibited an opposite trend. This may be associated with both the retardation effect on crack propagation caused by the spheroidization of β phase particles, which were stabilized by the Y additions, and the lower critical resolved stress for non-basal slips resulting from the Y solute. As a result, the compression-tension yield asymmetry ratio decreased from 1.37±0.07 to 1.15±0.02 with Y additions. For the as-extruded sheets, the YS decreased with Y addition in all three directions, and this resulted in less anisotropy. The texture intensity of the as-extruded AZ80, AZ80-0.2Y, and AZ80-0.8Y was 13.83, 17.68, and 12.81, respectively, and the volume fraction of the low-angle grain boundaries (LAGB) was 0.168, 0.090, and 0.056, respectively. TD tension had the lowest average schmid factor SF value of <a> slip in basal and prismatic plane. The comprehensive effect of the evident increase of the SF, the decreasing volume fraction of the LAGB, and the grain coarsening with Y addition may have contributed to the weakening of the yield strength.

*This work was supported in part by China Scholarship Council*
Abstract: A material’s thermoelectric efficiency is represented by its figure of merit, $zT$. In order to maximize $zT$, the electrical conductivity and Seebeck coefficient of a material must be simultaneously increased. Materials with anisotropic crystal structures are of particular interest as they present a method of decoupling the Seebeck coefficient from the electrical conductivity. The focus of the research are Ca$_5$M$_2$Sb$_6$ (M = Al, Ga, or In) Zintl compounds, containing covalently-bonded MSb$_4$ tetrahedral polyanions that resemble infinite double chains. Density functional theory predicts light band mass and improved thermoelectric performance in the direction parallel to the MSb$_4$ chains. Verifying this effect experimentally requires single crystals of sufficient size. Synthesis and characterization of single crystal Ca$_5$Ga$_2$-xIn$_x$Sb$_6$ are demonstrated using either Ga-Sb, In-Sb, or Ga-In-Sb flux. Grown crystals were analyzed using single crystal X-ray diffraction, scanning electron microscopy, and energy dispersive X-ray spectroscopy to determine phase purity and crystal structure.

This work was supported in part by National Science Foundation

Poster Number: MSE-19
Authors: Erik Stitt; Markus Downey; Mahmoodul Haq; Lawrence Drzal
Title: Application of High-Impact Polystyrene (HIPS) as a Graphene Nanoparticle Reinforced Composite Thermoplastic Adhesive

Abstract: Adhesive bonding is a more efficient joining method for composites than traditional mechanical fasteners and provides advantages in weight reduction, simplicity, and cost. In addition, the utilization of mechanical fasteners introduces stress concentrations and damage to the fiber-matrix interface. Adhesive bonding with thermoset polymers distributes mechanical loads but also makes disassembly for repair and recycling difficult. The ability to utilize thermoplastic polymers as adhesives offers an approach to address these limitations and can even produce a reversible adhesive joining technology through combining conductive nanoparticles with a thermoplastic polymer. The incorporation of the conductive nanoparticles allows for selective heating of the adhesive via exposure to electromagnetic (EM) radiation and simultaneously can augment the mechanical properties of the adhesive and the adhesive joint. This approach provides a versatile mechanism for efficiently creating and reversing structural adhesive joints across a wide range of materials. In this work, a high-impact polystyrene (HIPS) co-polymer containing butadiene as a toughness modifier is compounded with graphene nano-platelets (GnP) for investigation as a thermoplastic adhesive. The properties of the bulk composite adhesive are tailored by altering the morphology, dispersion, and concentration of GnP. The thermal response of the material to EM radiation in the microwave frequency spectrum was investigated and optimized. Surface treatments of the adhesive films were explored to enhance the viability of this nanoparticle thermoplastic polymer to function as a reversible adhesive. As a result, it has been shown that lap-shear strengths of multi-material joints produced from aforementioned thermoplastic adhesives were comparable to similar thermoset bonded joints.

This work was supported in part by The U.S. Department of Energy

Poster Number: MSE-20
Authors: Mingmin Wang; Shreyas Balachandran; Santosh Chetri; Anatolii Polyanskii; Peter Lee; Chris Compton; Thomas Bieler
Title: In-Situ Ecci Characterization of Microstructural Defects and Their Effect on Superconducting Properties of SRF Cavity Niobium

Abstract: Microstructural defects such as dislocations and grain boundaries in high purity niobium can degrade superconducting cavity performance by trapping magnetic flux, degrading thermal conductivity, and perturbing superconducting currents. Understanding the relationship between microstructural defects and their influence on magnetic flux behavior in niobium is necessary to reduce performance variability. In this study, seven bi-crystal tensile samples were extracted on strategically chosen grain boundaries from two niobium slices. Electron Channeling Contract Imaging (ECCI) was performed to evaluate dislocation structure evolution in samples deformed to 5% strain in-situ in an SEM. Samples for Magneto-Optical Imaging (MOI) extracted from the tensile samples enabled visualization of magnetic flux penetration with a magnetic field applied below the critical temperature, such that the effect of grain boundaries and dislocations on the superconducting properties can be evaluated. Research supported by DOE/OHEP contracts DE-SC0009962, DE-SC0009960, NSF-DMR-1157490, and the state of Florida.

This work was supported in part by Research supported by DOE/OHEP contracts DE-SC0009962, DE-SC0009960, NSF-DMR-1157490, and the state of Florida.
Abstract: Tetrahedrite materials demonstrate good thermoelectric properties while also being composed of earth-abundant, non-toxic elements. A major drawback for these materials is the time and energy intensive synthesis by the traditional solid-state furnace-ampoule technique. Recently, several new synthetic approaches have been explored in our lab to alleviate the constraints of the conventional method. First, the low energy solution-based modified polyol synthesis has been shown to yield tetrahedrite with an exceptionally high figure of merit (ZT=1.09 at 723 K). This technique can successfully synthesize the parent copper-based compound as well as tetrahedrite doped with transition metals (Zn and Fe). Nanoparticles ranging from 50-200 nm in size were obtained from the chemical synthesis, and nanostructuring was maintained after densification by spark plasma sintering. The nanostructured compounds demonstrated lower thermal conductivity, higher electrical resistivity, and increased thermopower compared to samples processed using the traditional approach. Accordingly, the effects of doping and nanostructuring on the thermoelectric properties of tetrahedrite synthesized by the solution-phase modified polyol process will be discussed. Next, reactive spark plasma sintering may be used to synthesize a broad range of tetrahedrite compositions, making this process amenable to commercial applications and expedited research. In our lab, this method was used to synthesize zinc and nickel co-doped tetrahedrite by simple vibratory ball milling combined with an elongated spark plasma sintering step. These samples demonstrated comparable thermoelectric properties while being synthesized in a significantly shorter amount of time (2 hours versus 2-3 weeks by the traditional method). Structural, electrical, and thermal properties of these materials were measured, and will be compared with the current state-of-the-art materials. Overall, these two novel synthetic approaches have provided groundbreaking results for tetrahedrite materials, both in terms of thermoelectric performance as well as synthetic versatility.

This work was supported in part by NSF, Department of Education
MECHANICAL ENGINEERING

Poster Number: ME-01
Authors: Basil Abdelemegied; Ahmed Naguib
Title: Characterization of a Jet-Flow Module for use in a New Impinging-Jet-Array Facility

Abstract: Impinging jets have a wide range of applications, such as heating, cooling, and drying. One significant application, which motivates the present work, is the use of impinging jet arrays for cooling of gas turbine stator and rotor blades. Cooling the turbine blades allows higher temperature tolerance; consequently, the maximum cycle temperature can be increased, resulting in a larger gas turbine efficiency. The overarching goal of the present research is to employ active flow control to manipulate jet instabilities with the purpose of enhancing the heat transfer rate resulting from the impingement of an array of three in-line jets on a heated wall. To address the goals of the research, a new facility is under construction. As an initial step in the construction process, the flow quality produced by one of the jet modules in the array is characterized prior to finalizing the design of the individual jets and completing the construction of the facility. The jet flow characterization is conducted for a jet Reynolds number based on diameter ranging from 4,200 to 34,000. Results presented relate to long-time flow stability of the compressed-air driven facility, mean and fluctuating streamwise velocity profiles of the jet, at different streamwise locations reaching up to six jet diameters downstream of the jet exit, and flow axisymmetry. Velocity measurements are conducted using hot-wire and pitot probes. In addition, the jet's vortical structure is visualized using a smoke-wire and a high-speed camera.

This work was supported in part by NSF Grant CBET-1603720

Poster Number: ME-02
Authors: Fatemeh Afzali; Brian F. Feeny
Title: Floquet-Based Analysis of the Equation with Periodic Damping Coefficient

Abstract: we study the response of a linear differential equation, for which the damping coefficient varies periodically in time. We use Floquet theory combined with the harmonic balance method to find the approximate solution and capture the stability criteria. Based on Floquet theory the approximate solution includes the exponential part having an unknown exponent, and a periodic part, which is expressed using a truncated series of harmonics. After substituting the assumed response in the equation, the harmonic balance method is applied. We use the characteristic equation of the truncated harmonic series to obtain the Floquet exponents. The free response and stability characteristics of the damped system for a set of parameters are shown.

This work was supported in part by This work is based on a project supported by the National Science Foundation.

Poster Number: ME-03
Authors: Mitchell Albrecht; Ahmed Naguib; Manoochehr Koochesfahani
Title: Lift and Drag on a Low Reynolds Number Airfoil Translating Across a Uniform-Shear Flow

Abstract: Fluid dynamics analyses of external flows most commonly consider uniform-velocity approach flow. Considering non-uniform-velocity approach flow, on the other hand, is more appropriate for many flow situations, such as wings experiencing atmospheric wind gradients or wake behind structures. To study these types of situations, experiments were conducted on a NACA-0012 airfoil translating across both uniform-velocity and uniform-shear (linear velocity profile) approach flows at various angles of attack in a water tunnel. In the latter case, the airfoil, with a chord Reynolds number of 12,500 at the water tunnel's centerline position, translated from the high- to the low-speed side of the shear layer. A fundamental question addressed by this research is whether the well-known quasi-steady analysis of airfoils steadily translating in a uniform-velocity approach flow is also applicable to slowly translating airfoils in a uniform-shear approach flow. If applicable, the quasi-steady analysis would allow computation of the lift and the drag on the translating airfoil using static-airfoil force information under the same flow conditions. The results provide the aerodynamic forces acting on, and the streamwise velocity of the flow over the suction surface of, the translating airfoil, which allows examination of the applicability of quasi-steady analysis.

This work was supported in part by Office of Naval Research (ONR) grant number N00014-16-1-2760, and National Defense Science and Engineering Graduate Fellowship (NDSEG)
**Poster Number:** ME-04  
**Authors:** Ali Al-Hajjar; Sean Swei; Guoming Zhu  
**Title:** Active Flutter Suppression of A Smart Airfoil with Saturation

**Abstract:** Flutter is dynamic instability of an airplane wing due to interaction among the elastic, inertial, and aerodynamic forces during the flight. The flutter could cause catastrophic failure and many control methods were proposed to reduce and suppress flutter. Using a smart airfoil is one of the proposed solutions for flutter suppression especially for unmanned air vehicles (UAVs). A smart airfoil has a groove where a control mass moves forward and backward in the groove to reduce the airfoil plunging and pitching motions due to flutter. The physical saturation constraint of a smart airfoil for active flutter suppression is studied in this work. The mechanism of the controller to stop the control mass before hitting the ends of the groove is introduced by implementing an additional gain-scheduling parameter during control design of the guaranteed performance $H_{\infty}$ controller. Simulation results show the effectiveness of the proposed method.

*This work was supported in part by HCED*

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**Poster Number:** ME-05  
**Authors:** Borhan Alhosseini Hamedani; Ahmed Naguib; Manoochehr Koochesfahani  
**Title:** Aerodynamics of an Airfoil Translating Across a Shear Flow

**Abstract:** The focus of traditional aerodynamics has been mainly on steady airfoils and uniform approach flow. Unsteadiness of the airfoil and/or non-uniformity of the approach stream add complexities to the aerodynamics of the airfoil; which have not been studied sufficiently. Such complexities arise, for example, during the landing of an aircraft in windy conditions, where the upstream velocity varies with the elevation of the aircraft; due to the existence of ground-level shear in the atmospheric boundary layer.

An experimental setup was developed to replicate the aforementioned complexities under simplified, well-controlled conditions in a wind tunnel. In this setup, a NACA-0012 airfoil is steadily translated across a canonical shear flow while conducting direct force measurements to investigate the lift and the drag forces acting on the airfoil. Data were acquired for different angles of attack, with the airfoil traversing at different cross-stream velocities, as well as while stationary near the center of shear (where the chord Reynolds number is approximately 75,000). Comparison of the traversing and stationary airfoil measurements were used to evaluate the deviation of forces between the two cases taking into account the apparent angle of attack of the moving airfoil (i.e. to evaluate the applicability of quasi-steady analysis for the shear flow). Results indicate that the cross-stream motion brings about a deviation in the lift force from stationary airfoil measurements, with larger deviation seen for higher cross-stream velocities.

*This work was supported in part by ONR grant number N00014-16-1-2760*

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**Poster Number:** ME-06  
**Authors:** Gaurav Chauda; Dr. Daniel Segalman  
**Title:** Elastic Half-plane Contact Analysis Using Trigonometric Polynomials

**Abstract:** Nonlinearity in structural dynamics due to surfaces in contact plays an important role in predicting complex mechanics of systems. In contact surfaces such as mechanistically jointed bolts, friction introduces nonlinearity and generates dissipation in the structures. By studying multiple frictional models, this study investigates nonlinear behavior over simple geometries and resulting energy dissipation in the contact region. This study focuses on the simplest plausible mathematical representation for such interfaces in order to bring insight into the behavior of friction in mechanical joints.

*This work was supported in part by National Science Foundation (NSF) Grant;(CMMI-1561628) "New Nonlinear Modal Analysis Framework for Multi-Scale Modelling of Structures with Bolted Interfaces"*
Poster Number: ME-07
Authors: Sheng Chen; Justin Scott; Tamara Bush, PhD; Sara Roccabianca, PhD
Title: Determination of the Proper Constitutive Model for a Subject Specific FE Model of the Human Thigh

Abstract: Finite element (FE) models are a popular choice to investigate the stress/strain distribution within soft tissues in vivo. One of the applications of FE in this capacity is the study of pressure ulcer formation. The ability of the models to represent the nonlinear mechanical behavior of soft tissues undergoing large deformation in vivo has, however, yet to be addressed. The intention of this study is to verify and compare the capability of four widely used constitutive models for soft tissue: neo-Hookean, Mooney-Rivlin, Ogden, and Fung orthotropic. The overall geometry of a subject’s thigh was gathered using a 3D scanner, the volume was then meshed to develop an FE model. Compressive force-deflection data from proximal, middle, and distal thigh regions of the subject were collected. Three regions, corresponding to the testing sites, were then identified in the FE model. The soft tissue mechanical behavior was described using one of the four material models mentioned previously at a time. Each region was endowed by different material parameters, while the femur was modeled as a rigid body. Material parameters best-representing experimental data were then identified using the Simplex Search Method implemented in the software Matlab. The optimized force-deflection curves from thigh models using different material models show that neo-Hookean model and Mooney-Rivlin model fail to represent the nonlinear behavior of thigh soft tissue, while Ogden model and Fung orthotropic model provide good fitting. The finding of this study is crucial for researchers who are interested in soft tissue modeling.

This work was supported in part by NSF CBET, grant number 1603646

Poster Number: ME-08
Authors: Jinbo Chen
Title: Design and Development of a ULTRA Low Head Axial Hydro Turbine for Electricity Supply

Abstract: As a major resource for electricity, hydropower is widely used around the world for renewable energy. Traditionally, large high-capital cost dam equipped with large turbine system is preferred to produce sufficient power supply. However, recently large hydropower system is questioned because of the impact of dams on the local environment, which could be a major barrier for development of large hydropower system. Besides, billions people remain without access to electricity and most of them are in remote and rural location where is not suitable for large hydropower system. Therefore, the utilization of ultra-low-head (ULH) water energy (situations where the hydraulic head is less than 3m or the water flow rate is more than 0.5m/s with zero head) has becomes more attractive. This reserach focus on developing a design methodology for a low-impact, damless Kaplan turbine system for ULH water resource.

Poster Number: ME-09
Authors: Prasanna Chinnathambi; Elisa Toulson
Title: Effect of Nozzle Area and Nozzle Orientation on Performance of a TJI System for use in Lean Natural Gas Engines

Abstract: Lean burn technology provides a means to reduce engine emissions and increase engine thermal efficiency. Turbulent Jet Ignition (TJI) involves the use of a chemically active, turbulent jet to initiate combustion in lean fuel mixtures. A rapid compression machine at the Energy and Automotive Research Lab at MSU was used for evaluating the effect of nozzle area and nozzle orientation in a turbulent jet igniter. Methane, one of the main constituents of natural gas was used as the fuel for the main chamber and the pre chamber. Pressure traces and high speed color images are used for comparing the nozzle performance.

This work was supported in part by California Energy Commission (CEC) work titled “Advanced fueled and unfueled spark ignited prechambers utilizing turbulent jet ignition for rapid natural gas combustion at very high dilution in a heavy-duty natural gas engine to obtain very low NOx” under
**Poster Number:** ME-10  
**Authors:** Joshua Drost; Tamara Reid-Bush  
**Title:** Functional Differences Between the Four Fingers

**Abstract:** To better treat loss of hand function, design upper extremity prosthetics, and develop products that interface with the hand, there is a need to better understand its functional abilities. While many studies have investigated the strength or motion abilities of hands, they use a small number of experimental positions, a small sample of healthy participants and do not evaluate both motion and force. The long-term goal of this project is to model the complete functional abilities of the entire hand; the focus of this work is to investigate the differences between the four fingers. 

Ten young healthy participants were included in this study. Maximum forces were measured in thirteen trials over the range of motion for each finger. After collection, the data were analyzed in terms of direction and magnitude of the force applied, as well as the fingertip position (x,y,z coordinate). The fingers were compared using ranges of motion, total force abilities and simple linear mixed effect models to predict full force abilities for the fingers.  

Future work will seek to improve on the models through the addition of participants and understand how each fingers’ ability changes due to hand osteoarthritis. Also, the motion and force of the thumb will be compared to the other digits.

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**Poster Number:** ME-11  
**Authors:** Berk Can Duva; Lauren Elizabeth Chance; Dr. Elisa Toulson  
**Title:** Design of a Constant Volume Combustion Vessel for Laminar Flame Speed Measurements

**Abstract:** Many essential flame characteristics, such as stability, extinction, flashback and blow-off, are reliant on laminar flame speed. Therefore, experimental laminar flame speed results are widely used for the validation of chemical mechanisms, determination of flammability limits and representation of important information on diffusivity, turbulent flame speed and the amount of energy released through combustion processes.

An optically accessible constant volume combustion vessel was designed and built to measure the laminar flame speeds of various fuels. Laminar flame speeds are measured using high speed Schlieren imaging to visualize the flame propagation of centrally ignited premixed fuel air mixtures. The constant volume vessel can be used for operation conditions of up to 130 bar and 200 degree Celsius, enabling fuel testing at engine-like conditions.

*This work was supported in part by Fiat Chrysler Automobiles (FCA)*

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**Poster Number:** ME-12  
**Authors:** Hamidreza Gharahi; Vasilina Filonova; C. Alberto Figueroa; Seungik Baek  
**Title:** Defining Homeostatic Baseline for Growth and Remodeling of the Arterial Tree

**Abstract:** The onset and early progression of many vascular diseases can be traced to permanent changes in the thickness, size, or stiffness of the distal arterial tree. Although pressure measurements and high resolution medical images are available, the present medical imaging modalities are unable to provide accurate information about the downstream blood vessels. Therefore, it is critical to use models to determine the geometry and the homeostatic baseline state of the blood vessels in the distal arterial tree. The objective of the present work is to determine the homeostatic state in the distal arterial tree based on an extension of Murray's law and steady state hemodynamics.

The minimum work principle is used to determine a target state defined by a homeostatic radius and a homeostatic material composition. This minimization problem involves the metabolic cost of maintaining the blood volume, the power needed to overcome viscous drag on the blood flow, and the metabolic cost of the materials that constitute the vessel wall under the constraint based on the mechanical equilibrium. The minimization is coupled with the steady state hemodynamics of the arterial tree by prescribing the flow at the inlet and pressure at the terminal vessels, namely terminal pressure, and using Poiseuille’s equation in each segment. The results of the coupled problem determine the composition of the arteries in the arterial tree as well as their geometry. When the homeostatic state is defined, arterial growth and remodeling can be used to test different hypotheses on pulmonary arterial hypertension.

*This work was supported in part by National Institute of Health*
**Poster Number:** ME-13  
**Authors:** Marissa Grobbel; Matthew T. Lewis; Robert W. Wiseman; Sara Roccabianca  
**Title:** Mechanical Analysis of Urinary Bladder Tissue Affected by Diabetic Cystopathy

**Abstract:** Diabetic cystopathy, loss of neurological connection with the urinary bladder (UB), is a condition that affects the ability of a diabetic patient’s UB to communicate a sense of "fullness." This loss of sensation leads to an increase in urine volume in the UB, which can trigger remodeling. UBs of patients affected by this condition show increased distensibility and thinned walls. Additionally, these patients’ UBs have been shown to have higher density of glycosaminoglycans (GAGs) within their walls compared to UBs of healthy patients. To measure the mechanical effect of varying levels of GAG concentration, we have developed a protocol to analyze swelling capabilities of diabetic and healthy rat UB samples. Isosmotic (300 mOsm/L) and hyposmotic (30 mOsm/L) modified Krebb’s solutions were used to induce swelling in UB tissue. Eight healthy UBs were submerged in isosmotic solution overnight to equilibrate for a physiological swelling state. Subsequently, half of the samples were submerged in hyposmotic solution, and half were kept in isosmotic solution. Measurements of each sample (weight/volume) determined that swelling had reached equilibrium after 2 hours. Moreover, submerging the tissue in hyposmotic solution resulted in a significantly higher weight of water intake (p<0.2) when compared to isosmotic solution. We plan to repeat this experiment, along with further mechanical testing, on UBs from Goto-Kakizaki (GK) rats—a non-obese type 2 diabetic model—to analyze the change associated with increase of GAG content and remodeling due to diabetic cystopathy.

**Poster Number:** ME-14  
**Authors:** Jun Guo; Rigoberto Burgueno  
**Title:** Tailoring the Spacing of Buckling Events and the Magnitude of Load Drops during the Postbuckling Response of Cylindrical Shells with Non-Uniform Stiffness Distributions

**Abstract:** The postbuckling response of thin-walled cylindrical shells has been gaining increased attention for smart applications due to their capacity to gain multiple bifurcation points in the postbuckling regime. Among the postbuckling characteristics of axially compressed cylindrical shells, the spacing of buckling events and the magnitude of load drops due to the buckling behavior are of particular interest for smart uses. Investigation has been taken on tailoring the spacing of buckling events and the magnitude of load drops of cylindrical shells subjected to axial compression by means of non-uniform stiffness distributions. An analog model to consider the non-uniform cylindrical shells as several parallel connected cylindrical panels was developed. Based on theoretical analysis of the analog model, numerical models were designed and analyzed using ABAQUS to evaluate the effect of thickness distribution design on the postbuckling response. Tests of the corresponding cylinders under axial compression were carried out to validate the numerical approaches. It was found that appropriate stiffness distribution designs allow controlling the spacing of buckling events and the magnitude of load drops during the elastic postbuckling response.

**Poster Number:** ME-15  
**Authors:** Syed Fahad Hassan; Suhail Hyder Vattathurvalappil; Mahmoodul Haq  
**Title:** Effect Of Adhesive Thermal Conductivity On Thermal Residual Stresses In Bonded Joints

**Abstract:** Thermoplastic adhesives modified with nanoparticle susceptors eliminate the sudden stress gradients experienced in conventional joining techniques in addition to providing manufacturing reversibility. The strength of these joints is a function of manufacturing efficiency, mechanical properties of the constituents and their thermal conductivity; factors, which ultimately dictate the amount of locked in residual stresses.

In this study, single lap joints with similar adherends (Aluminum 6061) were fabricated using adhesives containing different weight percentages of ferromagnetic nano-particles (FMnP) embedded in Acrylonitrile Butadiene Styrene (ABS). The thermal conductivity of the constituents and the tensile strength of the joints was experimentally evaluated and then compared with predictions from homogenized thermo-mechanical models using commercial software Digimat®. Experimental tensile (adhesive only) and Mode-I tests (Al 6061 adherends) were performed and multi-scale finite element (FE) models were used to predict, compare and quantify the effect of mismatch in thermal expansion coefficient at bi-material interface. Thermal conductivity of the adhesives increased with increase in weight fraction of the FMnP particles, whereas the modulus and tensile strength remained statistically constant. The micromechanical model for thermal and mechanical properties showed good agreement with experiments. The multi-scale finite element models and mode-1 tests showed that the bond strength increased with increasing adhesive thermal conductivity and reduction in locked-in residual stresses.

*This work was supported in part by American Chemistry Council*
**Poster Number:** ME-16  
**Authors:** Tianyi Ho; Guoming G. Zhu  
**Title:** Application of ICC LPV Control to a Blended-Wing-Body Airplane with Guaranteed H\(\infty\) Performance

**Abstract:** This paper addresses the Input Covariance Constraint (ICC) control problem with guaranteed $H_{\infty}$ performance for continuous-time Linear Parameter-Varying (LPV) systems. The upper bound of the output covariance is minimized subject to the constraints on input covariance and $H_{\infty}$ output performance. This problem is an extension of the mixed $H_2/H_{\infty}$ LPV control problem, in that the resulting gain-scheduling controllers guarantee not only closed-loop system robustness in terms of $H_{\infty}$ norm bound but also output covariance performance over the entire scheduling parameter space. It can be shown that this problem can be efficiently solved by utilizing the convex optimization of Parameterized Linear Matrix Inequalities (PLMIs). The main contributions of this paper are to characterize the extended $H_2/H_{\infty}$ LPV control problem using PLMIs and to develop the optimal state-feedback gain-scheduling controllers, while satisfying both input covariance and $H_{\infty}$ constraints. The effectiveness of the proposed control scheme is demonstrated through vibration suppression of a blended-wing-body airplane model.

*This work was supported in part by NASA Ames Research Center*

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**Poster Number:** ME-17  
**Authors:** Alexander Ho; Rajib Mandal; Rebecca Anthony  
**Title:** A Plasma-Based Route to GaN Nanocrystals

**Abstract:** Gallium nitride (GaN) has been used in bulk form for the fabrication of light-emitting devices, transistors, and various other electronics. Bulk GaN has a band gap of 3.4 eV which has been advantageous for use in ultraviolet and blue emitting LED’s. Synthesis of GaN at the nanoscale can allow tunable emission wavelength via quantum confinement. In addition, nanocrystals can be assembled into thin films on arbitrary substrates, enabling new device morphologies such as stretchable or bendable displays.

Here we present a gas-phase-only plasma-based route to synthesis of GaN nanocrystals (NCs) with tunable size. This low-temperature approach to freestanding GaN NCs eliminates common issues of hazardous solvent use and defects caused by lattice mismatch between the GaN and the substrate. The plasma reactor was operated using 13.56 radiofrequency (RF) power at pressures between 5-15 Torr. Trimethylgallium and ammonia were used as precursor gases and argon was used as the background gas. Samples were collected either by inertial impaction or diffusion onto a substrate.

Several techniques were used to characterize the synthesized GaN including x-ray diffraction (XRD), transmission electron microscopy (TEM), Fourier transform infrared spectroscopy (FTIR), absorption spectroscopy, and photoluminescence (PL). XRD in conjunction with TEM indicated crystalline GaN with a hexagonal structure and average sizes of 3.5 nm and 4.9 nm depending on the reactor parameters. A 325 nm LED was used as the excitation source to observe PL for GaN NCs dispersed in oleic acid. We observed a PL peak near 375nm for the suspended GaN NCs.

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**Poster Number:** ME-18  
**Authors:** Alborz Izadi; Mayank Sinha; Sara Roccabianca; Rebecca J. Anthony  
**Title:** Surface Instabilities in Silicon Nanocrystal Thin Films-Finite Bending

**Abstract:** Today, silicon has been considered as one of the most important material for semiconductor, electronic and sensors due to its abundance and low level of toxicity. Silicon nano-crystals also attracted lots of interests regarding their novel application for renewable energy and device fabrication to biological sensors. Here in Plasma and Nano-material Laboratory we would try unique techniques for fabricating Silicon Nanocrystals in a gas phase plasma and investigating various surface chemistry and physical properties. Since mechanical behavior of thin film has been barely studied. We are looking to modulate the mechanical behavior of silicon nano crystals in thinfilm forms and corresponding their instabilities and try to fit numerical models for the experiment observations.

*This work was supported in part by National Science Foundation. NSF*
Title: On the Effect of Vortex Pairing on the Heat Transfer from a Heated Wall during Vortex-Wall Interaction: a Computational Study

Abstract: Impinging jets are widely used in heating/cooling in industrial and manufacturing processes. The heat transfer process is known to be influenced by the jet's vortical structures and their interaction with the impingement wall. The nature of the vortex-wall interaction significantly depends on the distance from the jet exit to the wall. Depending on this distance, the pairing of two jet vortices may take place ahead of reaching the wall, or while the two vortices convect past, and interact with the wall. In this study, a CFD simulation is conducted in order to find which of the two aforementioned scenarios is more advantageous for enhancement of thermal transport from the wall. The simulation considers simplified model problems in which isolated vortex rings interact with a constant-temperature heated wall, in the absence of the jet flow. Two cases were studied: the first, where the pairing process happens above the heated wall; and the second, where pairing happens before reaching the wall. Results showed that vortex pairing near the wall causes significant enhancement in heat transfer in comparison with vortex pairing before reaching the wall. Additionally, using the time-dependent radial distribution of Nusselt number (Nu), an analysis is conducted to establish the connection between the instantaneous maximum and minimum Nu evolution with the radial and the wall-normal location of the core-centers of the merging/merged vortices, and with the wall shear stress.

This work was supported in part by Fellowship by Higher Committee for Education Development (HCED) of Iraq and NSF grant number CBET-1603720

Poster Number: ME-20
Authors: Xue (Zoe) Jiang; Peter B. Lillehoj
Title: Hollow Microneedle Arrays for Minimally Invasive Diagnostics and Therapeutics

Abstract: Microneedles have gained considerable attention in recent years due to their ability to significantly reduce the pain and infection risks associated with hypodermic needles. We demonstrate a new method for fabricating hollow microneedle arrays using SU-8 photoresist via a combination of laser cutting and photolithography. Various fabrication parameters, including the laser cutting energy, UV exposure energy and photomask gap distance, were optimized to generate microneedles with aspect ratios (ARs) of 2-3 with a tip diameter of 30 microns. Experiments were performed to characterize the mechanical properties of microneedle arrays, which exhibit sufficient strength for skin insertion. Microneedle arrays were also tested for liquid transport capabilities (i.e. extraction and delivery) to demonstrate their usefulness for diagnostic and therapeutic applications. The simplicity of this approach provides a low-cost, scalable method for generating hollow, polymer microneedle arrays for many important biomedical applications.

This work was supported in part by Bill and Melinda Gates Foundation

Poster Number: ME-21
Authors: Zhenxiang Jiang; Seungik Baek
Title: A Credibility Plan of Vascular G&R Simulation Tool

Abstract: Numerical models, based on the constrained mixture approach, have been emerged as a powerful tool that enables us to elucidate the characteristics of major constituents and their mechano-sensitive growth and remodeling (G&R) in arterial adaptation and maladaptation. Yet, there remains a pressing need for a powerful tool to be efficient in practical applications, such as calibration of the G&R model with experimental and/or clinical data. Although there has been a rapid expansion of using parallel computing, such calibration of a 3D subject-specific simulation with clinical data is still challenging. Motivated by this challenge, this study has twofold: (1) The finite element model is developed using FEniCS (https://fenicsproject.org/) for modeling vascular G&R, namely, vascular-G&R (V-G&R) simulation tool, that is implemented in parallel computing and (2) we employ a multi-fidelity approach that aid to determine optimal conditions that balance between accuracy and efficiency for a specific problem. Model verification is conducted to ensure that the simulation tool is “error-free” and to benchmark their results against those obtained from an ideal geometry. In this study, several types of fidelity V-G&R models are constructed, including different dimensionality (e.g., axisymmetric, 3D membrane, and 3D thick wall models), element size, and element types. Finally, the credibility plan of the V-G&R simulation tool will be demonstrated in abdominal aortic aneurysm (AAA) simulation.

This work was supported in part by NIH U01 1HL135842 and R01 HL115185
Abstract: Contactless grip has been utilized in industry with the use of Bernoulli grippers. In its simplest form, a Bernoulli gripper is a device which consists of an axial jet originating at the center of a disk. When the disk is brought in close proximity to a surface, the confined radial outflow produces a pressure field which exerts a net attraction between the disk and the surface. Varying the mass flow rate at the inlet will change the equilibrium gap height, where the net force is zero. Experimental data that measured both the next force and the radial pressure profile from literature was used to validate a computational model using the same geometry. Computations rather than experiments have been employed for the present work to expand the parameter space being investigated (111 points) in order to identify a trend. Input fluid power was calculated using the density, velocity, and pressure at the inlet that were monitored in Fluent for every design point. The power required at a given equilibrium gap height is most dramatically dependent upon the pad diameter. In contrast, the inner diameter and wall roughness are only marginally influential. Non-dimensionalizing Power versus equilibrium gap height, collapses all data, proving that there is a relationship based on shear losses.

This work was supported in part by Navy Undersea Research Program

Abstract: Blast-induced traumatic brain injury (bTBI) has become a "signature wound" for our military personnel in recent decades, and is likely linked to post-traumatic stress disorder (PTSD). Primary bTBI is characterized when a shock wave causes damage directly to brain tissue while propagating through the skull. Whereas, secondary and tertiary bTBI involves damage caused by matter thrown by the explosion or a person being physically moved by a shock wave, respectively. With the purpose of understanding the mechanics of bTBI, we used controlled blasts to load cranial phantoms made of gelatin. Gelatin-based simulants have multiple advantages compared to animal based studies. Phantoms allow for much greater control in accuracy and reproducibility, along with reducing cost, time, and ethical issues accompanied with any experiments. Four gelatin-based materials were used in the creation of the cranial phantoms for our experiments. White and gray matter have been mimicked by tailoring the mechanical properties of bovine skin and bone gelatin along with Polyacrylamide (PAA). These gelatin simulants were seeded with glass micro-spheres, nanobubbles, or silica carbide to determine the strain and strain-rates experienced during blast loading. This is possible due to the relative position change of particles embedded in gels which result from material deformation. Local correlation-based algorithms like Particle Image Velocimetry (PIV) help to detect these changes in relative position. To this end, PIV is used to analyze deformation on snapshots of cranial phantoms acquired with an ultrahigh-speed imaging system. Currently, time and spatial resolutions of 10 microsecond and 40 micro-meters respectively were used.

This work was supported in part by United States Airforce

Abstract: Adhesively bonded Pi/T-joint is a common ‘out-of-plane’ structural joint that connects a vertical (web) and a horizontal (base) load bearing substrates using an adhesive and a 3D-braided π (pi) preform. The stress-transfer between the substrates and the preform occurs through the bond-line via complex mechanisms governed by the loading condition and material properties of the substrates and the adhesive. Optical techniques, specifically photoelasticity enables the visualization of these complex fields. Photoelasticity technique will enable a better understanding of the load transfer and the failure mechanisms. Furthermore, these stress fields can be used for validating numerical simulations. In this work, a Pi/T-joint was made with aluminum substrates (both web and base) and 3D braided carbon fiber preform using SC-15 resin as an adhesive. The joints were manufactured using liquid resin transfer molding technique. Reflection photoelasticity was used to visualize and measure plane strains and stress directly on the joint using polarized light. The joints were experimentally tested in ‘out-of-plane’ (web pull-out) configuration until failure, and the isochromatic photoelasticity fringes or strain field images from the surface of the specimen were recorded. Force-displacement data was also characterized. Numerical models were developed using commercially available software ABAQUS®. Initial results show good agreement between the strain maps from photoelasticity and simulations for similar load levels. Further experimental work is in progress to fully exploit the benefits offered by photoelasticity to validate the simulations.

This work was supported in part by Dept of Civil and Environmental Engineering Michigan State University. Indonesia Endowment Fund for Education. Indonesian Ministry of Minance (LPDP)
Poster Number: ME-25  
Authors: Christine Li; Guoming George Zhu  
Title: A Two-Step Reaction-Based Multi-Zone Combustion Model of SI Gasoline Engine for Knock Prediction  

Abstract: A two-step reaction-based multi-zone combustion model is developed in this research. The combustion process of SI engine has been modeled with two zones: reaction zone and unburn zone. With arhenius functions, the reaction rate of each species in reaction zone can be calculated and then to model the temperature change in the zone. The mass transfer and heat transfer are also been modeled to reflect the temperature and pressure change. With this model, two-zone temperatures are modelled independently and accurately, this is very important for the knock prediction and intensity in unburn zone.

Poster Number: ME-26  
Authors: Faezeh Masoomi; Adam M. Willis; Ricardo Mejia-Alvarez  
Title: Experimental Study of Flow Through Carotid Aneurysms  

Abstract: There is evidence that traditional endovascular techniques like coiling are not effective for treatment of wide-neck cerebral aneurysms [1]. Flow Diverter Stents (FDS) have emerged as promising devices for treating complex aneurysms since they enable treatment of aneurysms that were considered untreatable before. Recent studies suggest a number of associated risks with FDS, including in-stent thrombosis, perianeurysmal edema, delayed hemorrhage, and perforator occlusions. Chong et. al. [2] simulated hemodynamic behavior using patient-specific data. From their study, it is possible to infer that the standard deviation of energy loss could be a good predictor for intervention success. The aim of this study is to investigate the flow in models of cerebral aneurysms before and after FDS insertion using PIV. These models will be based on actual clinical studies and will be fabricated with advanced additive manufacturing techniques. These data will then be used to explore flow parameters that could inform the likelihood of post-intervention aneurysm rupture, and help determine FDS designs that better suit any particular patient before its procedure.  

Poster Number: ME-27  
Authors: Yifan Men; Guoming Zhu  
Title: A Multi-Zone Reaction-Based Combustion Model for Diesel Engines  

Abstract: As the requirements for performance and restrictions on emissions become stringent, diesel engines are equipped with multiple techniques and strategies, which makes them incredibly complex systems. To enable model-based engine control, control-oriented combustion models, including Wiebe-based and single-zone reaction-based models, have been developed to predict burn rate or in-cylinder pressure of diesel engines. In spite of their simplicity, they are not suitable for engines operating outside the normal range because of the large error and calibration effort. The purpose of this paper is to obtain a parametric understanding of diesel combustion by developing a physics-based model which can predict the combustion metrics, such as in-cylinder pressure, burn rate, and IMEP accurately, over a wide range of operating conditions, especially with multi-injections. In the proposed model, it is assumed that engine cylinder is divided into three zones: a fuel zone, a reaction zone, and an unmixed zone. The formulation of reaction and unmixed zones is based on the reaction-based modeling methodology, where the interaction between them is governed by Fick's law of diffusion. The fuel zone is formulated as a virtual zone, which accounts for only the mass and heat transfer associated with fuel injection and evaporation. The model is validated with test data from a GM 6.6 L 8-cylinder Duramax diesel engine under different speed and load conditions, with multi-injections and EGR. It is shown that the multi-zone model outperformed the single-zone model in the prediction of in-cylinder pressure and calibration effort, with a negligible penalty in computational time.
Poster Number: ME-28
Authors: Thomas J. Pence; Indrek S. Wichman; Yen T. Nguyen
Title: Morphology Analysis of Material Degradation under Combustion

Abstract: The interaction between solids and flame during combustion has been studied. As solids are heated by the flame, they undergo an internal thermo-chemical breakdown process known as pyrolysis. The pyrolysis front propagates into the sample, leaving behind a charring layer which contains voids, fractures and defects. These defects enhance the combustion process by allowing hot gases to travel further into the solid thus widen the flammability limit. A new mechanism of cracking for pyrolyzing solid materials is proposed and numerical simulation is used to investigate the degradation process. It is found that crack patterns vary depending on materials properties as well as boundary conditions which could be characterized by nine dimensionless groups. The morphology of crack patterns generated is examined using image analysis program which can automatically label and quantify certain network properties such as spacing, branching, junction angle, segment length, loops, etc...Fundamental theoretical principles are uncovered.

This work was supported in part by This work was partially supported by the CVRC

Poster Number: ME-29
Authors: Ahmed Okasha; Norbert Müller
Title: Simulation and Performance Correlations for Transcritical CO2 (R744) Heat Pump Cycle

Abstract: For more than a decade, carbon dioxide (R744) has been revived as a natural environmentally friendly refrigerant. Compared to HFC refrigerants with a global warming potential (GWP) in the order of 1300-1900, R744 has GWP of 1. As it is relevant for R744 heat pumps, a transcritical cycle has an extra degree of freedom with the gas cooler pressure and outlet temperature being thermodynamically independent of each other. Utilizing MATLAB integrated with the NIST REFPROP thermodynamic database, a single stage transcritical R744 heat pump cycle was modeled. The isentropic and volumetric efficiency correlations of a commercial semi-hermetic reciprocating compressor are generated as a function of pressure ratio, based on simulated data obtained from the manufacturer software. Developed with the cycle model, optimized control correlations are presented that relate the gas cooler pressure to gas cooler outlet temperature and evaporation temperature. The correlations are compared to common correlations available in the literature. The range of the gas cooler pressure varies from 80 to 140 bar, the gas cooler outlet temperature from 35 °C to 55 °C, and the evaporation temperature from -20 °C to 15 °C. The developed correlations are for maximizing the coefficient of performance (COP) of the cycle during operation under various operating conditions.

This work was supported in part by - The James Dyson Fellowship.

Poster Number: ME-30
Authors: Kyle O'Shea; Rebecca Anthony
Title: Silicon Nanocrystals for Sustainable Light-Emitting Devices

Abstract: Efficiency and sustainability are two primary considerations for the manufacture of modern day electronics. Silicon is one of the most abundant elements on Earth, and silicon nanocrystals (SiNCs) exhibit potential for applications in light emitting devices (LEDs) and photovoltaic devices (PVs) that could, in theory, rival the efficiencies of the more commonly used (but more expensive, toxic, and rare) cadmium-based chalcogenide NCs. Despite these advantages, SiNCs are not commonly used because the surface defects and oxidization that lower the efficiencies of their optical properties (and which plague most NC materials) are more difficult to eliminate due to the covalent nature of the SiNC surface. The covalent surface prohibits the ligand exchange and shell growth processes that have led to the success of these other materials. Here, we hypothesize that surface defects and oxidization of plasma-produced SiNCs can be mitigated via the “capping” of surface defects and reactive sites by injecting vapor-phase species into the plasma to anneal and protect the surfaces of individual SiNCs in-flight.
**Poster Number:** ME-31  
**Authors:** Matt Ryerkerk; Ron Averill; Kalyanmoy Deb; Erik Goodman  
**Title:** Metameric Optimization Problems and Length Niching Selection

**Abstract:** In many optimization problems it is necessary to determine the optimal number of analogous components to include in a system. Examples include the number of sensors in a coverage problem, the number of turbines in a wind farm problem, and the number of plies in a laminate stacking problem. We classify these under the proposed term of metameric problems. Such problems can be solved by assuming a fixed number of components, however this may lead to sub-optimal solutions. A better method is to allow the number of components to vary among solutions, however the changing dimensionality of the search space makes the application of gradient-based methods difficult. Evolutionary Algorithms using a segmented variable-length genome are a suitable alternative, but modifications are required to the traditional genetic operators. In literature these modifications are frequently limited to the recombination and mutation operators, however in some cases the selection operator must also be modified to reach optimal solutions. We demonstrate the effectiveness of a proposed length-niching selection operator and compare it to standard selection operators as well as a traditional fixed-length genetic algorithm.

*This work was supported in part by Funded by the BEACON Center for the Study of Evolution in Action at MSU.*

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**Poster Number:** ME-32  
**Authors:** Justin Scott; Tamara Reid Bush  
**Title:** Posture Effects on Thigh Tissue Properties

**Abstract:** Wheelchair users sit for the majority of their day causing high tissue stresses and in many cases tissue damage. Yet mechanical properties of the affected tissue in the thighs are not fully defined. Limited work has been conducted to identify in vivo tissue material properties in the seated position, and published work focuses on ex vivo properties or data collected from the prone position. Accurate material parameters for the thighs in all postures are needed for the design of devices that interface with users (such as wheelchairs). Thus, the goal of this work was to identify the material properties (force-deflection data sets) of the thigh regions and compare these properties across three postures: seated, prone, and the crawling position (crawling is a position used by therapists). For all thigh locations the prone position was significantly different than the seated and crawling positions (Figure 1). The seated and crawling positions experienced greater than thirty millimeters of deflection at forty Newtons of force, while none of the deflections in the prone position exceeded twenty millimeters. For the distal thigh, the seated and crawling positions were statistically the same, while the prone position was always statistically different from the seated and crawling positions.

*This work was supported in part by NSF CBET-1603646*

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**Poster Number:** ME-33  
**Authors:** Mayank Sinha; Alborz Izadi; Rebecca Anthony; Sara Roccabianca  
**Title:** Employing Bifurcations to Measure Mechanical Properties of Coated Deformable Structures

**Abstract:** A combination of flexible polymers and a thin film of SiNCs can be used to create structures that have interesting bifurcation-induced microstructural characteristics, and have potential to be used in photonic metamaterial applications. By employing continuum mechanics, a mathematical framework can be developed to predict the onset of these instabilities as a function of geometrical and mechanical characteristics. Due to the nature of the system, however, novel techniques have to be employed to determine the mechanical properties. The focus of the present work is to estimate the mechanical properties of the SiNC film by using the onset of bifurcation of a bi-layered structure under finite bending. We use a neo-Hookean constitutive law as a first approximation. Briefly, we record the onset of bifurcation and we use the continuum mechanics incremental theory to estimate the mechanical parameters of the thin layer of SiNC. The angle for which the system bifurcates is a function of the thickness and shear modulus ratio between the two layers. This is then validated by performing an inverse test in which a prestretch is applied in the nanocrystal layer by depositing it on a layer of PDMS, wrapped around a cylindrical surface. Based on the mechanical properties previously estimated, the onset of the instability in the SiNC layer due to the unwrapping of the substrate is predicted. The accuracy of the prediction is a measure of robustness of the mechanical description adopted.

*This work was supported in part by National Science Foundation*
**Poster Number:** ME-34  
**Authors:** Sedigheh Tolou; Harold Schock  
**Title:** High-Efficiency Distributed Combustion for Spark-Ignition Engines

**Abstract:** Dual Mode, Turbulent Jet Ignition (DM-TJI) is a distributed combustion technology with the potential to provide diesel-like efficiencies and minimal engine-out emissions for spark-ignition engines. Currently, there is not a model capable of estimating the fuel consumption and emission for a DM-TJI engine over standardized city/highway driving cycles. A driving cycle is a fixed schedule of a vehicle operation, defined in legislation, to test the real-world operation of the vehicle. The work represents the path from engine experiments and model development to a virtual vehicle simulator, which permits estimation of the fuel consumption and engine-out emission for a DM-TJI engine over real-world driving cycles. Engine experiments are conducted on a single-cylinder DM-TJI engine at Michigan State University. A 0D/1D engine simulation is performed using Gamma-Technologies GT-SUITE and is calibrated based on experimental data. The engine model includes the intake and exhaust systems, pre- and main combustion chambers, and the orifice connecting the pre- to the main combustion chamber. A cylinder heat transfer model, an engine friction model, and the predictive combustion models maintaining the burn dependency of pre- and main chambers are also parts of the model. Calibrating parameters of the model are globally and locally optimized using a Nondominated Sorting Genetic Algorithm and the Nelder–Mead SIMPLEX algorithm, respectively. The engine efficiency map, generated by both experiments and model development, will be translated into vehicle fuel consumption and emission over light-duty vehicle driving cycles, using “US Environmental Protection Agency” Advanced Light-Duty Powertrain and Hybrid Analysis (ALPHA) vehicle simulator tool.

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Tenneco Inc.  
State of Michigan*

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**Poster Number:** ME-35  
**Authors:** Tyler Tuttle; Sara Roccabianca  
**Title:** Swelling Capability of the Porcine Urinary Bladder Wall

**Abstract:** Neurogenic bladder is a term used to characterize loss of control of the urinary bladder (UB) due to brain, spinal cord, or nerve problems. The neurogenic bladder shows hypertrophy of the smooth muscle cells and deposition/removal of extracellular matrix, collagen, elastin, and glycosaminoglycans/proteoglycans (GAGs/PGs). The pathological increase/decrease of certain GAGs/PGs can modulate the cell proliferation (hypertrophy) and modify the extracellular matrix deposition rate/mechanical properties. Therefore, there is strong motivation to explore the biomechanical consequences of increased swelling (Donnan) pressure due to the accumulation of GAGs/PGs within the UB wall.

Isosmotic (300 mOsm/L) and hyposmotic (30 mOsm/L) modified Krebb’s solutions were made and adjusted to a pH of 7.4 using 1M HCl. Four frozen porcine UBs were sealed in waterproof bags and thawed in room temperature water for 2 hours. Four cylindrical samples with 4mm diameters were excised from each location: dorsal, ventral, lower body, and trigone. Each sample was submerged in isosmotic solution for 22 hours to equilibrate for a physiological swelling state. Samples were weighed, and imaged to estimate volume. Subsequently, half of the samples from each location were submerged in the hyposmotic solution and half were kept in isosmotic solution. Samples were weighed and imaged after 8 hours. Relative weights of bladder samples that were submerged in the hyposmotic solution (i.e., 30 mOsm/L) were significantly higher (p<0.02) when compared to the relative weights of samples submerged in the isosmotic solution (i.e., 300 mOsm/L), for each location. No difference was detected when comparing the swelling between locations.
**Poster Number:** ME-36  
**Authors:** Suhas Vihate; Atacan Yucesoy; Ricardo Mejia-Alvarez; Adam Willis; Thomas Pence  
**Title:** An Optimization Based Approach to Design a Complex Loading Pattern Using Modified Split Hopkinson Pressure Bar

**Abstract:** Split Hopkinson Pressure Bar (SHPB) technique is used to characterize mechanical behavior of materials during impact loading when a single stress wave pulse passes through the material. However, recent studies particularly related to blast induce traumatic brain injury focus on evaluating brain tissue response to a specific complex impulsive load experienced during a blast exposure. The traditional SHPB technique is not capable of replicating these highly dynamic loading patterns. This study introduces a novel approach to design such actuator based on the SHPB. The principal idea here is to build the incident bar of SHPB by joining multiple rods made up of different materials. When a stress wave propagates through the bar, the difference in elastic properties of materials on either side of the interface, will create an impedance mismatch for wave propagation resulting into reflection and transmission. This phenomenon will repeat at every intermediate interface and will generate a complex stress wave at the other end of the bar. With this in mind, a SHPB can be modified to generate a desired complex loading profile.

Initially, the actuator design will be simulated by using a finite element software for a random set of design parameters. An optimization algorithm, will be used to modify these parameters further and the modified design will be simulated again. This process will be iterated until optimal parameters are determined, which will eventually minimize the error between desired loading profile and the loading profile obtained by modified SHPB.

*This work was supported in part by United States Air Force*

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**Poster Number:** ME-37  
**Authors:** Amber Vocelle; Gail Shafer O.T.R. Ph.D.; Tamara Bush Ph.D.  
**Title:** The Effect of Hand Exercises on Thumb Function in Individuals with Thumb Carpometacarpal Arthritis

**Abstract:** Osteoarthritis (OA) is the most common degenerative joint disease in the U.S., affecting approximately 27 million American adults. When OA develops in the carpometacarpal (CMC) joint located at the base of the thumb, it can significantly impair hand function including the ability to open jars, self-administer medications, and grip keys and door handles. One of the mainstays of thumb CMC OA treatment is hand therapy and exercises. Several studies have investigated the effect of hand exercises on hand function in individuals with thumb CMC OA with mixed results. Additionally most of these studies solely self-administered questionnaire scores to determine treatment effect. In this pilot study, we use thumb range of motion (ROM) and force application to measure the effect of a six week prescribed hand exercise regimen on hand function in participants with mild to moderate thumb CMC OA. We hypothesized that exercise therapy would result in increased CMC joint ROM and thumb force application.

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Pearl J. Aldrich Endowment in Aging Related Research*

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**Poster Number:** ME-38  
**Authors:** Yingxu Wang  
**Title:** Sample and Hold Inputs for Non-minimum-Phase System Implementation on Inverted Pendulum

**Abstract:** Focusing on the application of sample and hold inputs that can result in minimum phase (MP) discrete time virtual systems of a non-minimum-phase (NMP) system. A previous research investigates the MP characteristics of discrete-time systems obtained by sampling continuous-time single-input-single-output NMP systems with three sample and hold inputs (SHI): square pulse, forward triangle and backward triangle. It was showed that compare to conventional zero-order holder, smaller sampling period that result in an MP discrete-time system can be achieved while using the proposed SHIs. This theory can be used to improve NMP system performance under high gain control. In this project, an inverted pendulum platform, which is showing NMP property was used to implement the SHI theory. A primary linear quadratic regulator (LQR) was designed to regulate both the cart position and pendulum angle around zero location so that the closed loop system was stable; A secondary LQR was designed and combined with the SHIs so that the resulting closed loop system has minimum-phase property at sampling points. Both square pulse and forward triangle SHIs were implemented with different combinations of sample and hold parameters in the experiment. The results show that the SHIs can not only change the system property at the sampling points, but also improve the system performance with regard to the cart position. The performance variation under different scenarios is discussed.
### Poster Number: ME-39

**Authors:** Peng Xu; Thomas R Bieler; Neil T Wright  
**Title:** The Role of Phonon Dispersion in the Lattice Thermal Conductivity of Deformed Superconducting Niobium

**Abstract:** The phonon contribution to the thermal conductivity of niobium (Nb) dominates contribution of the electrons at the working temperature (~2 K) of superconducting radio-frequency (SRF) cavities. This is due to the condensation of electrons into Cooper pairs, which do not carry thermal energy or scatter phonons. Understanding the mechanisms of lattice thermal conductivity (k) of Nb may aid in the design and manufacture of future SRF particle accelerators. Existing models of the thermal conductivity of Nb include a theoretical model for the lattice k and a semi-empirical model that includes the electron contributions. Dislocations contribute significantly to the lattice k of superconducting materials, and dislocation density increases after deformation. The semi-empirical model omits some scattering mechanisms of dislocations. Here, the phonon dispersion relation is used to a) inspire a new scattering term in the semi-empirical model and b) to improve the calculation of group velocity in the theoretical model. Calculation of the lattice k for undeformed and deformed sample, including both screw and edge dislocation, agree well with the data when the new term is added to the model. This theoretical model uses the relaxation time approximation to solve the Boltzmann Transport Equation, has fewer fitting parameters than the semi-empirical model, and agrees well with experimental results.

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### Poster Number: ME-40

**Authors:** Shutian Yan; Xinran Xiao  
**Title:** Measurement of the Through Thickness Compression of a Battery Separator

**Abstract:** The mechanical integrity of the separator is critical to the reliable operation of a battery. Due to its minimal thickness, compression experiments with a single/a few layers of separator are difficult to perform. In this work, a capacitance based displacement set-up has been developed for the measurement of the through thickness direction (TTD) compression stress-strain behavior of the separator and the investigation of its interaction with the electrode. The experiments were performed for a stack of two layers of Celgard 2400 separator, NMC cathode, and separator/NMC cathode/separator stack in both dry and wet (i.e. submersed in dimethyl carbonate DMC) conditions. The experimental results reveal that the separator compression modulus can be significantly affected by the presence of DMC. The iso-stress based rule of mixtures was used to compute the compressive stress-strain curve for the stack from that of the separator and NMC layer. The computed curve agreed with the experimental curve reasonably well up to about 0.16 strain but deviated significantly to a softer response at higher strains. The results suggest that, in the stack, the TTD compressive deformation of the separator is influenced by the NMC cathode.

*This work was supported in part by NSF and General Motors*

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### Poster Number: ME-41

**Authors:** Atacan Yucesoy; Thomas J. Pence; Ricardo Meija-Alvarez  
**Title:** Developing a Numerical Model for Human Brain under Blast Loading

**Abstract:** Blast-induced traumatic brain injury (bTBI) is a leading cause of mortality and morbidity for personnel deployed in conflicts overseas. Exploring the mechanics of brain tissue is critical to predict intracranial brain deformation and injury resulting from severe blast loading. This capability would help in obtaining a prognosis and choosing adequate neurosurgical procedures before a physical intervention takes place. Increasing sophistication of numerical methods and computer power have enabled computational mechanics to play a leading role in the understanding of the physics of blast TBI. Due to microstructure heterogeneity, brain tissue exhibits highly nonlinear, viscoelastic, and region dependent mechanical responses under different loading conditions such as shear, compression and tension. Nevertheless, existing constitutive models of human brain tissue are not definitive, and the characteristics of material interfaces are obscure. It is necessary to address these issues by developing a framework for the understanding of the response of human brain to complex loading. The main goal of this study is to build a numerical model with the ability to capture the complex deformations induced by blast loading of the human brain. To this end, we will test different contact and material approaches available on a brain geometry obtained from Magnetic Resonance Imaging (MRI). The mechanical behavior of brain tissue is being investigated with different finite strain constitutive models that seek to account for hyperelastic, viscous and porous media effects with coupling method of LBE and MM-ALE. Along with seeking a constitutive model that reflects the mechanical behavior of brain tissue, we will investigate the effect of contact mechanisms and swelling on the interaction between different tissues, in particular, grey and white matter, and vasculature and surrounding matter.

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