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BIOMEDICAL ENGINEERING

Poster Number: BME-01
Authors: M. Hossein M. Kouhani, Arthur J. Weber, Wen Li
Title: Wireless Intraocular Pressure Sensor Using Stretchable Variable Inductor


Poster Number: BME-02
Authors: Joseph Salatino, Bailey Winter, Matthew Drazin, Erin Purcell
Title: Plasticity in the Excitability of Neurons Surrounding Implanted Neuroprostheses

Abstract: Implanted microelectrode arrays in the brain provide a unique opportunity for studying and treating neurological injury and disease by directly recording or modulating neuronal activity. However, neuronal loss and glial encapsulation plague long-term devices, and understanding of the effect of these observations on functional outcomes remains incomplete. Here, we investigate the hypothesis that alterations in the excitability of neurons surrounding implanted devices contribute to variable signal quality. Initial evidence for these effects was collected from non-functional, single shank microelectrode arrays implanted in the primary motor cortex of adult rats for predetermined timepoints, where brains were processed for immunohistochemistry, imaged with a confocal microscope, and analyzed using a custom-modified, open source MATLAB script. Antibodies against voltage-gated sodium and potassium channels were chosen to study fluctuations in the expression of ion channels around devices. We observed initially increased ion channel expression (potentially indicating hyperexcitability) during early time points, followed by a subsequent reduction in channel expression (a possible indicator of hypoexcitability) at later time points within the recordable radius of the device-interface. These results were coupled with observations of shifts in the relative expression of markers of inhibitory and excitatory neurotransmission surrounding the device, where long-term time points were associated with increased inhibitory marker expression. Combined, these results support the hypothesis that local shifts in the excitability of neurons may contribute to the reported instability in recording quality over time, informing new strategies for improving long-term performance.

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

Poster Number: BME-03
Authors: Monica Setien-Grafals, Nathan Blake, Cort Thompson, Kylie Smith, Wasif Afsari, Wen Li, Steve Suhr, Erin Purcell
Title: Optical Approaches to Patterning Neural Circuitry

Abstract: The field of optogenetics focuses on using light to control genetically modified cells, which can express light-sensitive ion channels to precisely control neural activity. We are using optogenetics-based strategies to pattern the identity and connectivity of neurons within a network. Two methods for optical control of neural circuitry are being tested. The first method involves the use of channelrhodopsin (ChR2), a protein that functions as a light-gated ion channel, via genetic targeting using a uniquely designed lentivirus to determine the effects of light-stimulation on neurons and neural progenitor cells. We are exploring the potential to use synchronous firing driven by ChR2 to affect connectivity between neurons in vitro, where patch clamp electrophysiology is used to validate light-evoked action potentials for cells infected with ChR2. The second method is the use of a bacterial transcription factor (EL222), which allows for blue light-dependent transcriptional activation, where the system is validated through spatial patterning of fluorescent reporter genes. Here, we report progress with developing both approaches, where the long-term goal is to develop optical means of regenerating neural circuitry.

This work was supported in part by NIH 5R03NS095202-02
**BIOSYSTEMS ENGINEERING**

**Poster Number:** BAE-01  
**Authors:** Alexandre Chabrelie, Jade Mitchell, Bo Norby  
**Title:** A Quantitative Multi-criteria Decision Analysis (MCDA) Approach to Exposure-based Antimicrobial Product Prioritization

**Abstract:** Antimicrobial resistance (AMR) is recognized as a future major threat for public health by WHO. AMR results in a staggering yearly human health impact in US, with 23,000 deaths, 2 million people sick and 8 million days in hospitals. The use of antibiotics in animal husbandry is an area of high concern with respect to the proliferation of AMR. Specifically, dairy cattle may contribute to the potential human exposure to AMR via meat and dairy products. Therefore, this study focuses on prioritizing antibiotics used in these animals for future research on them, or directly altering their usage through stewardship programs. A Multi-Criteria Decision Analysis is a promising approach because it allows for the integration of disparate sets with expert judgments, which is necessary because a full mechanistic model across all pathways from source to outcome is impossible due to numerous uncertainties. In our study, four criteria driving the transmission of AMR from cows to humans were defined for estimating the exposure potential for each antibiotic: (1) antibiotic usage in dairy cows; (2) cow metabolism/excretion; (3) environmental fate of antibiotics; and (4) effects for human health. A score for each criteria was calculated and a weighted average approach was used to produce an overall exposure score, which is used for relative ranking of the antibiotics analyzed. Twelve antibiotics were used for conducting a preliminary prioritization. Next steps will be to expand the model to the complete set of antibiotics and benchmark the model with environmental samples collected and analyzed on farms.

**Poster Number:** BAE-02  
**Authors:** Younsuk Dong, Steven Safferman, Steve Miller, John Hruby, Dave Bratt  
**Title:** Understanding of Food Processing Wastewater Irrigation

**Abstract:** Food processing wastewater, containing various nutrients, is a valuable resource for food production. Recycling food processing wastewater for irrigation helps to reduce the use of fresh water and fertilizer, and conserves energy which results in a greenhouse gas reduction. Land application treatment has been used for domestic wastewater and entails lower cost and energy, and less maintenance, in comparison to a traditional wastewater treatment system. The performance of treatment relies on hydraulic loading, organic loading, frequency of loading, types of soil, depths of soil, temperature, and microbial communities. Understanding the complexity of soil is important. Aerobic and anaerobic condition of soil may result in nitrate leaching and metal mobilization into groundwater, respectively. This examined the safe recycling of food processing wastewater. Monitors and soil sensor clusters have been installed to measure the parameters of soil such as water contents, oxygen levels, and temperature. Measurements were taken every 5 minutes and recorded average daily values. Complexity of soil will be understood using HYDRUS CW2D model, and the model will be calibrated based on column study.

**Poster Number:** BAE-03  
**Authors:** Yuzhen Lu, Renfu Lu  
**Title:** Spiral Phase Transform for Fast Processing of Fringe Pattern Images in Structured-illumination Reflectance Imaging for Food Quality Evaluation

**Abstract:** Structured-illumination reflectance imaging (SIRI) under sinusoidal fringe patterns of illumination has shown great potential as a new imaging modality for enhancing the detection of food quality. In addition to direct component (DC) images for uniform illumination, SIRI also provides amplitude component (AC) images about the depth-varying features of the sample, and phase images on the sample's three-dimensional (3-D) geometry. Retrieval of DC, AC and phase images from captured fringe pattern images is a critical step in implementing the SIRI technique. Phase shifting demodulation technique is the most widely used in fringe image analysis, but it generally requires at least three phase-shifted images with fixed phase offsets, thus making it impractical for real-time SIRI applications. This study was, therefore, aimed at developing a new, fast and effective demodulation technique for fringe pattern images, in order to achieve the goal of implementing the SIRI technique for real-time food quality evaluation. We proposed spiral phase transform (SPT), a two-dimensional (2-D) extension to conventional Hilbert
transform, for demodulating 2-D fringe patterns. The mathematical concept and procedures of using SPT for retrieving DC, AC and phase images were developed. The effectiveness of the SPT algorithm was demonstrated through bruise detection and 3-D geometry reconstruction of apples from two phase-shifted SIRI images. Comparisons were also made between SPT and conventional three-phase based demodulation approach. The SPT algorithm was able to demodulate single or two phase-shifted images with flexible phase offsets, and it is thus advantageous in fast implementation of SIRI for food quality evaluation.

Poster Number: BAE-04
Authors: Leann Lenie Matta, E. C. Alocilja
Title: Rapid Detection of Pathogen Contamination in Milk Using Bare AuNP with Electro-chemical Sensing: Collaborative Development of the “SPEL” Vial with Concurrent MNP-cell-AuNP Verification

Abstract: Development of a sensitive, biocompatible sensor to continuously monitor our extensively integrated food supply chain on a per-package basis has been elusive. A collaborative project combining nano-particles and electrochemical sensing to design a wireless biosensor for food contamination through passive RFID packaging tags is ongoing. Initial work has focused on wirelessly sensing the presence of bacteria through unlabeled gold nanoparticle, AuNP, attachment within a specialized “SPEL” vial. Verification of this working concept is made possible using novel carbohydrate-functionalized magnetic nanoparticles, MNP-F#2, that are proven to extract cells from milk, while allowing simultaneous attachment of the AuNP sensing agent. Bare AuNP are proven to attach to cells without the need of expensive surface binding ligands. MNP-F#2 binding to pathogens simulates cell attachment to the SPEL vial wall, while the MNP-cell-AuNP complexes can then be removed from solution using an external magnet for further testing. Spectrophotometric testing confirms that cells attach to either the SPEL vial and MNP alike. DPV electrochemistry using a simple hand-held potentiostat and 1 cm² SPCE chip then quickly quantifies the amount of AuNP present in the sample, simulating the wireless sensing of AuNP. This electro-chemical response to AuNP quantity is directly related to the cell concentration. In fact, biosensing MNP-cell-AuNP with DPV has proven to be an inexpensive yet reliable method to easily detect pathogens within complex matrices such as milk with minimal liquid handling. Optimization of this method is currently ongoing to improve sensitivity, while concurrently continuing the design of the wireless sensor.

This work was supported in part by Midland Research Institute for Value Chain Creation (MRIVCC) grant; Dr. Alocilja’s Nano-Biosensors lab

Poster Number: BAE-05
Authors: Quincy J. Suehr, Bradley P. Marks, Elliot T. Ryser, Sanghyup Jeong
Title: Quantification of Adhesion Force of Salmonella attached to Food Grade Surfaces in Low Moisture Environments

Abstract: Understanding pathogen adhesion to food grade surfaces, in low-moisture environments is critical to model cross-contamination of Salmonella and to remove bacteria from surfaces. This study aimed to develop a method to determine the adhesion force of Salmonella at a large scale in a low-moisture environment, and validate using individualized bacterium adhesion data. Salmonella Enteritidis PT 30 cells were attached on square stainless steel coupons of different surface finishes (984 nm and 9.34 nm root mean square (RMS) roughness) in 5 mL of Phosphate Buffer Solution, coupons were then desiccated overnight. Samples were then centrifuged at relative centrifugal forces (RCF) varying from 0 to 40,000 × g; increasing centrifugal force detaches more bacteria. Bacteria remaining on the coupons were then enumerated. The initial Salmonella populations on the rough and smooth coupons were 4.01±0.05 Log(CFU/cm²) and 4.38 ± 0.07 Log(CFU/cm²), respectively, which indicating that a greater (P<0.05) number of bacteria adhered to the smoother surface. After centrifuging at 2990 × g, the rough and smooth surfaces resulted in Salmonella populations of 3.84 ± 0.19 Log(CFU/cm²) and 3.62 ± 0.32 Log(CFU/cm²) on the surface, respectively, with the latter being reduced significantly (P<0.05). These results suggest that surface roughness has an effect on the force required to detach bacteria. Quantifying the adhesion forces at the individual bacterium scale can help develop and validate first-principle based cross-contamination models.

This work was supported in part by United States Department of Agriculture: Agriculture and Food Research Initiative
Poster Number: BAE-06

Authors: Yuan Zhong, Juan Pablo Rojas Sossa, Wei Liao
Title: Effects of Agricultural Wastes and Energy Crops Anaerobic Co-digestion on Anaerobic Microbes and Corresponding Digestion Performance

Abstract: In the past decades, microbial communities of anaerobic digestion (AD) have been intensively investigated, with majority of these studies focusing on the correlation between microbial diversity and biogas production. However, currently there is a lack of comprehensive research on the relationship between microbial communities and compositional changes of the solid digestate (AD fiber). Therefore, a distinct understanding on the relationship between mixed feedstock, microbial communities, biogas production, and solid digestate quality should be concluded to promote AD technology for the next-generation biorefining. The objective of this study was to understand the responses of microbial communities to different feedstock combinations and ratios of anaerobic co-digestion and their influences on biogas production and solid digestate quality. Three feedstock combinations (dairy manure with corn stover, dairy manure with switchgrass and dairy manure with miscanthus) and two feedstock ratios (4 to 1 and 3 to 2) were investigated with a completely randomized design. The 16S rRNA gene-based 454 pyrosequencing, Terminal Restriction Fragment Length Polymorphism (T-RFLP) and clone library were used to investigate the communities. Microbial communities were also statistically correlated with performance parameters such as total solids reduction, biogas production, and AD fiber quality (cellulose, xylan, and lignin).

This work was supported in part by Michigan State University AgBioResearch
CHEMICAL ENGINEERING

Poster Number: CHE-01
Authors: Kirti Bhardwaj, Greg M. Swain
Title: Electrochemical Studies of Carbon Electrodes in Room Temperature Ionic Liquids – Effect of IL Type, Surface Chemistry, and Electrode Microstructure on Capacitance

Abstract: The properties of room temperature ionic liquids (RTILs) and the structure of the electrified interfaces they form with carbon electrodes has been the subject of both fundamental and applied research, particularly in the field of energy storage devices like supercapacitors. RTILs have great potential to replace conventional organic solvent/electrolyte systems because of environmentally-benign characteristics (non-volatility, non-toxicity) and thermal and electrochemical stability. The physicochemical properties of RTILs can be flexibly tuned through selection of the component ions. Research is needed to better understand the structure of electrified interfaces formed in these novel media at carbon electrodes of different surface chemistry and microstructure. Traditional models of the electrochemical double layer based on the dilute-solution approximation do not applicable to RTILs because of the absence of solvent, the high concentration of ions, strong interionic columbic forces, and electrostatic and hydrophobic interactions of charged ions with the electrode surface. The electrochemical investigation of the capacitance of carbon electrodes as a function of potential, the RTIL type, and surface termination will be reported on. 1-alkyl-3-methylimidazolium- based RTILs were studied at boron-doped-diamond thin-film electrodes. Comparison measurements were made using glassy carbon and nitrogen-incorporated tetrahedral amorphous carbon thin-film electrodes. Cyclic voltammetry and electrochemical impedance spectroscopy were used to measure the electrode capacitance.

This work was supported in part by U.S. Army Research Office W911NF-12-R-0011

Poster Number: CHE-02
Authors: Sayli Bote, Ramani Narayan
Title: Design and Engineering of Value Added Industrial Products from Soybean Refinery

Abstract: Polyurethanes are most versatile polymers which have wide range of applications in foams, coatings, adhesive, sealants and elastomers. Polyurethane foams have variety of applications in buildings & construction, electronics, automotive, packaging materials and cushioning. Different densities polyurethane rigid foams can be used over wide range of temperatures. Polyols and isocyanates are two important components of polyurethanes. Isocyanates are synthesized from petroleum feedstocks but polyols can be synthesized from petroleum as well as from bio-based feedstocks. In current study, bio-based polyols for rigid as well as flexible foam application were synthesized from soymeal and soybean oil. Protein rich-source i.e. soymeal was used without any pre-treatment, without generating waste in one pot synthesis of bio-based polyol using transamidation chemistry. The ratio of primary to secondary hydroxyl groups in this polyol was higher. Also, use of inexpensive soymeal as raw material in synthesis of the polyol reduces its cost and makes its commercial production viable. Further, this bio-based polyol was used in synthesis of polyurethane rigid foams which were characterized for industrial applications. The soymeal was used in this study because of its high protein content and low moisture content as compared to algae proteins or other meals. In future work, soybean oil will be used for synthesis of polyol for flexible foam applications.

Poster Number: CHE-03
Authors: Kanchan Chavan, Scott Calabrese Barton
Title: Simulation of Nanoscale Confinement for Process Intensification

Abstract: Nature has developed very efficient pathways to carry out multi-step reactions with controlled transport and kinetics.1 One such approach to reaction control is the confinement of active sites and the resulting reaction intermediates within a physical tunnel, by which the intermediate can be restricted from the bulk. Studying transport properties and kinetics of the confined systems provides a framework for the design of integrated catalytic systems and process intensification. In the present study, computational modeling has been performed to study the effect of geometric, kinetic, and transport parameters on intermediate channeling via confinement, using a continuum model. The efficiency of transport is quantified by reactant yield. Interaction of the intermediate with the confined channel

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has been addressed by molecular dynamics studies of diffusion coefficient and retention time. Retention of intermediates within the confined assembly, with minimal access to bulk solution, is shown to be the key to efficient channeling. References 1. I. Wheeldon et al., Nat. Chem., 8, 299–309 (2016) http://www.nature.com/doifinder/10.1038/nchem.2459.

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Poster Number: CHE-04
Authors: Tridip Das, Jason D. Nicholas, Yue Qi
Title: Computational Study of the Charge Distribution of Mixed Valance Fe in La1-xSrxFexO3-δ and its Impact on Oxygen Vacancy Interactions

Abstract: It has been challenging for both modeling and experiments to determine the distribution of mixed charge states of Fe in La1-xSrxFexO3-δ. In this work, we first calibrated the Hubbard-U parameter to describe Fe from 2+ to 4+, then determined the charge on Fe in various phases of La1-xSrxFexO3-δ by interpreting the density functional theory (DFT) predicted magnetic moment on Fe. We discovered that the charge distribution is originated by different d-orbital splitting in octahedral (Oh) and square pyramidal (SP) Fe-oxygen polyhedra. This underlining theory successfully explained why the two electrons left behind by a charge-neutral oxygen vacancy can localize to the two Fe atoms directly connected to the oxygen vacancy in LaFeO3 or distribute to the second nearest neighbor Fe in cubic SrFeO3. The latter is named as ‘long-range charge transfer’ mechanism, causing strong oxygen vacancy interactions. This strong vacancy interaction causes increasing oxygen vacancy formation energy with oxygen vacancy site fraction. Therefore a new DFT-based thermodynamics model for interacting vacancies was also developed to predict δ and oxygen vacancy site fraction (X) separately as a function of temperature and partial pressure of oxygen. The predicted δ showed good agreement with experiments in a broad range of temperature. The variation of vacancy site fraction explained why high oxygen nonstoichiometry (δ) in many mixed ionic conductors does not translate into high ionic conductivity due to strong interactions between oxygen vacancies.

This work was supported in part by Department of Energy

Poster Number: CHE-05
Authors: Preetam Giri, Jeffrey Schneider, Caleb Andrews, Shilpa Manjure, Ramani Narayan
Title: Polylactide-Polydimethylsiloxane Block Copolymer as an Impact Modifier for PLA

Abstract: Polylactide (PLA) is a biodegradable aliphatic polyester formed by the polymerization of lactide, which can be derived completely from renewable biobased sources such as cornstarch. PLA has a high tensile strength and modulus, exhibits excellent barrier properties, and has also been found to be biocompatible. Despite its numerous advantages, its inherently low toughness severely restricts its applications. This study aims at improving the toughness of PLA while ensuring the minimum reduction in its tensile strength. A two-step process was adopted to achieve the desired toughness in PLA. First, a PLA-PDMS (polydimethylsiloxane) copolymer was synthesized through the reactive extrusion of PLA and bis(3-aminopropyl) terminated polydimethylsiloxane (NHPDMS). The amount of NHPDMS used was varied from 10 to 30 weight percentage. This was followed by the melt blending of the PLA-PDMS copolymer with neat PLA, where the copolymer was intended to act as an impact modifier. The mechanical properties, including tensile and impact, were studied for both the copolymer as well as the impact-modified PLA. Differential scanning calorimetry, and scanning electron microscopy, was used to study the thermal properties, and the surface morphology of the copolymer and the impact-modified PLA respectively. It was found that the elongation at break for the copolymer was significantly improved as compared to PLA. Similar trends were also observed for the impact-modified PLA. The improvement in the toughness was attributed to the enhanced compatibility of the PLA-PDMS copolymer in the PLA matrix, thus leading to better load transfer at the interface of the two phases.

Poster Number: CHE-06
Authors: Alex Mirabal, Scott Calabrese Barton
Title: Scanning Electrochemical Microscopy of Catalytic Cascades with Substrate Channeling

Abstract: Enzymatic cycles in nature 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. Deconvoluted signals can be achieved through nano-sensing, attaching a highly specific enzyme to the electrode, allowing for analysis of a substrate of choice. This complex system of analysis has many factors that contribute to the overall results. Modeling of nano-scale tip interactions with these cascades can confirm fundamental understanding of the processes occurring in solution or provide an insight to expected responses. Tip insulation can affect the response of the system due to decreased diffusion [3], so called hindered diffusion. Enzymatic cofactors, if required, will diffuse from the bulk, while intermediates will be concentrated around the cascade. Solution of a 2D axisymmetric model of hindered diffusion of cofactors combined with multiple active sites in a cylindrical model was solved for a SECM response with regards to transport efficiency. 1. I. Wheeldon, S. D. Minteer, S. Banta, S. C. Barton, P. Atanassov and M. Sigman, "Substrate channelling as an approach to cascade reactions", Nat. Chem., 8, 299–309 (2016). doi:10.1038/nchem.2459. 2. J. Kim, C. Renault, N. Nioradze, N. Arroyo-Currás, K. C. Leonard and A. J. Bard, "Electrocatalytic Activity of Individual Pt Nanoparticles Studied by Nanoscale Scanning Electrochemical Microscopy", J. Am. Chem. Soc., 138, 8560–8568 (2016). doi:10.1021/jacs.6b03980. 3. A. J. Bard, G. Denuault, R. A. Friesner, B. C. Dombler and L. S. Tuckerman, "Scanning electrochemical microscopy: theory and application of the transient (chronoamperometric) SECM response.", Anal. Chem., 63, 1282–1288 (1991). doi:10.1021/ac00013a019.

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Poster Number: CHE-07
Authors: Manas Nigam, Ramani Narayan
Title: Modifications in Thermoplastic Starch by Reactive Extrusion

Abstract: With rising use of plastics in day to day life, pollution has increased manifolds. Bio-based polymers are product of carbon neutral technology. Poly-lactic acid (PLA) is an established commercial bio-based and biodegradable polymer and used as standalone polymer as well as in blends. Starch is a major agro-industrial product and abundant in United States market. Thermoplastic starch (TPS) is a widely-researched starch based biopolymer which is relatively hard to process as compared to PLA. Modifications in the matrix of TPS are therefore needed for increasing its commercial value. Variations in TPS with additives were done using reactive extrusion process. This study compares the conventional TPS and TPS processed with additives through material characterization such as thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), spectroscopy (FTIR) and end group analysis. Grafting of additives to backbone of starch is examined using soxhelet extraction. Film forming ability of TPS based polymer is compared with that of modified TPS based polymers.

This work was supported in part by National Science Foundation (NSF)

Poster Number: CHE-08
Authors: Neda Rafat, Paul S. Satoh, R. Mark Worden
Title: Electrochemical Enzyme Immunoassay Biosensor (EEIB)

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 is being 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.
Poster Number: CHE-09
Authors: Eric Straley, Jason Nicholas
Title: Calibration of Pulsed-laser Deposited Ruby Thin Film Fluorescent Pressure Sensors

Abstract: Currently, pressure measurements are done using macro-sized crystals of a fluorescent pressure sensor. This method is useful for measurements of external pressure/stress, but it does not allow for the measurement of stresses generated within a material. By depositing a thin film pressure sensor onto a material of interest, the internal stresses of a material can be easily measured under any condition. The work presented here shows that high quality, crystalline thin film ruby can be deposited using pulsed-laser deposition and the stress generated from thermal expansion and lattice mismatch can be accurately calculated. Ruby thin films were deposited onto single crystal yttria stabilized zirconia (YSZ) and sapphire circular wafers with one inch diameter. X-ray diffraction and Raman Spectroscopy confirmed the crystallinity and phase purity of the thin films. Film stress was calculated first from the position of the ruby fluorescence peaks. The stress value was confirmed by measuring the sample curvature and calculating stress from Stoney’s Equation. The results suggest that thin film ruby can be used to accurately determine sample stress.

This work was supported in part by National Science Foundation (NSF) award number CBET-1254453

Poster Number: CHE-10
Authors: Hong-Kang Tian, Yue Qi
Title: Simulation of the Impact of the Loss of Contact Area in All-solid-state Battery

Abstract:
Maintaining the physical contact between the solid-state electrolyte and the electrodes is important to improve the performance of the Li-ion battery. The initial interface contact depends on the fabrication process of the battery. Typically, the deposited thin-film battery would have better interface contact than the bulk-type (mixed powder) battery. Increasing the compression pressure during the fabrication process could lead to a better initial contact. On the other hand, the contact area would continuously lose due to the volume change of the electrodes during the cycling of the battery. To illustrate this problem, a 1-D continuum model was developed to simulate the discharging process of an all-solid-state Li-ion battery, which is composed of Li as the anode, LiCoO2 as the cathode, and Li3PO4 as the electrolyte. The parameters were taken from a thin-film battery model that has fitted to experimental data. We incorporated the effect of the imperfect contact into this model by assuming the current and Li concentration will be localized at the contacted area. We correlated the percentage of lost contact area with the discharging capacity and energy. We observed that the capacity and energy decrease with the loss of contact area and discharge rate. For example, when discharging at 1 C-rate, the capacity decreased 20% as the contact area losses 19.8%. At a higher discharging rate of 32 C, the capacity dropped quickly to be less than 20% when the contact area losses 1.52%. Since Li3PO4 and LiCoO2 are both ceramic materials, and considering the property of self-affine, we applied the person theory, which could be used for elastic contact and include different length scale of contact, to build the relationship between the contact area and the applied pressure. We found that it is more effective to apply the pressure when the battery just starts to decay when the battery capacity loss is less than 10%. Therefore, in practical application, this model and method can be used to estimate the extent of the loss of contact area during the operation of the all-solid-state Li-ion battery, and further suggesting how much pressures should be applied to recover the capacity.

Poster Number: CHE-11
Authors: Daniel Vocelle, Olivia Chesniak, Mitch Smith, Christina Chan, S.Patrick Walton
Title: Role of Nanoparticle Characteristics in siRNA Trafficking and Gene Silencing

Abstract: New therapeutic approaches are needed for treating disease-associated proteins that cannot be targeted by small molecule and protein based drugs. One potential candidate approach, short interfering RNA (siRNA) therapeutics, is capable of specific targeting for a wide range of proteins. With the assistance of target specific delivery vehicles, siRNAs are transported from the extracellular environment into the cytoplasm of eukaryotic cells. Utilizing the RNA Interference (RNAi) pathway, siRNAs degrade messenger RNA (mRNA) in a sequence-specific manner and thereby reduce target protein expression. siRNA therapeutics are being developed for cancers, genetic disorders, and infectious diseases. Clinical adoption of siRNAs is somewhat limited by the inefficiency of delivering them to the targeted cells. This has resulted in considerable study of different types of siRNA delivery vehicles. To date, there is little consensus regarding the delivery mechanisms or particle characteristics essential for high activity of the siRNA cargo. Using silica nanoparticles (sNPs), we have investigated the influence of particle characteristics
on four mechanistic steps in the RNAi pathway: SNP-siRNA complex dissociation, siRNA strand separation, intracellular trafficking, and gene silencing. Our current data indicate that sNP-siRNA binding affinity and location of dextran functionalization are important in facilitating active silencing. Intracellular trafficking data support sNPs utilizing scavenger receptor mediated endocytosis and preferentially accumulating within acidic organelles, where dissociation of the siRNA-sNP complex occurs.

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Poster Number: CHE-12
Authors: David Vogelsang, Parker Dunk, Robert Maleczka, Andre Lee
Title: Separation of Double Decker Shaped Silsesquioxanes Condensed with Multiple Functional Groups

Abstract: Tetrasilanol double decker shaped silsesquioxanes (DDSQ-tetrasilanol) were condensed in this study by the addition of equimolar fractions of DDSQ-tetrasilanol, methyltrichlorosilane, and X-methylidichlorosilane, where X stands for hydrogen (H), methyl (Me), or vinyl (Vi). Adsorption HPLC experiments were run for the condensation products and four peaks were identified. The remaining Cl groups were hydrolyzed passing the products through a Si-gel column where three fractions were separated from the mixture. Each fraction was characterized by 29Si-NMR, adsorption HPLC, and mass spectroscopy. It was found that the first fraction obtained by LC was always a DDSQ cage with the X-Me-siloxane attached to both sides. 29Si-NMR presented trans and cis isomers in the spectrum. A single peak with tR = 2.43 min was resolved in the chromatogram. The second LC fraction was DDSQ cages with a X-Me-siloxane attached to one side and OH-Me-siloxane attached to the opposite side. Trans and cis orientations were identified in the 29Si-NMR spectrum. After HPLC experiments, both isomers were in a single peak located in tR = 4.21 min. Finally, the third fraction had trans and cis DDSQ molecules with OH-Me-siloxanes in both sides. Two peaks corresponding to trans and cis isomers of Me-OH-DDSQ-Me-OH were identified in this fraction by HPLC. Trans isomers were detected after tR = 8.02 min and cis isomers after tR = 8.55 min. Mass spectroscopy for separated cages showed the expected molecular weights for each molecule. The material produced and separated in this study can be further reacted taking advantage of the multiple moieties in the cages. It can be used in different applications such as drug delivery, block copolymers, compatibilizers, among others.

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Poster Number: CHE-13
Authors: Ziwei Wang, Mark Worden
Title: Shear and Temperature Damage on Cells During Microbubble Fermentation

Abstract: Microbubble fermentation is being studied as a viable method for biogas production. Current design uses high-speed shear plate to generate microbubble and the flow of the reactor system was recycled through a pump. Previous researches on this topic had encountered an unexpected drop in production rate as the reaction time increases. It is suspected that the cells were damaged by shear force or high temperature inside the reactor system. It is our interest to identify the source of shear damage and to seek alternative design once the source is discovered. We propose to isolate individual part of the previous reactor system and replace them with equivalent components. The cell death rate will be measured with flow cytometry. The temperature of the flow system around the pump will also be measured to find out whether or not temperature is playing a role in cell death inside the reaction system.

Poster Number: CHE-14
Authors: Margaret Young, John Suddard, Tyler Patrick, Christopher Traverse, Natalia Pajares, Richard R. Lunt
Title: Heptamethine-based Organic Salts for Solar Cells with Near-infrared Photoresponse up to 1600 nm

Abstract: Near-infrared absorbing organic molecules are critical in developing transparent photovoltaics, multijunction photovoltaics, and low-cost infrared photodetectors. However, few molecules with absorption past 900 nm have been demonstrated in optoelectronic devices, and their small bandgaps complicate the task of aligning energy levels for efficient charge transfer in photovoltaics. In this study, we synthesize and demonstrate organic salts with photoresponse out to 1400 and 1600 nm with a peak external quantum efficiency of 5%. Record high open-circuit voltages for this spectral range near the theoretical excitonic limit are achieved using this material. We also
show that the energy levels in these narrow bandgap donors can be precisely tuned using alloyed blends of different organic anions with no change to the photoresponsive organic cation bandgap. The relationship between short-circuit photocurrent and the donor-acceptor interface gap will be discussed in the context of correlated exciton binding energies and carrier diffusion lengths.

*This work was supported in part by NSF Faculty Early Career (CBET-1254662); DuPont Young Professor Award; Department of Education Graduate Assistantship in Areas of National Need Award (GAANN, GU0115873)*

**Poster Number:** CHE-15  
**Authors:** Yuelin Wu, Andre Lee  
**Title:** Investigate the Disappearance of Cu9Al4 from Cu-Al Bonding Interface using Anodic Potentiodynamic Polarization Study

**Abstract:** This study proposed a corrosion mechanism of the Cu-Al wire bonding interface (Cu-Cu9Al4-CuAl2-Al) based on the anodic polarization measurement. The observed disappearance of Cu9Al4 was the result of a two-step corrosion process: the initial penetration of the interface between Cu9Al4 and CuAl2, and the following galvanic corrosion of Cu9Al4 in the Cu-Cu9Al4 couple. The initial penetration of the interface between Cu9Al4 and CuAl2 results from crevice corrosion of CuAl2 through the voids formed at the interface during the intermetallic transformation. After the interface between Cu9Al4 and CuAl2 is penetrated, the four-metal galvanic couple Cu-Cu9Al4-CuAl2-Al is divided into two separate galvanic couples: Cu-Cu9Al4 and CuAl2-Al. For the CuAl2-Al couple, Al is the anode, however, its corrosion rate is not significantly increased due to the low cathode-to-anode area ratio. For the Cu-Cu9Al4 couple, Cu9Al4 is the anode and its corrosion rate is significantly increased due to the large cathode-to-anode area ratio. Therefore, Cu9Al4 appears to corrode faster than the other entities. This proposed corrosion mechanism emphasizes that the bond failure is caused by penetration of the interface between Cu9Al4 and CuAl2, instead of the preferential corrosion of Cu9Al4. In order to effectively reduce the bond failure rate, the void formation along the interface between the two intermetallic needs to be inhibited.
CIVIL ENGINEERING

Poster Number: CE-01
Authors: Ankit Agrawal, Venkatesh Kodur
Title: Factors Governing Residual Response of Fire Damaged Reinforced Concrete Beams

Abstract: Reinforced concrete (RC) structural members when exposed to fire, experience loss of strength and stiffness as a result of temperature rise in reinforcing steel and concrete. Thus, it is imperative to ascertain the residual capacity of fire damaged structural members through rational engineering methods for facilitating re-occupancy or to develop subsequent retrofitting measures. The extent of residual capacity in a fire exposed RC member is dependent on a number of factors including fire severity, peak rebar and concrete temperatures, level of loading (load ratio), restraint conditions and cross-sectional dimensions. Although earlier studies indicated these factors to be critical, the extent of influence of these parameters is not studied in literature. In this study, a finite element based numerical model is developed in ABAQUS to evaluate residual response of fire damaged RC beams. The influence of fire severity, load level, restraint conditions and sectional dimensions on residual capacity of fire exposed RC beams is studied. Results from the parametric study indicate that fire severity, cross-sectional size and load level have significant influence on both post-fire residual capacity, and residual deformations in the beam. Presence of axial restraint however, has only moderate influence on the post-fire response of RC beams. Moreover, under most real life fire scenarios, RC beams can retain up to 70% of their room temperature capacity provided tensile rebar temperature does not exceed 450°C.

This work was supported in part by United States Agency for International Development (through Pakistan-US Science and Technology Cooperative Program grant PGA-2000003665); Michigan State University

Poster Number: CE-02
Authors: Areej Almalkawi, Sameer Hamadna, Parviz Soroushian
Title: Use of Aerated Cement Slurry for Infiltration in Ferro-cement Application: Mechanical and Thermal Investigations

Abstract: The bulk of the building weight resides in the binder, and lowering its density would help reduce the gravity and seismic. The cementitious binder used in development of the indigenous building systems is a slurry capable of infiltrating multiple layers of chicken mesh. Reduction of density of slurry has been accomplished via aeration using a vegetable-based foaming agent (saponin; this slurry produced a satisfactory balance of compressive strength and interaction with the chicken mesh reinforcement. After design and construction of example structural components with this aerated slurry, it was concluded that further weight savings are required for simplifying and expediting the construction process. Steps were thus taken to tailor the aeration conditions for lowering the density of the slurry to 1.3, 1.17 and finally 0.9 gr/cm³. At each step, the compressive strength was evaluated prior to further reduction of density. The data available at this point suggest that, considering the constraints imposed by the need for reliance on locally available labor and facilities, further reduction of density below 0.9 gr/cm³ would be challenging. The aerated slurries with reduced density were characterized for assessment of their strength, sorptivity, thermal conductivity and microstructural characteristics. Preliminary efforts were also initiated to develop nondestructive test methods for evaluating the quality of the low-density aerated slurries

Poster Number: CE-03
Authors: Saleh Alogla, Venkatesh Kodur
Title: Transient Creep Strain of Concrete at High Temperature Measurements

Abstract: Concrete possesses good fire resistant properties due to its low thermal conductivity, high heat capacity, and slow degradation of its mechanical properties with temperature. However, concrete structures undergo significant deformations under fire exposure relative to that under ambient conditions. These deformations result from four strain components namely; mechanical, thermal, creep, and transient. The latter two strain components are typically combined as transient creep strain due to the complexity of separating them. This transient creep strain represents the additional strain, besides mechanical and thermal, which is observed under simultaneous loading and transient heating conditions. To quantify transient creep strain of different concrete types, four concrete mixes were...
prepared, and cylindrical specimens were casted to be tested under transient heating conditions. The unique testing equipment was specifically designed for this purpose and comprised of an electrical furnace, hydraulic loading system, and deformation measuring apparatus. Concrete specimen is first loaded in compression to a specific stress level, and then heated, while under constant load, at a pre-selected rate of heating. Results from these experiments include change in axial displacement of the concrete specimen with time. Transient creep strain can be then quantified by deducing other strain components from total strain of the specimen. The findings clearly indicate that most of concrete total strain at high levels of stress and temperature is composed of transient creep. At stress level of 50% and higher, and at temperatures exceeding 500°C, transient creep strain amount to most of concrete total strain and governs failure of concrete specimens.

Poster Number: CE-04
Authors: Mansour Alturki, Rigoberto Burgueño
Title: Self-centering Reinforced Concrete Bridge Pier-wall System with Elastic Instability Devices

Abstract: Conventional reinforced concrete (RC) bridge pier-walls designed to resist seismic loads rely on dissipating seismic induced forces by undergoing permanent inelastic deformations. These pier-walls satisfy safety requirements, but usually suffer unrepairable damage after strong earthquakes. This damage could be eliminated, or highly reduced, by using a self-centering (SC) system. In this system, high seismic demands (damage) locations in pier-walls are replaced with SC devices. This study focuses on SC devices that depend on recoverable elastic instabilities of multiple interconnected cosine-curved domes (CCD) to absorb the seismic demands. Experimental and numerical studies are being carried out to develop and optimize the SC system. Experimental tests are being conducted on 3D printed SC device prototypes to examine: 1) the local behavior of individual and multiple interconnected CCD under load, and 2) the global system behavior of the SC pier-wall. The experimental investigation is associated with finite elements analysis to optimize the geometrical and material properties of the SC device. Primary results show that individual CCD units offer large post-buckling elastic recoverable deformation capacity. The SC device has bilinear response with relatively high initial stiffness and large post-buckling deformations. The device is also capable of recovering its original shape upon load removal. The SC system could be an economic alternative to conventional RC pier-walls where yielding components, or locations with localized plastic damage, are replaced with SC devices that absorb seismic demands through elastic instabilities.

Poster Number: CE-05
Authors: Ata Babazadeh, Rigoberto Burgueño
Title: Proposed Guidelines to Consider Nonlinear Second-order Moments in Seismic Design of Slender Reinforced Concrete Bridge Columns

Abstract: Previous research on reinforced concrete (RC) columns demonstrated that second-order effects, i.e., nonlinear moment profiles and P-delta moments increase the length of the plastic region in proportion to the columns' slenderness. In this research, a parametric study, which was conducted to determine the magnitude of the slenderness effects on the nonlinear response of RC columns, is presented. The effects of different design parameters such as geometrical, structural, and material properties on the susceptibility of RC bridge columns to second-order effects were investigated. A large set of all the design configurations that are permissible according to the latest seismic design guidelines for bridge columns was considered. It was found that longitudinal steel reinforcement, axial load, and aspect ratio dominate the extent of second-order effects on RC columns. Moreover, this study led to the identification of proper limits for the aforementioned parameters beyond which the nonlinear second-order moments are significant and can no longer be ignored. Recommendations are made based on the presented findings to update the current design guidelines for consideration of second-order effects. Finally, simple expressions are proposed to predict the effects of second-order P-delta moments on the length of the plastic region using common design parameters.

This work was supported in part by U.S. National Science Foundation grants CMMI-1000549 and CMMI-1000797
**Poster Number:** CE-06  
**Authors:** Danilo Balzarini, Imen Zaabar, Karim Chatti  
**Title:** Impact of Concrete Pavement Structural Response on Rolling Resistance and Vehicle 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 paper investigates the increase in vehicle energy consumption caused by the structural response of a concrete pavement to a moving load. The pavement structural response under moving load is determined for three sections under different wheel loading conditions (Passenger car, SUV, and Articulated truck), vehicle speed and temperature using a finite element model (DYNASLAB). As the rolling wheels move forward, the local deflection basin caused by the delayed deformation of the subgrade and the rotation of the slab forms a positive slope. The energy dissipated is calculated as the energy required for a rolling wheel to move uphill. Finally, the energy is converted into fuel consumption excess using the calorific value of gasoline and diesel. The maximum deflection-induced energy consumption is about 0.08% of the total consumption for articulated trucks, which is very small compared to 1.9% for asphalt pavements at high temperatures and low speeds, as reported by other studies.

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

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**Poster Number:** CE-07  
**Authors:** Srishti Banerji, Venkatesh Kodur  
**Title:** Effect of Age on Temperature Dependent Thermal Properties of Concrete

**Abstract:** The thermal properties of concrete are critical for evaluating the fire resistance of concrete structures. These properties include thermal conductivity, specific heat, thermal diffusivity, mass loss and they vary with the age of concrete. Hitherto studies to assess concrete thermal properties have been conducted on concrete specimens after full curing (28 days) or long time after casting (much beyond 28 days). However, there is no reported data on the effect of aging on the evolution of thermal properties of concrete. Most properties of concrete including thermal properties change significantly with age, specifically in the first few weeks of casting. Hence, early age variation in thermal properties of is crucial for capturing the rate of hydration and rapid change in its moisture content during this period. In order to characterize the evolution of the thermal properties of concrete with age, experimental studies were conducted on normal strength concrete specimens. Thermal properties of concrete were evaluated at 3, 7, 14, 28 and 90 days after casting of concrete with the means of sophisticated instruments. Data from the tests is utilized to establish the effect of age on the evolution of thermal properties of concrete. These age dependent properties can be highly useful for evaluating heat of hydration, early age cracking as well as fire resistance of other concrete structures.

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**Poster Number:** CE-08  
**Authors:** Meghna Chakraborty, Timothy J. Gates  
**Title:** Developing Safety Performance Functions for Rural Unpaved Roadway Segments in Michigan

**Abstract:** More than 59% of fatal crashes in Michigan in 2015 occurred in rural areas. Unpaved roads, including both gravel and unimproved surfaces, are a critical component of the transportation network in Michigan, accounting for over 57% (43,606 miles) of the total roadway rural collector and local mileage (FHWA). However, safety research related to unpaved roads in the United States is very limited. To address this knowledge gap, research to develop safety performance functions (SPFs) for rural unpaved roadway segments in the state of Michigan is currently underway. SPFs are regression models that are used to estimate the expected crash frequency for a specific site type as a function of various factors that include traffic volumes, along with factors related to the roadway environment and roadway geometry, including functional classification, driveway counts, roadway widths, roadway curvature, and other factors. These roadway data have been collected from a variety of sources for roadway segments located within more than 20 counties statewide and have been merged with traffic crash data from 2011 to 2015. The data is currently being prepared for further analysis, including developing of the SPFs for rural unpaved road segments.
Abstract: Lake Urmia, the second largest saline lake in the world, is on the verge of drying up completely and creating a massive environmental disaster in the region. Several studies have partly blamed the intensive irrigation activities and prolonged droughts as the reason for this current condition of Lake Urmia. This paper studies the Lake Urmia watershed using a number of remote sensing data sets like current and historical Landsat imagery and MODIS, etc. to quantify the change in agricultural areas and inland water bodies as a result of intensive irrigation in the period of 1980-2016. Furthermore, the Total Water Storage (TWS) anomalies by GRACE and a global land surface model called HiGW-MAT are studied to get the TWS variations in the Lake Urmia region. HiGW-MAT simulates all the components of an energy balance and water balance including the human land-water relationship and groundwater pumping. An attempt to calculate the Total Agricultural Water Consumption from 1980-2016 in the Lake Urmia watershed will be made, using the methodology based on Penman-Monteith method stated in Yuan & Shen, 2013, provided we get the weather station data from the region. Initial results show that the lake has shrink by about 56% with a corresponding increase of 98% in agricultural cropland and 180% in urban areas. The TWS change in the Lake Urmia basin by GRACE is about -1.69 cm/year which is in agreement with the simulated trend from HiGW-MAT.

Abstract: The integrated ABM-DTA framework requires implementing one of the least generalized cost path finding algorithms at different levels. The least generalized cost path finding algorithm is the most time-consuming module in DTA, thus rerunning this algorithm at the ABM level, where just least generalized cost information is needed (not the actual path information), is not efficient. An alternative approach, which is commonly practiced in ABM models coupled with the static traffic assignment, is to output zone-to-zone travel cost skims when they are calculated during the traffic assignment problem. The stored data can be used in the destination and mode choice models. However, in the ABM-DTA integration framework storing the dynamic travel skims considering multi-class users is not efficient due to the large size of the data and memory requirement. This calls for an alternative heuristic approach that can estimate least generalized costs in the network to be used at the ABM level in destination and mode choice models. This study finds the distance, travel time, and monetary cost of the path with the least generalized cost function for a certain origin and destination pair at a specific departure time. The algorithm incorporates simulated trajectories of the vehicles at the DTA level to estimate these costs as a function of Euclidian distance between the origin and destination zones. Numerical results for two real-world networks suggest the applicability of the method in large-scale networks in addition to its lower computational burden including solution time and memory requirements relative to other alternative approaches.

Abstract: Safety Performance Functions (SPFs) are a widely used procedure utilized by transportation agencies and engineers to predict crash frequency along roadway segments or at intersections. SPFs are particularly useful for determining the effect of various characteristics pertaining to traffic volume and composition, roadway geometry, area type, and cross-sectional features on traffic crash occurrence. The Highway Safety Manual (HSM) suggests using SPFs as the analysis method in highway safety studies used to support traffic safety improvement programs. SPFs are generally dependent on geographic regions along with functional class. Over 59% of fatal crashes in Michigan in 2015 occurred in rural areas and more than 74% (89,444 miles) of paved roadways in Michigan are rural county routes (FHWA, MDOT). This project focuses on determining an accurate SPF model for non-trunkline two-lane, two-way paved highway segments based on 30 Michigan counties. The SPF variable inputs include, but are not limited to, Average Annual Daily Traffic (AADT), segment length, access driveway density, pavement travel way and shoulder width, pavement marking presence as well as additional factors such as curb or parking lane presence. Due to over dispersion of the variance, a negative binomial regression model is utilized as the functional form for the SPF. Crash Modification Factors (CMFs) and further model calibrations will be included to improve precision of the SPF.

This work was supported in part by Michigan Department of Transportation
**Poster Number:** CE-12  
**Authors:** Iman Harsini, Parviz Soroushian  
**Title:** Nondestructive Monitoring of Alkali-Silica Reaction in Concrete Using Portable NMR

**Abstract:** This paper documents the application of nondestructive NMR techniques towards detection and characterization of progressive Alkali-Silica Reaction (ASR) in standard concrete specimens made with reactive aggregates exposed to accelerated ASR aging. Relaxation times and self-diffusion coefficient were measured using the nondestructive NMR test system for specimens (prior to and after different aging periods to study the formation of ASR gel and microcracks in cement-paste matrix. The formation of ASR gel and the subsequent imbibing of water into the gel alter the water distribution and binding condition in concrete. An increased concentration of water in ASR gel where it can exist in a distinct binding (mobility) condition is expected. The swelling of ASR gel is accompanied by formation of microcracks where water could reside in bulk form, and can create new structural gradients with respect to depth. The nondestructive NMR test data were interpreted in light of these effects of ASR aging on concrete structure, and distinct trends in NMR test data that point at the presence and extend of ASR were identified. Corroborative nondestructive tests were also conducted in order to verify the trends identified in NMR tests. These nondestructive tests involved measurement of ultrasound pulse velocity (UPV), dynamic elastic modulus, petrographic analysis, dye treatment and weight and volume changes.

*This work was supported in part by US DOT*

**Poster Number:** CE-13  
**Authors:** Bang He, Mingzhe Li, Sihao Gu, Weiyi Lu  
**Title:** Enhanced Buckling Behavior of Liquid Filled Cylindrical Tubes under Uniaxial Compression Load

**Abstract:** With the advance of the nano-porous material, liquid nanofoam (LN) filled structures (tube, micro-truss, etc.) have been developed in past couple years. The prominent energy absorption capability of these structures and their promising implementation in auto industry, civil engineering has drawn considerable attention. However, the mechanical behavior of these structures with the presence of the interaction of confined liquid and structure are still completely unfolded. This study aimed to investigate the behavior of liquid-filled structures under quasi-static compression loading through experimental observation and analytical work. Our study demonstrate that the existence of increased hydro-static pressure in cylindrical tubes under compression load leads to the following enhanced mechanical behavior comparing to empty tubes. (a) the collapse is successive and less sensitive to circumferential imperfection than empty tube, (b) the axisymmetric buckling of both liquid filled tubes shows a stable tendency in term of the buckling modes and reaction loads after initial collapse, (c) the load in axial direction is proportional to the tube shortening after initial collapse, (d) the tubes ends up with an uniformed bugling instead of collapse of localized wrinkles. As a result, the axial rigidity wasn’t reduced in the existence of the internal pressure. These findings shed light on the potential engineering applications of liquid filled structures where successive and stable collapse are desired, like the energy absorption device. From the analytical work, the understanding on shell behavior with increasing internal pressure is also extended.

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

**Poster Number:** CE-14  
**Authors:** Derek Hibner, Venkatesh Kodur  
**Title:** Residual Capacity of Fire Exposed Reinforced Concrete Columns

**Abstract:** Reinforced concrete (RC) structural members exhibit high fire resistance due to relatively low thermal conductivity, high thermal capacity, and a slower degradation of mechanical properties of concrete with increasing temperature. Complete collapse of RC structures is rare, due to advancements made in active fire protection systems and efficient firefighting strategies. However, this fact does not ensure safety of a structure for immediate reoccupation after a fire is extinguished. Unlike fire induced spalling, which is a visible sign of fire damage, structural deterioration due to degradation of mechanical properties at elevated temperatures and redistribution of stresses within the member is not too apparent. Thus, it is imperative to ascertain the residual capacity of structural members through rational engineering methods. A combination of numerical and experimental studies was applied for developing an approach for assessing residual capacity of fire exposed RC columns. The effect of varying fire scenarios and thermal properties on the thermal profile experienced within an RC column was studied using a numerical model developed in ABAQUS. Results from the analysis show that much of the capacity of a fire exposed RC column will be retained, as long as the temperature of the fire does not exceed 800 °C. Further, a drastic reduction of capacity was observed in a fire exposed column when fire temperatures exceed 1000 °C.
Poster Number: CE-15
Authors: Ali Imani Azad, Roozbeh Dargazany
Title: Multi-scale Study of Mechanical Behavior of CNT Fibers

Abstract: The interest in carbon nanotube (CNT) fibers have been highly increased due to their light weight, high strength, and high electrical conductivity. Still, the hierarchical structure of the helical and twisted fibers yields significant loss in translation of mechanical properties from individual CNTs to fiber. The sources of the loss has not been well understood. Studying the sources of energy loss and contribution of each sources could be helpful for maximizing the tensile strength and rigidity of these fibers. A CNT fiber made by braiding CNT strands. The strands are also formed by twisting CNT yarns, which are similarly formed by twisting the CNT ribbons around themselves. Those ribbons are thin plates of CNTs extracted from the forest of nanotubes. Thus, CNT fibers are the result of bending of twisted structures around each other. This makes the bending behavior of a twisted structures a vital key to study the tensile behavior of the final fiber product. Our study employs a multi-scale approach to describe the hierarchical structure of fibers and understand the sources of losses with respect to phenomena such as decrease in void area in a cross section of fiber, and the effect of plastic behavior of each strand in the fiber.

Poster Number: CE-16
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 Michigan Department of Transportation

Poster Number: CE-17
Authors: Guoting Kang, Han Qiu, Shu-Guang Li, David Lusch, Mantha S. Phanikumar
Title: Understanding High-resolution Spatiotemporal Dynamics of Groundwater Recharge Using a Physically Based Hydrologic Model: A Case Study in Ottawa County, Michigan

Abstract: Quantifying the natural rates of groundwater recharge and identifying the location and timing of major recharge events are essential for maintaining sustainable water yields and for understanding contaminant transport mechanisms in groundwater systems. Using Ottawa County, Michigan as a case study in sustainable water resources management, this research is part of a larger project that examines the issues of declining water tables and increasing chloride concentrations within the county. A process-based hydrologic model (PAWS) is used to mechanistically evaluate the integrated hydrologic response of both the surface and subsurface systems to further compute daily fluxes due to evapotranspiration, surface runoff, recharge and groundwater--stream interactions. The model is built based on three major watersheds at 300m spatial resolution and daily temporal resolution, covering all of Ottawa County and is calibrated using streamflow data from USGS gauging stations. In addition, synoptic and time-series baseflow data collected using Acoustic Doppler Current Profilers and electromagnetic flow meters during the summer of 2015 are used to test the ability of the model to simulate baseflows and to quantify the uncertainty. The MODIS evapotranspiration product is used to evaluate model performance in simulating ET. The primary objectives of this study are to (1) understand the periods and locations of high and low groundwater recharge in the county between the years 2011 and 2015; and (2) analyze the impacts of different types of land use, soil and elevation on groundwater recharge.
Poster Number: CE-18
Authors: Leila Khalili, Roozbeh Dargazany
Title: A Micro-mechanical Model for Predicting Visco-elastic Behavior of Elastomeric Composites Based on Visco-elastic Response of Single Polymer Chain

Abstract: In this work a viscoelastic model is developed to simulate and predict the inelastic and time-dependent damage behavior of elastomeric composites. The concept here is that single polymer chain has a visco-elastic behavior which describes creep in one chain with respect to local matrix relaxation. The reason for considering time dependent behavior for single chain is that the stiffness of a polymer chain segment dissipates over time due to chain sliding or breakage of physical links. Linking polymer softening to the creep behavior observed in uniaxial tension of the composite, the damage mechanism in one polymer chain is derived with respect to the deformation history. Having the time-dependent behavior of single polymer chains, through a micro-macro-scale transition using microsphere concept, the viscous effects in rubber viscoelasticity can be described. Using the network evolution concept, the kinetic energy of rubber matrix is calculated in each direction. Accordingly damage history will be measured in each direction and extended to represent the viscous contribution of polymers in mechanics of the matrix. This proposed model includes a few number of physically motivated material constants and demonstrates good agreement with experimental data.

Poster Number: CE-19
Authors: Puneet Kumar, V.K.R. Kodur
Title: Thermo-mechanical Behavior of Prestressed Concrete Hollow Core Slabs Exposed to Vehicle Fires

Abstract: Prestressed hollow core (HC) concrete slabs are widely utilized in parking structures due to their cost effectiveness, speedy construction, low maintenance costs, superior quality, optimized production, and inherent high fire resistance. While structural performance of HC slabs is investigated thoroughly, information related to fire performance of these slabs is rather sparse in the literature. Fire resistance of these slabs is mostly estimated through standard fire tests or prescriptive approaches, without any consideration to critical factors governing fire behavior under vehicle fire exposure in parking structures. In order to overcome current knowledge gaps, a set of numerical studies is undertaken using a generic 3D finite element model. The model, developed using ANSYS, is capable of capturing fire behavior of HC slabs for a wide range of variables such as: different fire scenarios, concrete strength, member dimensions, cover thickness, load level, and support restraints. This validated model is utilized to perform a series of parametric studies to identify critical factors affecting fire behavior of these structures under vehicle fire exposure in parking structures. Results from these parametric studies can be further utilized to propose a rational design approach, for performance based fire design of HC slabs.

This work was supported in part by Prestressed Concrete Institute (PCI)

Poster Number: CE-20
Authors: Yogesh Kumbargeri, Ugurcan Ozdemir, Derek Hibner, Michele Lanotte, M. Emin Kutay, Aksel Seitllari
Title: An Acceptance Test Protocol for Chip Seal Projects using Image Analysis Techniques

Abstract: Chip seal is a popular preventive maintenance techniques implemented by many Departments of Transportation (DOTs) and other road agencies. Its performance depends on Percent Embedment (PE) of aggregates in the asphalt layer. Main objective of the research study was to develop a standard test protocol to directly calculate the PE via digital image analysis. Three image-based algorithms, namely (i) peak & valley method, (ii) surface coverage area method, and (iii) each aggregate method, were developed to analyze chip seal samples. Then, validated algorithms were used to analyze lab produced samples as well as cores from eight different road sections across Michigan. Chip seal samples produced in laboratory were used to investigate effect of binder and aggregate application rates on PE. It was concluded that PE was sensitive to binder application rates but not to aggregate. Core samples were used to compare the ED results from image-based algorithms against the results of sand patch and laser-scanning tests carried out in-situ. Among the image analysis algorithms, peak & valley method was found to show similar results as obtained from sand patch tests. Surface coverage area method was recommended as the most appropriate to analyze chip seal pavements as it omits the assumptions made in the other methods. The image-based algorithms were implemented in a user-friendly software package, named as CIPS, to analyze chip seal samples fundamentally and accurately. The test protocol, along with software can be easily used, distributed to various road agencies and contractors, aiding as a robust QA/QC tool for chip seal performance investigation.

This work was supported in part by Michigan Department of Transportation (MDOT); University Transportation Center for Highway Pavement Preservation (UTC-HPP)
Poster Number: CE-21
Authors: Junfeng Li, Bang He, Weiyi Lu
Title: Mechanical Response of Metallic Tube with Structural Defect Filled with Compressive Liquid

Abstract: Lightweight design is desired for various engineering applications including structural design of columns, machine tool components, etc. Hollow structures are one major type of lightweight designs. However, hollow structures are more sensitive to defects than their solid counterpart, due to damage localization introduced by their structural configurations and dimensions. In current study, we use a compressive liquid to fill metallic tubes with structural defects and hypothesize that the hybrid structure (1) is much less sensitive to defects, and (2) possesses higher specific buckling strength and energy absorption capacity. To test our hypotheses, we characterized the mechanical behavior of empty tubes, incompressible liquid filled tubes, and compressible liquid filled tubes with and without structural defects by uniaxial compressive tests. The size, shape and location of the defects on the testing specimens were precisely controlled. Our experimental results demonstrate that the liquid filled tubes have better load carrying capacity and defect tolerance. In addition, the compressible liquid filled tube has larger deformability and higher energy absorption capacity. With the improved mechanical properties, the liquid filled metallic tubes can be developed into lightweight, strong, and stable structural components for load carrying and energy dissipation. The enhanced defect resistance of liquid filled tubes can lower the manufacturing requirement, and thus reduce the total cost of structural components.

Poster Number: CE-22
Authors: Mingzhe Li, Bang He, Sihao Gu, Weiyi Lu
Title: Enhanced Gravimetric and Volumetric Energy Absorption Efficiencies of Thin-walled Steel Tubes Filled with Liquid Nanofoam

Abstract: Thin-walled metal tubes have been widely used as energy absorbers to mitigate adverse effects of impact and protect structures and facilities. However, once the initial buckling stress of the tube is reached, the post-buckling plateau of the tube has a much reduced average stress which determines the energy absorption efficiency of the empty tube. As a result, the real energy absorption efficiency of the thin-walled tube is much lower than the theoretical limit which is proportional to the value of initial buckling stress. We hypothesize that by filling thin-walled tubes with the novel liquid nanofoam (LN), (i) the energy absorption efficiency of the hybrid structure can reach the theoretical limit, and (ii) the main working mechanism is the effect of solid-liquid interaction on tube buckling. To test these hypotheses, we have characterized the energy absorption efficiency of LN filled steel tubes by quasi-static compression tests and dynamic impacts. Under quasi-static compression, the gravimetric and volumetric energy absorption efficiencies of LN filled steel tubes are 25% and 118% higher than the values of empty tubes, respectively. This is due to the changed buckling mode and the promoted post-buckling stress of the hybrid structure by the highly compressible LN. In addition, under dynamic impact, both the gravimetric and volumetric energy absorption efficiencies of LN filled tubes are further increased by 16%. The strain rate dependent behavior of LN filled tubes must be attributed to the solid-liquid interaction between the LN and the steel tube wall. Our experimental results have demonstrated that the energy absorption efficiency of thin-walled tubes are significantly improved by the LN filler especially at higher strain rates. This hybrid structure has merit in guiding the design of light-weight and small scale cellular structures for vehicle safety and crashworthiness.

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

Poster Number: CE-23
Authors: Muhammad Munum Masud, Syed Waqar Haider
Title: Incorporation of Pavement Preservation Treatments in Pavement- ME Analysis and Design

Abstract: Moisture in pavement subsurface layers has a major influence on Pavement performance. Variation in moisture content over time in subsurface layers predominantly in subgrade, is dependent on temperature, moisture, precipitation and surface conditions of pavements. Sources, which allow moisture change in unbound layers, include surface cracks, untreated shoulders, side ditches and longitudinal/transverse joints. Consequently, resilient modulus is adversely affected, which ultimately leads to premature failures in pavements and reduced life. Keeping in view the contribution of moisture damage in pavements, there is a dire need to relate the extent of discontinuities to the increase in moisture levels in unbound layers. In this study, an effort will be made to develop relationships between the amount of surface cracking (joints/cracks) and the infiltration rate of water into the subsurface layers in different climates using the SMP data, to study the effects on unbound layers’ resilient modulus. For this, Drainage Requirement in Pavements (DRIP) microcomputer program is used to evaluate and validate existing models available.
for analysis of moisture change in pavements. Existing models will be used to establish impact of moisture on unbound layers moduli and subsequently use the pavement ME to quantify performance requirements. This study will also emphasize on effect of pavement preservation treatment timings on pavement performance in the analysis and design process.

Poster Number: CE-24
Authors: Gopikrishna Musunuru, Syed Waqar Haider
Title: Comparisons of Traffic Patterns Overtime in Michigan for Mechanistic Empirical Pavement Design

Abstract: The 1993 AASHTO Design guide has been used for the design of pavements for several years. Although it has been an important tool in pavement design, it is severely limited in the sense that the guide is empirical and the overall traffic is represented by a single value called the equivalent single axle load (ESAL). Several studies have found that the ESAL is incapable of representing the complex failure modes of pavement structures. To address these limitations, AASHTOWare Pavement ME Design was developed by National Cooperative Highway Research Program (NCHRP). Pavement ME requires an extensive amount of traffic inputs for design/analysis of pavement systems; such as base year truck traffic volume, traffic volume adjustment factors, axle load distribution factors, and general traffic inputs. These traffic volume adjustment factors include monthly adjustment factors (MAF), vehicle class distribution (VCD), hourly distribution factors (HDF), and traffic growth factors. The general traffic input data includes number of axles per truck, axle configuration, and wheel base. Pavement ME required traffic data can be obtained through weigh-in-motion (WIM), automatic vehicle classification (AVC), and vehicle counts. Axle load distribution factors or spectra (ALS) can only be determined from WIM data. A study has been conducted in 2009 to develop these traffic inputs for MEPDG using the data collected from the WIM and classification sites between the years 2006 and 2007 across the State of Michigan. The objective of this study is to develop the inputs using the data between 2011 and 2016 and compare the old and the new traffic patterns. Any change in patterns observed would severely affect the pavement design. The results of this study could be used by MDOT to incorporate into their pavement design process.

This work was supported in part by Michigan Department of Transportation

Poster Number: CE-25
Authors: M. Z. Naser, V. K. Kodur
Title: An Approach for Evaluating Shear Capacity of Steel and Composite Beams Subjected to Fire Conditions

Abstract: Steel structures exhibit lower fire resistance due to high thermal conductivity, low specific heat and rapid degradation of strength and stiffness properties of steel. In fact, steel structural elements can rapidly lose much of their load carrying capacity within the first 20-25 minutes from exposure to fire conditions. As a result, steel structural members can be highly vulnerable to fire-induced damage leading to collapse of a structure. Therefore, behavior of steel and composite beams, under fire conditions, is of critical concern from fire safety point of view. In current design philosophy, fire design of these beams is carried out based on flexural limit state only. However, this design philosophy may not be conservative (or realistic) especially when shear forces in a beam are dominant or shear capacity degrades at a rapid pace under fire. Since current design provisions do not provide specific guidance on fire resistance of steel and composite beams subjected to combined shear and fire loading, this paper presents the development of an approach for evaluating shear capacity of steel and composite beams as a function of fire exposure. This proposed approach accounts for temperature-induced degradation of mechanical properties of concrete and steel, temperature-induced sectional instability and level of composite action offered by concrete slab in evaluating shear capacity in beams. The validity of the proposed approach will be established by comparing predicted response parameters against test data through numerical analyses.

This work was supported in part by National Science Foundation under Grant number CMMI-1068621

Poster Number: CE-26
Authors: Tula Ngasala, Phanikumar Mantha, Susan Masten
Title: Using Groundwater Modeling System (GMS) to Estimate the Contamination Load of Domestic Wells from Septic Systems in Tanzania

Abstract: Groundwater is one of the main sources of water in many urban low-income areas of Dar-es-Salaam, Tanzania. People rely on domestic wells for their daily water supply. The on-going study was done in one of the urban communities of Dar-es-Salaam city. In this area, many domestic wells are located approximately 5 meters to 12 meters away from septic tanks or pit latrines (WHO standard is 60 meters). At least one latrine or septic tank was
found at each household and there was a domestic well after every five to ten households. Groundwater Modeling System (GMS) will be used to develop a conceptual model based on data from nearly 65 boreholes. The model will use a steady state calibration and transmissivity data to simulate nitrate, total dissolved solids and E. coli load from septic systems to groundwater as well as global sensitivity analysis. The main goal is to conduct groundwater modeling to analyze the performance of existing wastewater collection systems and the negative impact to groundwater. Specific objectives are to estimate the load (mass rate) of contaminants, distance, velocity and time that contaminant plumes will take to reach the nearby domestic wells. Soil, aquifer and domestic wells properties were collected from the study area as input parameters for calibration and simulation purposes. Results are expected to show the significant contamination level of domestic wells in terms of distance, velocities and time. An estimated level of contamination will help with the future implementation of new technologies to minimize groundwater contamination.

Poster Number: CE-27
Authors: Rajendra Prasath Palanisamy, Yiming Deng, Mahmoodul Haq, Sung-Han Sim
Title: Virtual Sensing for Structural Health Monitoring of Offshore Structures

Abstract: Offshore structures are generally subjected to harsh environment with strong tidal current and wind loading, which demands robust and reliable Structural Health Monitoring (SHM) to avoid any catastrophic failure. The growing size, complexity, and harsh environment of offshore structures lead to difficulties in sensor deployment and maintenance. Response at critical locations in complex offshore rigs are inaccessible during sensor deployment. Moreover, their operational environment demands frequent sensor maintenance for uninterrupted monitoring. Virtual sensing addresses these issues by estimating unmeasured responses with the help of measured responses. This dissertation delineates a virtual sensing method based on Kalman state estimator to combine multi-sensor data under non-stationary random excitation. The estimation algorithm effectively uses the FE model of a structure to predict and fuse different type of structural response (acceleration and strain). The performance of virtual sensing is successfully verified with numerical and experimental test over a bottom fixed off-shore structure. Test results conclude that the unmeasured responses are reasonably recovered form measured responses.

Poster Number: CE-28
Authors: Shabnam Rajaei, Karim Chatti, Roozbeh Dargazany
Title: Tire-pavement Interaction in Micro-scale: Hysteresis Contribution

Abstract: Understanding the interaction between tire and pavement surface is of great importance since it can improve the perception of friction and rolling resistance. Friction plays an important role in vehicle safety while rolling resistance can affect fuel consumption of the vehicle. Several factors influence these two phenomena. In this study, the effect of pavement surface characteristics on friction and rolling resistance is investigated at the microscale level. Focusing on the effect of pavement surface micro-texture on tread rubber energy loss, a finite element model is generated using commercial software ABAQUS. The pavement surface is considered as simple sinus waves. The energy loss due to predefined surfaces is calculated. A UMAT subroutine code has also been prepared for characterizing the rubber material properties as hyper-viscoelastic material. The results of the model are validated by Persson’s theory of rubber friction.

This work was supported in part by Center for Highway Pavement Preservation (CHPP)

Poster Number: CE-29
Authors: João Rodrigues, Venkatesh Kodur, Mohannad Naser
Title: Effect of Shear on the Fire Response of Steel and Composite Steel and Concrete Beams

Abstract: Structural elements in case of fire experience loss of load bearing capacity and stiffness due to degradation of strength and modulus properties of constituent materials. Current provisions on design of structural elements takes into account the temperature induced actions but in general shear effects is quite always not taken into account. However shear can be important on high slender beams, such as the case of bridge girders, beams with reduced cross sectional area and beams with short-span. In these beams shear effects can be more predominant than flexural effects because shear capacity can degrade at a more rapid pace than flexural capacity due to possible temperature induced local buckling of the web. The design codes consider shear design as a minor problem. The Eurocodes, for example, examines the shear capacity of cross-section as for normal temperature, but affecting the resistance by the yield strength reduction coefficient of the steel for the temperature of the web. Research on the
effects of shear on beams is still scarce. However the available research have shown that shear can be a problem especially in high slender beams. As part of current research the problem inherent to the effects of shear on failure of steel and composite beams under fire is studied. Based on results from numerical studies, methodologies are proposed for shear design under fire exposure. Further possibilities to overcome shear effects such as using corrugated or trapezoidal web beams is discussed.

**Poster Number:** CE-30  
**Authors:** Ramin Saedi, Mohammadreza Saeedmanesh, Ali Zockaie, Meead Saberi, Nikolas Geroliminis, Hani S. Mahmassani  
**Title:** Network-wide Fundamental Diagram (NFD) and Travel Time Reliability Relations for a Heterogeneous Network and its Density-based Clusters  

**Abstract:** The primary objective of this paper is to elaborate homogeneous well-defined Network-wide Fundamental Diagrams (NFD) after clustering a heterogeneous network, in order to alleviate the variance of congestion within each cluster. Partitioning is based on the spatial properties of congestion in the course of a specific time span. In this paper we intend to represent the travel time reliability models both for the heterogeneous network and its partitioned homogeneous subnetworks. The proposed model for reliability of travel time and extracting NFD in subnetwork level are calibrated for realistic large-scale network of Chicago when effectively serve the morning and evening peak demands. This study establishes important results in describing two main features of the transportation network: (i) network-level and subnetwork-level relationships between main traffic flow components and (ii) overall reliability of travel time as a performance descriptor for network and its clusters. These results could allow the application of methodological strategies to organize the real-time hierarchical perimeter traffic control configuration to reduce the network overall congestion. Employing NFD in transportation planning stipulates the implementation of a new generation of traffic control scheme and enhance the mobility. Formulation of travel time reliability takes advantage of estimation of the level of service from users’ perspective. Characterizing the NFDs and variability of travel time can be utilized to develop the routing strategies and urban planning activities.

**Poster Number:** CE-31  
**Authors:** Hadi Salehi, Saptarshi Das, Shantanu Chakrabartty, Subir Biswas, Rigoberto Burgueño  
**Title:** An Image-based Machine Learning Paradigm for Health Monitoring of Aerospace Structure through a Self-powered Sensing Concept  

**Abstract:** This study proposes an intelligent strategy for damage identification in aerospace structures. The strategy was evaluated based on the simulation of the binary data generated from self-powered wireless sensors along with a pulse switching architecture. A system employing such an energy-efficient technology requires dealing with power budgets for sensing and communication of binary data that leads to time delay constraints. This paper develops an innovative image-based machine learning paradigm using pattern recognition (PR) for health monitoring of aerospace structures. Time-delayed binary data extracted from self-powered sensors was utilized to determine damage indicator variables. The performance and accuracy of the damage detection strategy was examined and tested for the case of an aircraft stabilizer. Damage states were simulated on a finite element model by reducing stiffness in a region of the stabilizer’s skin. Results indicate that the proposed damage detection strategy show satisfactory performance to identify damage in spite of high noise levels. It is observed that PR can be applied as a promising machine learning paradigm for damage detection using novel self-powered wireless sensors with time-delayed binary data.

**Poster Number:** CE-32  
**Authors:** Mahmood Sarwar, Venkatesh Kodur  
**Title:** Characterizing Compressive Strength and Explosive Spalling Behavior of Ultra High Performance Concrete (UHPC) at Elevated Temperatures  

**Abstract:** Concrete is one of the most widely used materials in construction applications. Newer types of concrete are being developed to improve the performance and durability properties and explore environmentally friendly considerations. One recent development in concrete technology is ultra high performance concrete (UHPC). UHPC offers excellent material properties including strength, durability, ductility, and sustainability, and thus finding wide ranging application in infrastructure. When used in building applications, UHPC structural members must satisfy fire resistance requirements as specified in building codes. For evaluating fire resistance, high temperature mechanical properties of UHPC is critical. Unfortunately, data pertaining to UHPC’s mechanical properties at elevated
temperatures is quite limited. Preliminary studies indicate that UHPC, due to low permeability, experiences rapid strength degradation at elevated temperatures. In addition, UHPC can undergo significant spalling under fire conditions. These two factors can lead to significant loss of strength and stiffness properties in structural elements resulting in lower fire resistance, and sudden failure. To develop data on temperature induced strength degradation, and explosive spalling behavior of UHPC, an experimental study on UHPC specimens is carried out at Michigan State University. UHPC cylinders were fabricated from three different design mixes, namely two mixes of UHPC with varying content of steel fibers and one UHPC mix with steel and polypropylene fibers. The cylinders were tested in a hot state under compressive loads at various temperatures (20 – 700°C). In the presentation, detailed results pertaining to explosive spalling, and the empirical relation showing the variation of compressive strength with temperature will be presented.

Poster Number: CE-33
Authors: Aksel Seitllari, Yogesh Kumbargeri, Michele Lanotte, M. Emin Kutay
Title: Investigation of the Effect of Polymer and Rubber Modifications on Bubble Size Distribution of Foamed Binders using X-ray Microtomography Imaging

Abstract: Rapid implementation of foam-based Warm Mix Asphalt (WMA) technologies in the U.S. has significantly increased the need for understanding the behavior of foamed asphalt binders, especially the binders modified with polymers and other new additives. It is well known that foaming characteristics of binders are influenced by numerous factors including foaming technology, amount of water, temperature, binder grade and modification. The main objective of this study was to investigate the significance of neat (control), polymer (SBS) and partially devulcanized rubber (DVR) modified asphalt binder properties on foaming characteristics (e.g. bubble size distribution and surface area index). Internal morphology of bubbles in foamed asphalt binders were directly quantified using the nondestructive X-Ray Microtomography (XRM) imaging technique. The neat and modified binders were foamed at temperatures corresponding to the equi-viscous conditions. As soon as the binders were foamed, they were instantly frozen using liquid nitrogen to preserve the internal bubble morphology. Then the XRM system at the Michigan State University (MSU) was used to acquire the 3D internal images of the frozen foamed asphalt binders. Image processing techniques were employed to isolate the individual bubbles then their size, volume and shape characteristics were computed using image analysis methodologies. The results showed that polymer (PMB) and partially devulcanized rubber (DVR) modified binders significantly affected the foam characteristics and the morphology of the bubbles.

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

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Poster Number: CE-34
Authors: Sanghoon Shin, Yadu Pokhrel
Title: High Resolution Modeling of Reservoir Storage and Extent Dynamics at Continental Scales

Abstract: Land surface models have been used to assess water resources sustainability under changing Earth environment and increasing human water needs. Overwhelming observational records indicate that human activities have ubiquitous and pertinent effects on the hydrologic cycle; however, they have been crudely represented in large scale land surface models. In this study, we enhance an integrated continental-scale land hydrology model named Leaf-Hydro-Flood to better represent reservoir storage dynamics. The model is implemented at high resolution (5km grids) over the continental US. Reservoir operation and river-flood routing schemes are newly implemented and irrigation and groundwater pumping are simulated altogether. The new schemes improve river flow simulations in highly regulated regions through better representation of dynamic reservoir extent, an important mechanism that remains largely ignored in continental to global scale hydrological modeling. The dynamic reservoir extent is expected to allow better modeling of hydrologic storage and fluxes related to land-water management. The improvements in this study have potential to build consistent modeling framework for human-water-climate interactions.

Poster Number: CE-35
Authors: Meead Saberi, Mehrnaz Ghamami, Yi Gu, MohammadHossein Shojaei, Elliot Fishman
Title: Network Theoretic Investigation of the Influences of a Public Transit Disruption on Bike Sharing Use

Abstract: This paper employs a network theoretic analysis to realize the influences of a public transportation disruption on bike sharing usage in London. We initially compared statistical properties of the bike sharing use before, during, and after a disruption in London underground. Results showed that the disruption resulted in increase of both
the number and duration of bike trips. Also, new origin-destination demand were generated and the bike sharing network became more connected during the disruption. The observed changes are not homogeneous over space, such that stations in central London encountered greater increase in bike trip counts compared to outer areas. The main contributions of the paper are presentation of a network-based approach to analyzing bike trips and providing insights on the interconnections between public transportation and bike sharing systems. Results suggest that bike sharing systems can potentially reduce the load on public transport network and increase the resilience of the transportation system in times of disruptive events.

**Poster Number:** CE-36  
**Authors:** Roya Solhmirzaei, Venkatesh Kodur  
**Title:** Shear Behavior of Ultra High Performance Fiber Reinforced Concrete Beams

**Abstract:** Ultrahigh performance fiber reinforced concrete (UHPFRC) is an advanced cementitious material made with low water to binder ratio and high fineness admixtures; and possess superior mechanical properties, such as high compressive and tensile strength, improved durability and ductility properties. Being a relatively new construction material, there are limited experimental studies on shear behavior of UHPFRC beams at structural level. To develop an understanding on shear behavior of UHPFRC beams, two beams made of UHPFRC were tested under predominant shear loading. The beams were not provided with any shear reinforcement in order to take advantage of high tensile strength offered by UHPFRC. To capture cracking patterns and their propagation, a special digital image correlation (DIC) technique was utilized. In the presentation, detailed results including load-deflection response, crack propagation, and failure patterns will be presented. In addition, the feasibility of designing UHPFRC beams without any additional shear reinforcement (stirrups) will be discussed.

**Poster Number:** CE-37  
**Authors:** Steven Stapleton, Timothy Gates  
**Title:** Assessing Driver Yielding Compliance at Uncontrolled Midblock Pedestrian Crossing Areas on Low Speed Roadways

**Abstract:** A field study was performed to compare the relative effectiveness of various types of countermeasures commonly utilized at uncontrolled midblock crosswalks. A variety of crosswalk treatments were evaluated in a cross-sectional study at 31 low-speed midblock crosswalks located on or near three public universities in lower Michigan. The locations included unmarked crosswalks, in addition to various crosswalk marking strategies with and without additional enhancement devices, which included the pedestrian hybrid beacon (PHB), rectangular rapid flashing beacon (RRFB), and in-street R1-6 signs. Driver yielding compliance to pedestrian crossing events was the measure of effectiveness, which served as a surrogate for crashes due to a lack of adequate crash data. To isolate the crosswalk treatment effects, several roadway and traffic characteristics were included in the analysis, including crossing width, vehicular and pedestrian volumes, lane position of the vehicle, and position of the vehicle within a queue. The logistic regression model results indicated that the type of crosswalk treatment has a strong influence over driver yielding compliance. While yielding compliance improves substantially when crosswalk markings are utilized, the highest compliance rates are achieved when an additional enhancement device (i.e., RRFB, PHB, or R1-6 sign), is also provided. Furthermore, yielding compliance showed little sensitivity to driver lane position at locations where a crosswalk enhancement device was utilized. Yielding compliance rates also showed improvements across each of the crosswalk enhancement devices compared to prior studies performed within Michigan, suggesting that compliance improves as drivers become more familiar with these devices.

**Poster Number:** CE-38  
**Authors:** Timothy J. Gates, Peter T. Savolainen, Steven Stapleton, Trevor Kirsch, Santosh Miraskar  
**Title:** Development of Safety Performance Functions and Other Decision Support Tools to Assess Pedestrian and Bicycle Safety

**Abstract:** A field study was performed at 40 uncontrolled crosswalks and 26 signalized intersections on low-speed roadways at three major college campuses across lower Michigan. An array of existing traffic control devices existed at study sites, including various crosswalk marking strategies, and enhanced devices: PHBs, RRFBs and single in-street R1-6 signs. Sites included a variety of roadway and traffic characteristics, including crossing widths, median presence, and vehicular, pedestrian, and bicyclist volumes. Three evaluations were performed for the midblock segments and signalized intersection study sites: driver yielding compliance, vehicle-pedestrian conflicts, and non-
motorized traffic crash data. The yielding compliance study found that the type of crosswalk treatment has a strong influence over driver yielding compliance, finding that the highest compliance rates occur when an additional enhancement device is provided. To supplement small crash sample sizes at study sites, Michigan statewide pedestrian and bicyclist crash data were collected and utilized to develop safety performance functions (SPFs) for predicting pedestrian and bicyclist crashes. Because pedestrian and bicyclist volumes were not available statewide, models were developed for pedestrian and bicycle crashes based solely on vehicular AADT. In general, the models showed that pedestrian and bicycle crashes increase with increasing traffic volumes. However, even in the highest volume cases, only a fraction of crashes involved a pedestrian or bicyclist. Pedestrian and bicycle crashes were further estimated based on the respective proportion of the Michigan specific SPF models for total crashes. The primary limitation towards prediction of pedestrian and bicycle crashes is the lack of reliable exposure data.

This work was supported in part by TRCLC

Poster Number: CE-39
Authors: Jacob Swanson, Timothy Gates
Title: Safety Performance for Rural Trunkline Four-leg, Two-way Stop Controlled Intersections in Michigan

Abstract: More than 20 percent of all traffic fatalities in the United States occur at intersections and over 80 percent of intersection-related fatalities in rural areas occur at un-signalized intersections (FHWA). Of the 893 fatal crashes in Michigan in 2015, 223 (25%) occurred at intersections. When compared to all other intersection control types; intersections with stop signs represent the highest percentage of fatal crashes, with almost 40% (MTCF). To address the evident safety concerns, research has been ongoing for rural intersections within the state of Michigan; with the focus of the research concentrating on the development of safety performance functions (SPF’s) for rural four-leg, 2-way stop controlled intersections. Safety performance functions are a vital element of the Highway Safety Manual (HSM) statistical methods. SPF’s are regression models that work to correlate geometric roadway characteristics and traffic volumes with the expected number of crashes for specific site types and conditions. The SPF’s involved with this research will be a function of various factors; including, functional classification, number of lanes and their designations (left, right, thru), skew angle, number of driveways for each leg, and other factors (presence of railroad, sidewalk, pedestrian signal, flasher, and/or median). The intersection data has been collected for more than 20 counties across Michigan and has been joined together with Michigan’s traffic crash data from 2011-2015. An analysis will be performed on the merged data and a safety performance function will be developed for rural four-leg, two-way stop controlled intersections.

This work was supported in part by Michigan Department of Transportation

Poster Number: CE-40
Authors: Suhail Hyder Vattathurvalappil, Mahmoodul Haq
Title: Experimental and Numerical Modeling of Tri-axial Braided CFRP Crush-tubes

Abstract: The demand for novel crush tubes with high specific energy absorption has increased to meet the lightweighting goals, the stringent transportation safety requirements, and to produce high-safety ratings in vehicles. Despite the high specific stiffness and impact damage tolerance of braided composites, they are not extensively used in the automotive applications due to their complexity and limited understanding compared to conventional metal crash cans. In this work, experimental and numerical characterization of tri-axial braided composites for use in novel crush tubes is explored. Compressive coupon tests were performed and used to validate meso-scale unit-cell models. Resulting model/behavior was used to study the progressive compressive behavior of the cylindrical (6 in. long and 3 in. diameter) crush tube. Finally, experimental quasi-static compressive tests were performed on similar crush tubes to validate the numerical model. Preliminary results show that the numerical models agree reasonably with the experimental results. Future work would extend this work at higher strain rates and validate models can be used for better design of braided crush tubes.
Poster Number: CE-41  
Authors: Lijiang Xu, Mingzhe Li, Weiyi Lu  
Title: Influence of Pore Size on Yielding Strength of Ceramic Based Nanofoams

Abstract: Light-weight and strong structural components are desired for many engineering applications including airplanes, spacecraft and cars, helping to improve fuel efficiency, as well as in mobile electronics and biomedical devices. To enhance the loading carrying capability and extend service life, high yield strength is needed. Although foams are one major type of light-weight materials, the specific yield strength ($\sigma_y/\rho$) of these hollow structures is a constant by first order of estimation. In order to develop light but strong materials, i.e., increased value of the specific yield strength, one possible solution is ceramic based foams with nanoscale pores. The size effect on the elastic limit of ceramics is well known. In foams, once the pore size is reduced to nanometer scale, the size and density of defects can be much reduced, and thus the elastic limit can be significantly improved. To validate our hypothesis, we have conducted compressive tests on nanoporous silica gels, the most widely used nanoporous material. Four types of nanoporous silica spheres with same particle size and porosity but different nanopore sizes (10 nm, 20 nm, 30 nm, and 100 nm) were selected and pre-compressed by an Instron universal tester. Due to the nanopore size distribution and system compliance, the elastic limit was not directly observed from the stress-strain curves. Alternatively, we employed the liquid infiltration tests to analyze the degree of plastic deformation in the silica gels by evaluating the remaining porosity of the silica gels after mechanical compression. In addition, the effect of nanopore size on elastic limit of the nanoporous silica gels were studied by combining gas adsorption analysis with the mechanical tests. Our experimental results suggest that when the nanopore size is reduced from macroporous (>50 nm) to mesoporous (2 nm - 50 nm), the elastic limit of the nanofoams are increased. In mesoporous range, the smaller nanoporous silica gels possess higher elastic limit which may be attributed to the reduced defects of ceramics, corresponding to the assumption. These findings suggest that nanofoams bring us a promising way to design lightweight, strong, and durable materials.
COMPUTATIONAL MATHEMATICS, SCIENCE & ENGINEERING

**Poster Number:** CMSE-01  
**Authors:** Michael M. Crockatt, Andrew J. Christlieb, Cory D. Hauck  
**Title:** High Order Hybrid Methods for Radiative Transport

**Abstract:** A selection of high order hybrid schemes for solving linear, kinetic radiative transport problems are considered. The hybrid schemes are constructed by splitting the radiative flux into collisional and free-streaming components to which standard time integration techniques are applied. It is demonstrated that, compared to traditional approaches, such hybrid schemes have the potential to significantly reduce the computational cost required to produce accurate solutions to transport problems across a wide range of collisionality regimes.

*This work was supported in part by Oak Ridge National Laboratory (ORNL) and Oak Ridge Associated Universities (ORAU) through the ORAU/ORNL High Performance Computing (HPC) Grant Program*

**Poster Number:** CMSE-02  
**Authors:** Gautham Dharuman, Michael S. Murillo  
**Title:** Effective Quantum Potentials for Large-scale Simulation of Atomic and Molecular Cluster Explosion by High Intensity Lasers

**Abstract:** Ionization of clusters using high intensity lasers has gained significant attention as a source for fusion energy (T. Ditmire et al., Nature 1999). The process can also serve as a high energy (~1MeV) ion beam source (T. Ditmire et al., Nature 1997). Improved design for the applications requires detailed simulations of the correlated quantum dynamics post ionization. Cluster sizes can range from ~10^2 - 10^3 atoms or molecules (Last and Jortner, PRL 2001) requiring a simulation involving ~10^2-10^5 electrons and ions. An existing high fidelity approach is time-dependent density functional theory, but its O(N^3) scaling for N particles makes it intractable for the large cluster sizes of interest. We present an alternative approach using a classical Hamiltonian framework employing momentum-dependent potentials (MDPs) to approximately capture the large-scale quantum dynamics (Dharuman et al., PRE 2016). These MDPs are empirical, therefore need to be trained on suitable properties of the system with the expectation of a good predictive capability for properties not included in the training. Using a specific MDP form we showed that training on ground state energies of some atoms translated reasonably well into prediction of their first and second ionization energies. But, that MDP form failed to capture the momentum transfer cross section (MTCS) for an electron-ion scattering. We are currently exploring new MDP forms that can adequately predict MTCS and suitable properties of atoms or molecules that constitute the clusters of interest.

*This work was supported in part by AFOSR*

**Poster Number:** CMSE-03  
**Authors:** Connor Glosser, Jack Hamel, Shanker Balasubramaniam, Carlo Piermarocchi  
**Title:** Maxwell-Bloch Quantum Electrodynamics: A Full-wave Solution Strategy for Disordered Photonic Media

**Abstract:** Here we consider a disordered system of interacting quantum dots—nanoscale semiconductors with wide applicability in systems ranging from lasing to quantum computing to biological contrast imaging and next-generation displays. Much like atoms, individual quantum dots facilitate absorptive and emissive processes at specific frequencies over timescales independent of those in the incident radiation. These processes couple between dots due to the presence of electromagnetic fields, giving rise to emergent nonlinear behavior within the system. By treating quantum dots semiclassically within our simulation, we maintain the discrete dynamics inherent to quantum objects without resorting to cumbersome second quantization to describe electromagnetic fields (i.e. fields behave classically). This has the advantage of partitioning the simulation into two distinct parts, (1) determination of source polarizations through evolution of the differential optical Bloch equations, and (2) evaluation of radiation patterns through methods adapted from well-known computational electromagnetics techniques. We employ a highly-tuned predictor-corrector integration scheme to advance (1) in time and the subsequent polarizations serve as pointlike
sources to electromagnetic integral equations (chosen to facilitate accurate point-to-point communication of fields without the computational overhead of a `radiation grid`). The coupled solution of (1) and (2), then, gives a complete description of both the quantum and electromagnetic dynamics at each timestep, giving rise to nonlinear effects such as dynamical frequency shifts, strongly correlated quantum behaviors, and other optical phenomena.

This work was supported in part by NSF grant #1408115

Poster Number: CMSE-04
Authors: Stephen Hughey, Hasan Metin Aktulga, Shanker Balasubramaniam
Title: Parallel Adaptive Fast Multipole Method for Electromagnetics

Abstract: Multiscale electromagnetic (EM) scattering and radiation problems find a wide range of applications in modern engineering design and analysis, from military aircraft to consumer electronics. Integral equation (IE) solutions to these problems are desirable due to their accuracy; however, method of moments discretization of IEs produces dense NxN matrix systems whose solution requires O(N^2) operations in an iterative solver. The fast multipole method (FMM) is often employed to reduce this cost to O(N log N). As the problem size becomes very large, parallelization of the FMM becomes critical.

The FMM achieves this speedup by splitting the simulation domain into a tree of cubes of equal size at each level and having them interact according to a particular set of rules. In the traditional FMM, the densest region of spatial discretization dictates the leaf box size. For multiscale problems, the spatial discretization may be highly non-uniform. Regions outside the densely-discretized region may be over-partitioned, resulting in degradation of the scaling of the FMM.

We describe and demonstrate a set of parallel algorithms that facilitate adaptation of the FMM tree to a non-uniform distribution while preserving the accuracy of the FMM. We define the necessary operators and present an efficient method for handling the cross-level interactions incurred by adapting the tree.

Poster Number: CMSE-05
Authors: Scott O'Connor, Zane Crawford, Shanker Balasubramaniam, John Verboncoeur
Title: Stability Analysis of Dual Field Domain Decomposition

Abstract: Electromagnetic simulation tools are critical for many industrial applications. Time domain finite element methods are one class of methods to simulate transient Electric and Magnetic fields. A common approach to solve for both Electric and Magnetic fields in time is to use a leap frog method. In this approach, the electric field is solved at a time step, while the magnetic field is solved at the next half time step or vice versa. These methods have certain stability criterion that dictate various parameters of the simulation; e.g. time step size, mesh size or what range of frequencies can be simulated. One specific method, the Dual Field Domain Decomposition with an Element Level Decomposition (DFDD-ELD), provides a highly parallelizable framework. This work presents a stability analysis of the DFDD-ELD method along with improvements to the method.

Poster Number: CMSE-06
Authors: Jorge Suzuki, Mohsen Zayernouri
Title: A Fractional-order Uniaxial Visco-elasto-plastic Model with Damage for Structural Analysis

Abstract: We incorporate a damage formulation to a fractional-order visco-elasto-plastic model considering uniaxial large strains, to describe material degradation. The fractional-order modeling takes into account memory effects for the plastic strains and damage, in order to determine the internal plastic variables, damage and stress. In the context of Lemaitre’s ductile damage theory, we introduce a scalar damage variable to describe the stress softening, along with a differential equation in time that describes the evolution of damage coupled with the plastic strains. The model uses two fractional-orders, respectively, beta_E, beta_K in (0,1), for visco-elasticity and visco-plasticity. A nonlinear system of equations results from the damage evolution and consistency condition, and is solved for the plastic strains and damage using Steffensen’s method and fractional-order time integration in the framework of a fractional-order return-mapping algorithm with damage. We test the model for convergence, prescribed monotonic and cyclic strains, and subsequently implement the model in a finite element space truss code to solve a two-bar and a star-dome problem, that account with snap-through instability and dynamic plasticity with high strain rates. The simulation results demonstrate the flexibility of the fractional-orders beta_E and beta_K when using the Caputo derivative to describe the rate-dependent hardening, softening and viscous dissipation of the model. We believe that such models have promising potential for complex constitutive laws with rate-dependent behavior with damage, such as engineering materials and biological tissues involving low-cycle fatigue, dynamic plasticity and creep damage.
COMPUTER SCIENCE

Poster Number: CSE-01
Authors: Faraz Ahmed, Alex Liu, Rong Jin
Title: Social Graph Publishing with Privacy Guarantees

Abstract: Online social network graphs provide useful insights on various social phenomena such as information dissemination and epidemiology. Unfortunately, social network providers often refuse to publish their social network graphs due to privacy concerns. Recently, differential privacy has become the widely accepted criteria for privacy preserving data publishing because it provides strongest privacy guarantees for publishing sensitive datasets. Although some work has been done on publishing matrices with differential privacy, they are computationally unpractical as they are not designed to handle large matrices such as the adjacency matrices of OSN graphs. In this paper, we propose a random matrix approach to OSN graph publishing, which achieves storage and computational efficiency by reducing the dimensions of adjacency matrices and achieves differential privacy by adding a small amount of noise. Our key idea is to first project each row of an adjacency matrix into a low dimensional space using random projection, and then perturb the projected matrix with random noise, and finally publish the perturbed and projected matrix. In this paper, we first prove that random projection plus random perturbation preserve differential privacy, and also that the random noise required to achieve differential privacy is small. We then validate the proposed approach and evaluate the utility of the published data for two different applications, namely node clustering and node ranking, using publicly available OSN graphs of Facebook, Live Journal, and Pokec.

Poster Number: CSE-02
Authors: Kamran Ali, Alex X. Liu, Wei Wang, Muhammad Shahzad
Title: Recognizing Keystrokes Using Commodity Wi-Fi Devices

Abstract: Keystroke privacy is critical for ensuring the security of computer systems and the privacy of human users as what being typed could be passwords or privacy sensitive information. In this paper, we show for the first time that WiFi signals can also be exploited to recognize keystrokes. The intuition is that while typing a certain key, the hands and fingers of a user move in a unique formation and direction and thus generate a unique pattern in the time-series of Channel State Information (CSI) values, which we call CSI-waveform for that key. In this paper, we propose a WiFi signal based keystroke recognition system called WiKey. WiKey consists of two Commercial Off-The-Shelf (COTS) WiFi devices, a sender (such as a router) and a receiver (such as a laptop). The sender continuously emits signals and the receiver continuously receives signals. When a human subject types on a keyboard, WiKey recognizes the typed keys based on how the CSI values at the WiFi signal receiver end. We implemented the WiKey system using a TP-Link TL-WR1043ND WiFi router and a Lenovo X200 laptop. WiKey achieves more than 97.5% detection rate for detecting the keystroke and 96.4% recognition accuracy for classifying single keys. In real-world experiments, WiKey can recognize keystrokes in a continuously typed sentence with an accuracy of 93.5%.

Poster Number: CSE-03
Authors: Salman Ali, Kamran Ali, Alex X. Liu, Wei Wang
Title: Facial Gesture Recognition using WiFi Signals

Abstract: Gesture recognition from human facial expressions is crucial to enable several emotion based human-computer interaction applications, as facial expressions reveal different human attitudes. Recent techniques which focus on recognition of human facial gestures using video, sound, radar or physiological sensors, are either intrusive and/or require specialized hardware. In this work, we propose a wireless signal based facial gesture recognition system for devices with WiFi capability, e.g. smartphone, laptop. Our system is non-intrusive as users can express gestures or feelings even when they feel uncomfortable with speaking or turning on the camera of their device. We test our system in a real-world scenario, where users record facial gestures by holding a smartphone or sitting close to a laptop. Our experimental results show that the proposed system can detect eight different facial gestures with an average accuracy of 88% using k-Nearest Neighbor (k-NN) classification.
**Poster Number:** CSE-04  
**Authors:** Meznah Almutairy, Eric Torng  
**Title:** The Effect of Sampling on the Efficiency and Accuracy of k-mer Based Indexes: Theoretical and Empirical Comparisons Using Human Genome

**Abstract:** One of the most common ways to search a sequence database for sequences that are similar to a query sequence is to use a k-mer index. One of the biggest problems with k-mer indexes is the space required to store the lists of all occurrences of all k-mers in the database. One method for reducing space and also query time is sampling where we store only some k-mer occurrences rather than all of them. Most previous work uses "hard sampling" where enough k-mer occurrences are retained so that all similar sequences are guaranteed to be found. We study "soft sampling" where we further reduce the number of stored k-mer occurrences and thus risk decreasing query accuracy. We focus on finding highly similar local alignments over nucleotide sequences, an operation that is fundamental to several biological applications. We use the NCBI BLAST tool with the human genome and human ESTs. Our results show that soft sampling leads to significant reductions in both index size and query time with relatively small costs in query accuracy when compared to hard sampling. Extreme soft sampling reduces index size 4-10 times more than hard sampling and processes large queries 2.3-6.8 times faster while still achieving retention rates of at least 95%. When we apply extreme soft sampling to the problem of mapping ESTs, we are able to map more than 99% of ESTs perfectly while reducing the index size by a factor of 3-5 and reducing query time by 32-42% when compared to hard sampling.

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**Poster Number:** CSE-05  
**Authors:** Morteza Safdarnejad, Yousef Atoum, Xiaoming Liu  
**Title:** Temporally Robust Global Motion Compensation by Keypoint-based Congealing

**Abstract:** Global motion compensation (GMC) removes the impact of camera motion and creates a video in which the background appears static over the progression of time. Various vision problems, such as human activity recognition, background reconstruction, and multi-object tracking can benefit from GMC. Existing GMC algorithms rely on sequentially processing consecutive frames, by estimating the transformation mapping the two frames, and obtaining a composite transformation to a global motion compensated coordinate. Sequential GMC suffers from temporal drift of frames from the accurate global coordinate, due to either error accumulation or sporadic failures of motion estimation at a few frames. We propose a temporally robust global motion compensation (TRGMC) algorithm which performs accurate and stable GMC, despite complicated and long-term camera motion. TRGMC densely connects pairs of frames, by matching local keypoints of each frame. A joint alignment of these frames is formulated as a novel keypoint-based congealing problem, where the transformation of each frame is updated iteratively, such that the spatial coordinates for the start and end points of matched keypoints are identical. Experimental results demonstrate that TRGMC has superior performance in a wide range of scenarios.

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**Poster Number:** CSE-06  
**Authors:** Yousef Atoum, Joseph Roth, Michael Bliss, Wende Zhang, Xiaoming Liu  
**Title:** Monocular Video-based Trailer Coupler Detection using Multiplexer Convolutional Neural Network

**Abstract:** This work presents a fully automated computer vision system for autonomous self-backing-up a vehicle towards a trailer, by continuously estimating the 3D trailer coupler position and feeding it to the vehicle control system, until alignment of the tow hitch with the trailers coupler. This system is made possible through our proposed distance driven Multiplexer-CNN method, which selects the most suitable CNN using the estimated distance of the coupler to the vehicle. The input of the multiplexer is a group made of a CNN detector, trackers, and a 3D localizer. In the CNN detector, we propose a novel algorithm to provide a confidence score with each detection. The score reflects the existence of the target object in a region, as well as how accurate is the 2D target detection. We demonstrate the accuracy and efficiency of the system on a large trailer database using a regular PC. Our system achieves an estimation error of 1.4 cm when the ball reaches the coupler, while running at 18.9 FPS.

This work was supported in part by General Motors (GM)
Patient Subtyping via Time-aware Long-short Term Memory Networks

Abstract: In the study of various diseases, the heterogeneity among patients usually leads to different progression patterns and may require different types of therapeutic intervention. Therefore, it is important to study patient subtyping, the grouping patients into disease characterizing subtypes. Subtyping from electronic medical records (EHRs) is challenging because of the temporal dynamics in the patients' sequential records. Long-Short Term Memory (LSTM) has been successfully used in many domains for processing sequential data, and recently applied for analyzing EHRs. The LSTM units are designed to handle data with constant elapsed time between consecutive elements of the sequence. Given that time lapse between successive elements in EHR data can vary from days to months, the design of traditional LSTM may lead to suboptimal performance. To solve this issue, we propose a novel LSTM unit called Time Aware LSTM (T-LSTM) to handle irregular time intervals in EHR data. We learn a subspace decomposition of the cell memory which enables time decay to discount the memory content according to the environment. To solve this issue, we present BAT-sense—a prototype deployed to forecast trends in security events based on data from past security logs using machine learning. Forecasted security trend values are then compared against current security events to detect anomalies or deviations from expected patterns. Our application generated alerts to notify appropriate personnel whenever security event values in a given hour crossed a certain threshold beyond forecasted value for that hour. BAT-sense takes into account the multiple seasonality inherent in data pertaining to such environments. Test results from experiments conducted within MSU's security environment indicate that our application generated accurate predictive values for security event thresholds—hence generating low and acceptable false positives. BAT-sense raised alarms within 60 minutes of the first sign of malicious activity when a threshold bound was violated. BAT-sense is flexible to allow threshold bounds to be tweaked according to the environment.

This work was supported in part by Office of Naval Research (ONR) under grant number N00014-14-1-0631
**Poster Number:** CSE-10  
**Authors:** Denton Bobeldyk, Arun Ross  
**Title:** Attribute-based Ocular Biometrics: A New Paradigm for Iris Recognition

**Abstract:** Recent research has demonstrated the possibility of deducing soft biometric attributes, such as race and gender, from near-infrared (NIR) images of the iris and the surrounding ocular region. This work explores the possibility of extracting multiple such soft biometric attributes from the iris and the ocular region in order to develop a semantic description of the associated individual (e.g., middle-aged female Caucasian with blue eyes). The individual attributes, or their concatenated descriptions, can be used to (a) improve the recognition accuracy of traditional iris recognition systems; (b) reduce the search space in large-scale iris identification systems; (c) bridge the semantic gap between human and machine descriptions of biometric data; (d) facilitate cross-spectral iris recognition; etc. Thus, an attribute-based characterization of the ocular region will have applications in biometrics, forensics, and law enforcement. As a case study, we will demonstrate the benefits of combining soft biometrics with ocular recognition in a fusion framework.

*This work was supported in part by NSF Center for Identification Technology and Research*

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**Poster Number:** CSE-11  
**Authors:** Garrick Brazil, Xiaoming Liu, Xi Yin  
**Title:** Monocular Camera-based Pedestrian Detection

**Abstract:** Pedestrian detection is a critical problem in computer vision with an extraordinary impact on safety in urban autonomous driving. In this work, we introduce a cascade of networks using an exhaustive region proposal network followed by a binary classification network. We extend the region proposal network with a 30 class semantic segmentation side task to reduce confusion between non-pedestrian classes and improve overall proposal quality. To address the differences in pedestrian appearance at varying scales, we also adopt multi-scale rectangular filters in our network directly inspired by the span of pedestrian shapes themselves.

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**Poster Number:** CSE-12  
**Authors:** Nitash C G, Thomas LaBar, Arend Hintze, Christoph Adami  
**Title:** Origins of Life in a Digital Microcosm

**Abstract:** While all organisms on Earth descend from a common ancestor, there is no consensus on whether the origin of this ancestral self-replicator was a one-off event or whether it was only the final survivor of multiple origins. Here we use the digital evolution system Avida to study the origin of self-replicating computer programs. By using a computational system, we avoid many of the uncertainties inherent in any biochemical system of self-replicators (while running the risk of ignoring a fundamental aspect of biochemistry). We generated the exhaustive set of minimal-genome self-replicators and analyzed the network structure of this fitness landscape. We further examined the evolvability of these self-replicators and found that the evolvability of a self-replicator is dependent on its genomic architecture. We studied the differential ability of replicators to take over the population when competed against each other (akin to a primordial-soup model of biogenesis) and found that the probability of a self-replicator out-competing the others is not uniform. Instead, progenitor (most-recent common ancestor) genotypes are clustered in a small region of the replicator space. Our results demonstrate how computational systems can be used as test systems for hypotheses concerning the origin of life.

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**Poster Number:** CSE-13  
**Authors:** Xiang Wu, Juan L. Castro-Garcia, Juyang Weng  
**Title:** Actions as Contexts

**Abstract:** In artificial intelligence, many tasks of speech recognition, video analysis, and language processing involve temporal processing where the outputs depend on not only spatial contents of the current sensory input frame, but also the relevant context in the attended past. It is illusive how brains use temporal contexts. Many computer methods, such as Hidden Markov chains and recurrent neural networks, require the human programmer to handcraft contexts as symbolic contexts. Although it has been proved that our Developmental Networks (DN) are capable of learning any emergent Turing Machine (TM), their states have been supervised by human teachers as patterns. This demands much effort from the human trainer. In this paper, we study how agent actions are natural sources of
contexts. In humans, muscle actions correspond to the firings of muscle neurons. They are dense in time, correlated with the cognitive skills of the individual. Some actions are meant to handle time warping, while others are not (e.g., for time duration counting). We model actions as dense action patterns. We experimented with DN for recognition of audio sequences as an example of modality, but the principles are modality independent. Our experimental results showed how taking dense, frame-wise actions as contexts helps DN to generate temporal contexts. This work is a necessary step toward our goal to enable machines to autonomously generate contexts as actions through life-long development.

Poster Number: CSE-14
Authors: Jiao Chenk Yanni Sun
Title: De novo Haplotype Reconstruction in Virus Quasispecies Using Paired-end Reads

Abstract: Motivation: Quasispecies contain a population of closely related but different virus strains infecting individual host. As the selection acts on clouds of mutants rather than single sequences, quasispecies have abilities to escape host immune responses or develop drug resistance. Reconstruction of the viral haplotypes is a fundamental step to characterize the quasispecies, predict their viral phenotypes, and finally provide important information for clinical treatment and prevention. Advances of the next-generation sequencing technologies open up new opportunities to assemble full-length haplotypes. However, error-prone short reads, high similarity between related strains, unknown number of haplotypes all pose computational challenges for reference-free haplotype reconstruction. There is still big room to improve the performance of existing haplotype assembly tools. Results: In this work, we developed a de novo haplotype reconstruction tool for virus quasispecies data named PEHaplo. PEHaplo employs paired-end reads to distinguish highly similar strains. We applied it to both simulated and real quasispecies data. The results were benchmarked against several recently published haplotype reconstruction tools. The comparison shows that PEHaplo outperforms the benchmarked tools in a comprehensive set of metrics. Availability: The source code and the documentation of PEHaplo is available at https://github.com/chjiao/PEHaplo.

Poster Number: CSE-15
Authors: Anurag Chowdhury, Arun Ross
Title: Speaker Recognition in Degraded Audio Signals

Abstract: Identifying human subjects based on their biometric features such as face, fingerprint, iris and voice is an active area of research. The focus of this work is in detecting human speech and identifying its source, i.e., the speaker, from audio signals captured using recording devices such as microphones. As with other types of digital signals such as images and video, an audio signal can undergo degradations during its generation, propagation and recording. Identifying the speaker from such degraded speech data is a challenging task and an open research problem. In this research, we present a deep learning based algorithm for speaker recognition from degraded audio signals. We use the commonly employed Mel-Frequency Cepstral Coefficients (MFCC) for representing the audio signals. We design a convolutional neural network (CNN), which learns one dimensional filters instead of the traditional approach that learns two dimensional filters. The filters in the CNN are designed to learn inter-dependency between cepstral coefficients extracted from audio frames of fixed temporal expanse. From a biological standpoint, this approach, learns the human speech production apparatus from MFCC features and helps identify speakers from degraded audio signals. The performance of the proposed method is compared against existing baseline schemes on synthetically corrupted speech data. Experiments convey the efficacy of the proposed architecture for speaker recognition.

This work was supported in part by FBI-BCOE: Federal Bureau of Investigation's Biometric Center of Excellence

Poster Number: CSE-16
Authors: Tarang Chugh, Kai Cao, Elham Tabassi, Jiayu Zhou, Anil K. Jain
Title: Latent Fingerprint Value Prediction: Crowd-based Learning

Abstract: Latent fingerprints are one of the most crucial sources of evidence in forensic investigations. As such, development of automatic latent fingerprint recognition systems to quickly and accurately identify the suspects is one of the most pressing problems facing fingerprint researchers. One of the first steps in manual latent processing is for a fingerprint examiner to perform a triage by assigning one of the following three values to a query latent: Value for Individualization (VID), Value for Exclusion Only (VEO) or No Value (NV). However, latent value determination by
examiners is known to be subjective, resulting in large intra-examiner and inter-examiner variations. Furthermore, in spite of the guidelines available, the underlying bases that examiners implicitly use for value determination are unknown. In this study, we propose a crowdsourcing based framework for understanding the underlying bases of value assignment by fingerprint examiners, and use it to learn a predictor for quantitative latent value assignment. Experimental results are reported using four latent fingerprint databases, two from forensic casework (NIST SD27 and MSP) and two collected in laboratory settings (WVU and IIITD), and a state-of-the-art latent AFIS. The main conclusions of our study are as follows: (i) crowdsourced latent value is more robust than prevailing value determination (VID, VEO and NV) and LFIQ for predicting AFIS performance, (ii) two bases can explain expert value assignments which can be interpreted in terms of latent features, and (iii) our value predictor can rank a collection of latents from most informative to least informative.

This work was supported in part by National Institute of Standards and Technology

Poster Number: CSE-17
Authors: Melissa Dale, Arun Ross
Title: Multispectral Pedestrian Detection using Restricted Boltzmann Machines

Abstract: The US Department of Transportation Federal Highway Administration reports that approximately 22% of traffic crashes are a result of weather conditions. This is nearly 1,259,000 crashes a year caused by conditions such as rain, snow, fog, and wind. As autonomous vehicles equipped with cameras are deployed alongside mainstream traffic, it is necessary to ensure that they can continue detecting objects of interest such as pedestrians, automobiles, bicycles, etc. in challenging environmental and traffic conditions. To facilitate this, we propose a solution to augment data from the vehicle's digital cameras with thermal sensors. To initiate this study, we use the KAIST Multispectral Pedestrian Detection Benchmark dataset to investigate potential pedestrian detection based on the data from multiple sensors. This dataset consists of annotated videos recorded in both visible and thermal spectra from a moving vehicle. In 2016, the pedestrian detection accuracy on this dataset was greatly improved through the use of convolutional neural network (CNN) by researchers at Robert Bosch GmbH and University of Bonn. Their results highlighted the ability of deep learning methods to outperform hand crafted features used in the benchmark findings. In our research, we continue to explore the use of deep learning techniques to improve multispectral pedestrian detection. In particular, we hypothesize that treating the visible and thermal sensors as separate sources of information can further improve the detection accuracy. To this end, we investigate the use of Restricted Boltzmann Machines for pedestrian detection on the KAIST dataset.

This work was supported in part by Michigan State University (CANVAS Program)

Poster Number: CSE-18
Authors: James Daly, Eric Torng
Title: TupleMerge: Building Minimal Firewall Tables by Omitting Bits

Abstract: Packet classification is an important part of many networking devices, such as routers and firewalls. The rule lists defining these packet classifiers have generally become larger and more complicated over time, yet they must operate faster than ever to meet the demands of ever-increasing network requirements. Modern software-defined networks place an additional constraint; classifiers must now be able to update themselves quickly. This rules out many classifiers, such as HyperCuts, HyperSplit, and their derivatives. We build upon Tuple Space Search, the packet classifier used by Open vSwitch, to create TupleMerge. TupleMerge improves upon Tuple Space Search by combining hash tables which contain rules with similar characteristics. This greatly reduces search times by producing fewer tables. We compared TupleMerge to PartitionSort, the current state-of-the-art online packet classifier on rulelists generated by ClassBench. TupleMerge has faster classification times than PartitionSort on 10 of the 12 seeds. On those seeds, TupleMerge is an average of 45% faster to classify than PartitionSort. It is also always faster to update than PartitionSort, averaging 30% faster over all seeds.

Poster Number: CSE-19
Authors: Debayan Deb, Lacey Best-Rowden, Anil K. Jain
Title: Face Recognition Accuracy with Time Lapse: Performance of State-of-the-art COTS Matchers

Abstract: With the integration of face recognition technology into important identity applications, it is imperative that the effects of facial aging on face recognition performance are thoroughly understood. As face matchers evolve and improve, they should be periodically re-evaluated on large-scale longitudinal face datasets. In our study, we evaluate the performance of two state-of-the-art commercial off the shelf (COTS) face matchers on two large-scale longitudinal
datasets of operational mugshots of repeat criminals. The largest of these two datasets has 147,784 images of
18,007 subjects with 8 images per subject with a time span of 8.5 years. We fit multilevel statistical models to genuine
comparison scores (similarity between images of the same face) obtained by the COTS face matchers. This allows
us to analyze the effects of elapsed time between a query (probe) and its reference (gallery) image, as well as
subject’s gender and race, and face image quality. Based on the results of our statistical model, we can infer that
state-of-the-art COTS matcher can indeed verify 99% of the subjects at a false accept rate (FAR) of 0.01% for up to
9.5 years of elapsed time. Beyond that time lapse, there is a significant loss in face recognition accuracy.

**Poster Number:** CSE-20
**Authors:** Tyler Derr, Zhiwei Wang, Jiliang Tang
**Title:** Opinions Power Opinions: Joint Link and Interaction Polarity Prediction in Signed Networks

**Abstract:** Social media has been widely adopted by online users to share their opinions. Among users in signed
networks, two types of opinions can be expressed. They can directly specify opinions to others via establishing
positive or negative links; and they also can give opinions to content generated by others via a variety of social
interactions such as commenting and rating. Intuitively these two types of opinions should be related. For example,
users are likely to give positive (or negative) opinions to content from those with positive (or negative) links; and users
tend to create positive (or negative) links with those that they frequently positively (or negatively) interact with.
Therefore we can leverage one type of opinions to power the other. Meanwhile, they can enrich each other that can
help mitigate the data sparsity and cold-start problems in the corresponding predictive tasks -- link and interaction
polarity predictions, respectively. In this paper, we investigate the problem of joint link and interaction polarity
predictions in signed networks. We first understand the correlation between these two types of opinions; and then
propose a framework that can predict signed links and the polarities of interactions simultaneously. The experimental
results on a real-world signed network demonstrate the effectiveness of the proposed framework. Further
experiments are conducted to validate the robustness of the proposed framework to data with cold-start users.

**Poster Number:** CSE-21
**Authors:** Yaohui Ding, Arun Ross
**Title:** An Ensemble of One-Class Support Vector Machines for Fingerprint Spoof Detection Across Different
Fabrication Materials

**Abstract:** A fingerprint recognition system is vulnerable to spoof attacks, where a fake fingerprint can be used to
circumvent the system. To counter such attacks, researchers have developed automated spoof detectors that are
used to distinguish fake fingerprints from real fingerprints. Most spoof detectors adopt a machine learning approach,
where a classifier is trained to distinguish between “spoof” and “live” samples. Such an approach requires training
samples from both classes. However, there are two fundamental concerns. Firstly, the number of spoof samples
available during the training stage is typically much less than the number of live samples, resulting in imbalanced
training sets. Secondly, the spoof detector may encounter spoofs fabricated using materials that were not previously
“seen” in the training set, thereby failing to detect them. In order to alleviate some of these concerns, we adopt a One
Class Support Vector Machine (OC-SVM) approach that predominantly uses training samples from only a single
class, i.e., the live class, to generate a hypersphere that encompasses most of the live samples. The goal is to learn
the concept of a “live” fingerprint, and reject all other prints as being fake. The boundary of the generated
hypersphere is refined using a small number of spoof samples. The proposed method uses an innovative ensemble
of such OC-SVMs for spoof detection. Experimental results on the LivDet2011 database show the advantages of the
proposed ensemble of OC-SVMs for detecting spoofs generated from previously “unseen” materials.

*This work was supported in part by NSF Center for Identification Technology and Research*

**Poster Number:** CSE-22
**Authors:** Emily Dolson, Charles Ofria
**Title:** Creating Hotspots of Evolutionary Innovation

**Abstract:** Evolutionary computation is a powerful machine learning tool that has been used to solve a variety of
problems. Inspired by biological evolution, evolutionary algorithms maintain a population of solutions to a given
problem, wherein the best are copied and mutated. This creates an evolutionary pressure for better solutions to the
problem. However, evolving solutions to very complex problems can be challenging. A lot of evidence suggests that
evolution works best when there is pressure to evolve “building blocks”, i.e. solutions to simpler problems that are related to the overall problem. As such, rewarding solutions for solving these building block problems has shown a great deal of promise in making complex problems easier for evolution to solve. Previously, we found that rewarding these building-block problems in geographically limited regions of a spatially structured environment promotes population diversity, ultimately leading to a greater chance of solving the overarching problem. Interestingly, the spatial layout of the rewards seemed to have a strong impact on the results. Here, we investigate this result further and find that many reward layouts contain hotspots of evolutionary potential -- regions where a solution capable of solving a given problem are more likely to evolve. Research on the drivers of this effect is ongoing, but they appear to be complex. If we can understand what factors create these evolutionary hotspots, we will be able to build them on purpose to build better evolutionary algorithms.

This work was supported in part by National Science Foundation Graduate Research Fellowship

Poster Number: CSE-23
Authors: Nan Du, Yanni Sun
Title: Improve Homology Search Sensitivity of PacBio Data by Correcting Frameshifts

Abstract: Single-molecule, real-time sequencing (SMRT) developed by Pacific BioSciences produces longer reads than secondary generation sequencing technologies such as Illumina. The long read length enables PacBio sequencing to close gaps in genome assembly, reveal structural variations, and identify gene isoforms with higher accuracy in transcriptomic sequencing. However, PacBio data has high sequencing error rate and most of the errors are insertion or deletion errors. During alignment-based homology search, insertion or deletion errors in genes will cause frameshifts and may only lead to marginal alignment scores and short alignments. As a result, it is hard to distinguish true alignments from random alignments and the ambiguity will incur errors in structural and functional annotation. Existing frameshift correction tools are designed for data with much lower error rate and are not optimized for PacBio data. As an increasing number of groups are using SMRT, there is an urgent need for dedicated homology search tools for PacBio data. In this work, we introduce Frame-Pro, a profile homology search tool for PacBio reads. Our tool corrects sequencing errors and also outputs the profile alignments of the corrected sequences against characterized protein families. We applied our tool to both simulated and real PacBio data. The results showed that our method enables more sensitive homology search, especially for PacBio data sets of low sequencing coverage. In addition, we can correct more errors when comparing with a popular error correction tool that does not rely on hybrid sequencing.

This work was supported in part by NSF CAREER Grant DBI-0953738

Poster Number: CSE-24
Authors: Joshua Engelsma, Sunpreet Arora, Anil K. Jain, Nicholas Paulter, Jr.
Title: Universal 3D Fingerprint Target

Abstract: We present a design and manufacturing process to fabricate high fidelity 3D fingerprint targets. The main contribution is a single universal 3D fingerprint target which can be imaged on a variety of fingerprint sensing technologies, namely capacitive, optical-contact, and optical-contactless. As such, the universal 3D fingerprint target enables, for the first time, not only a repeatable and controlled evaluation of fingerprint readers, but also the ability to conduct fingerprint reader interoperability studies. Fingerprint reader interoperability refers to the ability of a fingerprint recognition system to adapt to variations in the raw data acquired from different types of fingerprint readers. As fingerprint recognition continues to become more and more pervasive (from smart phones to international border crossings) and new sensing technologies continue to emerge, quantifying reader interoperability has become a necessity. To build the universal 3D fingerprint target, we adopt a molding and casting framework. It consists of (i) digital mapping of fingerprint images to a negative mold, (ii) CAD modeling a scaffolding system to hold the negative mold (iii) fabricating the mold and scaffolding system with a high resolution 3D printer, (iv) producing or mixing a material with the same electrical, optical, and mechanical properties as that of the human finger, and (v) fabricating a 3D fingerprint target using controlled casting. Our interoperability experiments involve PIV & Appendix F certified optical (contact and contactless) and capacitive fingerprint readers from different vendors. The empirical results validate the use of universal 3D fingerprint targets for highly controlled fingerprint reader interoperability evaluation.

This work was supported in part by NIST (National Institute of Standards and Technology)
Poster Number: CSE-25
Authors: Sixue Gong, Vishnu Boddeti, Anil K. Jain
Title: Capacity of Face Recognition

Abstract: Human routinely use faces to recognize individuals. In a sense, faces are referred as the most popular indicator of identities in daily life. Suppose there exists an approach which, for each identity, generates a unique set of facial features (representation) that only encompasses the corresponding individual. In this case, any identity can be decoded from these unique features. However, in machine face recognition, features are generally extracted from “noisy” facial images, which are not adequate to uniquely represent an identity. The large variability in face images (intra-person variability and inter-person similarity) and the uncertainty in feature representation due to noise in face images are the two leading causes of face recognition errors. So, a natural question to ask is: how many identities can a given face representation resolve or, in other words, what is the capacity of a representation? If we model the process from ideal face representation to automatically extracted facial features as a communication system, face signal of each identity is mapped into some sequence of channel symbols, e.g., digital images, which then produces the output sequence of the channel, e.g. deep network features. During this process, digital camera and representation can be seen as channels that transmit face signals. The challenge is to determine the capacity of the information channel. To begin with, we consider face representation process a Gaussian channel with additive noise. The channel noise is also assumed to be Gaussian, independent of input signal. We cast the problem in an information capacity framework of a Gaussian channel and derive the capacity of a given face representation.

Poster Number: CSE-26
Authors: Aaron Gonzales, Arun Ross
Title: Detection and Tracking of Objects in Thermal Infrared Imagery

Abstract: Thermal cameras are becoming increasingly cost-effective, thereby making them more affordable in a number of applications. In this project, we will utilize thermal cameras for automated object analysis in two challenging nighttime environments: (a) livestock surveillance and (b) autonomous driving of vehicles. While extensive research on object detection and tracking has been conducted in the visible spectra, little work has been conducted in the thermal spectra. In this work, we will design a object detection and tracking system for the thermal spectra using a customized template-based correlation filter approach. We have acquired data using a thermal camera and will evaluate the performance of the proposed methods on this data. The proposed methods are expected to be resilient to a number of confounding factors such as occlusion, inclement weather, low-intensity images, etc.

This work was supported in part by Michigan State University (CANVAS Program)

Poster Number: CSE-27
Authors: Hussein A. Hejase, Kevin J. Liu
Title: FastNet: Fast and Accurate Inference of Phylogenetic Networks using Large-scale Genomic Sequence Data

Abstract: Advances in next-generation sequencing technologies and phylogenomics have reshaped our understanding of evolutionary biology. One primary outcome is the emerging discovery that interspecific gene flow has played a major role in the evolution of many different organisms across the Tree of Life. To what extent is the Tree of Life not truly a tree reflecting strict “vertical” divergence, but rather a more general graph structure known as a phylogenetic network which also captures “horizontal” gene flow? The answer to this fundamental question not only depends upon densely sampled and divergent genomic sequence data, but also computational methods which are capable of accurately and efficiently inferring phylogenetic networks from large-scale genomic sequence datasets. Recent methodological advances have attempted to address this gap. However, in a recent performance study, we demonstrated that the state of the art falls well short of the scalability requirements of existing phylogenomic studies. The methodological gap remains: how can phylogenetic networks be accurately and efficiently inferred using genomic sequence data involving many dozens or hundreds of taxa? In this study, we address this gap by proposing a new phylogenetic divide-and-conquer method which we call FastNet. Using synthetic and empirical data spanning a range of evolutionary scenarios, we demonstrate that FastNet outperforms state-of-the-art methods in terms of computational efficiency and topological accuracy.

This work was supported in part by National Science Foundation Grant CCF-1565719; BEACON Center for the Study of Evolution in Action (NSF STC Cooperative Agreement DBI-093954)
Poster Number: CSE-28  
Authors: Steven Hoffman, Arun Ross  
Title: Cross-spectral Periocular Biometrics  

Abstract: This work deals with the problem of matching ocular images of an individual across multiple spectral bands. The ocular region of the face consists of the eye - including the iris - and the surrounding skin region. The images considered in this work pertain specifically to two spectral bands: near infrared (NIR) and visible (VIS). Most iris recognition systems capture the ocular image of an individual in the NIR spectrum. However, in many legacy face databases, the ocular region is typically imaged in the VIS spectrum. In order to facilitate matching across these two modalities, we show a biometric method for ocular and periocular recognition. This problem, often referred to as "heterogeneous biometrics", also has applications in tactical scenarios where the biometric data of an individual (e.g., face or iris) is impacted by the type of sensor used for procuring data (e.g., infrared, shortwave infrared, thermal).

Poster Number: CSE-29  
Authors: Amin Jourabloo, Xiaoming Liu  
Title: Pose-invariant Face Alignment with a Single CNN  

Abstract: Face alignment has witnessed substantial improvements in the last decade. One of these recent focuses has been aligning a dense 3D face shape to face images with large head poses. The dominant technology used is based on the cascade of regressors, e.g., CNN, which has shown promising results. Nonetheless, it suffers from several drawbacks, e.g., lack of end-to-end training, hand-crafted features and slow training speed. To address these issues, we propose a new layer, named visualization layer, that can be integrated into the CNN architecture and enables joint optimization with different loss functions. Extensive evaluation of the proposed method on AFLW and AFW datasets demonstrates state-of-the-art accuracy, while reducing the training time by more than half compared to the typical cascade of CNNs. In addition, we compare multiple CNN architectures with the visualization layer to further demonstrate the advantage of its utilization.

This work was supported in part by Bosch Research and Technology Center North America

Poster Number: CSE-30  
Authors: Douglas Kirkpatrick, Arend Hintze  
Title: A Genetic Algorithm's Struggle with Tic-Tac-Toe  

Abstract: Computer games not only improve their graphic and sound quality, but also provide a great opportunity to apply artificial intelligence (AI). Beyond classic algorithms like A* we find that tools from neuro evolution such as artificial neural networks, NEAT, and Markov Brains can be introduced to play such games. These AI tools either control non-player characters (NPC) or the opponent in case of more traditional games like chess. While it is relatively simple, technically speaking, to control an NPC using an AI, the new challenge is to optimize said AI to either play in novel and interesting ways, or to play better than any human could. Here we investigate how and why a genetic algorithm struggles to optimize a simple Tic-Tac-Toe strategy, and explore options to remedy such issues.

Poster Number: CSE-31  
Authors: Tam Le, Matt W. Mutka  
Title: Access Control with Delegation for Smart Home Applications  

Abstract: With the emergence of smart home applications, it is important to have flexible access control so that users can create/transfer their permissions in a convenience way. We propose a lightweight authorization protocol with support of a delegation chain in which a user can easily transfer (part of) his/her access rights in form of a Bloom filter. In our mechanism, a trusted chain can be maintained and verified by a single request without need of an access control list. The security of our protocol is based on the false positive rate of a Bloom filter. The protocol was implemented and evaluated on an Arduino prototype.
Poster Number: CSE-32
Authors: Xinyu Lei, Alex X. Liu, Rui Li
Title: Secure KNN Queries Over Encrypted Data: Dimensionality is Not Always a Curse

Abstract: The fast increasing location-dependent applications in mobile devices are manufacturing a plethora of geospatial data. Outsourcing geospatial data storage to a powerful cloud is an economical approach. However, safeguarding data users’ location privacy against the untrusted cloud while providing efficient location-aware query processing over encrypted data are in conflict with each other. As a step to reconcile such conflict, we study secure k nearest neighbor (SKNN) queries processing over encrypted geospatial data in cloud computing. We design 2D SKNN (2DSkNN), a scheme achieves both strong provable security and high-efficiency. Our approach employs locality sensitive hashing (LSH) in a dimensional-increased manner. This is a counter-intuitive leverage of LSH since the traditional usage of LSH is to reduce the data dimensionality and solve the so-called “curse of dimensionality” problem. We show that increasing the data dimensionality via LSH is indeed helpful to tackle 2DSkNN problem. By LSH-based neighbor region encoding and two-tier prefix-free encoding, we turn the proximity test to be sequential keywords query with a stop condition, which can be well addressed by any existing symmetric searchable encryption (SSE) scheme. We show that 2DSkNN achieves adaptive indistinguishability under chosen-keyword attack (IND2-CKA) secure in the random oracle model. A prototype implementation and experiments on both real-world and synthetic datasets confirm the high practicality of 2DSkNN.

This work was supported in part by National Science Foundation under Grant Numbers CNS-1318563, CNS-1524698, CNS-1421407, and IIP-1632051; National Natural Science Foundation of China under Grant Numbers 61472184, 61321491, 61370226, and 61672156; Jiangsu Innovation and Entrepreneurship (S

Poster Number: CSE-33
Authors: Kaixiang Lin, Jiayu Zhou
Title: Collaborative Deep Reinforcement Learning

Abstract: The human learning process is highly effective partly because that we are capable of summarizing what has been learned, communicating it with other peers, and ultimately fusing knowledge from different sources to assist the current learning goal. This collaborative learning procedure ensures that the knowledge is shared, continuously refined, and passed from generation to generation. The idea of knowledge transfer has led to many advances in machine learning and data mining, but significant challenges remain, especially when it comes to reinforcement learning, heterogeneous model structures, and different learning tasks. Motivated by human collaborative learning, in this paper we propose a collaborative deep reinforcement learning (CDRL) framework that performs adaptive knowledge transfer among heterogeneous learning agents. Specifically, the proposed CDRL performs knowledge distillation from the agent models to enable the flexibility of model structure, efficiently incorporates the knowledge distillation into the online training of learning agents, and learns a deep alignment network to address the heterogeneity among different learning tasks. We present an efficient collaborative Asynchronous Advantage Actor-Critic (cA3C) algorithm, and demonstrate the effectiveness of the CDRL framework using extensive empirical evaluation on OpenAI gym.

This work was supported in part by Office of Naval Research (ONR) under grant number N00014-14-1-0631; National Science Foundation under Grant IIS-1565596, IIS-1615597

Poster Number: CSE-34
Authors: Chin-Jung Liu, Li Xiao
Title: RMIP: Resource Management with Interference Precancellation in Heterogeneous Cellular Networks

Abstract: Network densification by installing more cellular stations (cells) with smaller coverage is a promising technique to improve wireless capacity to meet the overwhelming demands for mobile data usage. These smaller cells with different coverage and the macrocellular base station form heterogeneous cellular networks (HetNet). However, the dense deployment of HetNet cells might result in unexpected inter-cell interference. In cellular networks, the data to all cells and to the mobile stations (MSSs) are originated from the core cellular network. We take advantage of this characteristic and propose a technique called interference precancellation. If the interferer to an MS is identified, the victim cell that serves the victim MS transmits the interference precanceled signal, which is the signal intended for the victim MS subtracts the interference signal. The interference precanceled signal and the interference signal scramble at the victim MS and become the intended signal. With interference precancellation, the interferer

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and the victim cell can utilize the same wireless resources and thus the capacity is further improved. However, some MSs are interference-free and for MSs whose exact interferers cannot be determined, the MSs still require isolated resources. We propose an algorithm for resource management with interference precancellation (RMIP) that jointly considers MSs experiencing different level of interference. Through experiments on GNURadio/USRP, we show that the known interference signal can be precanceled and the combination of the interference signal and the precanceled signal becomes the intended signal. Through simulation, we evaluate the performance in larger HetNets.

Poster Number: CSE-35
Authors: Xi Liu, Pang-Ning Tan
Title: Human Daily Activity Recognition for Healthcare Using Wearable and Visual Sensing Data

Abstract: Wearable digital self-tracking technologies for monitoring individuals’ health condition have become more accessible to the public in recent years with the development of connected portable devices, such as smart phones, smart watches, smart bands, and other personal biometric monitoring devices. Mining behavioural patterns from such wearable data along with other available sensory data, has the potential to offer an objective, insightful service in clinical professionals and healthcare. For example, accurate identification of human activities could help us provide a better patient recovery training guidance, or an early alarm of emergency that may happen to elder people, such as stroke, falls, etc. In this paper, we introduce an activity recognition system, which learns a nonlinear SVM algorithm to identify 20 different human activities from accelerometer and RGB-D camera data. Our early experimental results show that the proposed approach is promising and effective.

Poster Number: CSE-36
Authors: Yaojie Liu, Xiaoming Liu
Title: Dense Face Alignment

Abstract: Large-pose face alignment is a challenging problem due to the large variation in appearance of different face poses. Previous methods tackle this problem via fitting a 3DMM model to a set of facial landmarks. In this paper, we propose to learn a single CNN to fit a dense and accurate 3D model to a single face image. The dense fitting process is constrained by landmarks, edges and other special information. We leverage the quality and quantity power of the synthesized data along with real data to train the network. Restart Training(RT) strategy is adapted when previous training stage is converged, and different constrains are deployed at different training stages. We also propose a novel evaluation metric to measure our dense face alignment performance. Experiments show our proposed method can run effectively and efficiently at real time and achieve the state-of-the-art performance at many challenging in-the-wild data.

Poster Number: CSE-37
Authors: Vahid Mirjalili, Arun Ross
Title: Biometric Privacy: Modifying Soft Biometric Attributes of Face Images

Abstract: Biometrics refers to the use of physical or behavioral attributes such as face, fingerprints and iris to automatically recognize an individual. While biometric data is solely expected to be used for recognizing an individual, advances in machine learning has made it possible to extract additional information such as age, gender, ethnicity, and health indicators from biometric data. These auxiliary attributes are referred to as soft biometrics. Extracting such attributes from the biometric data of an individual, without his or her knowledge, has raised several privacy concerns. In this work, we focus on extending privacy to face images. In particular, we design a technique to modify a face image such that auxiliary information such as gender, race, and age cannot be easily extracted from it, while the image can still be used for biometric recognition purposes. The proposed method entails iteratively perturbing a given face image such that the performance of the face matcher is not adversely affected, but that of the soft biometric classifiers is confounded. The perturbation is accomplished using a gradient descent technique. Experiments involving a face matcher (commercial SDK) and soft biometric classifiers for gender and race (IntraFace) convey the efficacy of the proposed method.

This work was supported in part by National Science Foundation (NSF)
**Poster Number:** CSE-38  
**Authors:** Chen Tian, Ali Munir, Alex X. Liu, Jie Yang  
**Title:** OpenFunction: An Extensible Data Plane Abstraction Protocol for Platform-independent Software-defined Middleboxes  

**Abstract:** The state-of-the-art OpenFlow technology only partially realized software-defined networking (SDN) vision of abstraction and centralization for packet forwarding in switches. OpenFlow falls short in implementing middlebox functionalities due to the fundamental limitation in its match-action abstraction. In this paper, we advocate the vision of Software-Defined Middleboxes (SDM) to realize abstraction and centralization for middleboxes. We further propose OpenFunction, an SDM reference architecture and a network function abstraction layer. Our SDM architecture and OpenFunction abstraction are complementary to existing SDN and Network Function Virtualization (NFV) technologies. SDM complements SDN as SDM realizes abstraction and centralization for middleboxes, whereas SDN realizes those for switches. OpenFunction complements OpenFlow as OpenFunction addresses network functions whereas OpenFlow addresses packet forwarding. SDM also complements NFV in that SDM gives NFV the ability to use heterogeneous hardware platforms with various hardware acceleration technologies.

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**Poster Number:** CSE-39  
**Authors:** Kurt A. O'Hearn, H. Metin Aktulga  
**Title:** Efficient, Scalable Techniques for Charge Distribution in Polarizable and Reactive Molecular Dynamics Models  

**Abstract:** Incorporating atom polarizability in molecular dynamics (MD) simulations is important for high-fidelity simulations. Solvers for charge models that are used to dynamically determine atom polarizations constitute significant bottlenecks in terms of time-to-solution and the overall scalability of polarizable and reactive force fields. The objective of this work is to enhance the efficiency and scalability of the commonly used iterative Krylov subspace solvers on massively parallel shared memory architectures. 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 (QEq), electronegativity equilibration (EE), and atom-condensed Kohn-Sham density functional theory approximated to second order (ACKS2). Furthermore, extensive performance results on the computation and application of preconditioning factors and the overarching solver on multi-core and GPU systems are also discussed.

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**Poster Number:** CSE-40  
**Authors:** Chen Qiu, Matt Mutka  
**Title:** iLoom: Self-improving Indoor Localization by Profiling Outdoor Movement on Smartphones  

**Abstract:** Indoor localization systems provide the accurate location information when people stay and walk in buildings. Based upon the obtain location information, indoor localization system supports various applications, such as indoor navigation, activity detection, augmented and virtual reality. Unfortunately, GPS cannot be applied indoors because of various interferences. Smartphones are equipped with many low-cost sensors. As a result, opportunities open for smartphones to serve as a platform for many challenging ubiquitous applications, including indoor localization. By employing accelerometers on smartphones, dead reckoning is an intuitive and common approach to generate a user’s indoor motion trace. Nevertheless, dead reckoning often deviates from the ground truth due to noise in the sensing data. We propose iLoom, an indoor localization approach that benefits by transferring learning from tracking outdoor motions to the indoor environment. Via sensing data on a smartphone, iLoom constructs two datasets: relatively accurate outdoor motions from GPS and less accurate indoor motions from accelerometers. Then, iLoom leverages an Acceleration Range Box to improve a user’s acceleration value used for computing dead reckoning. After using a transfer learning algorithm to the two datasets, iLoom boosts the Acceleration Range Box to achieve better indoor localization results. In addition, iLoom exploits indoor GPS exception cases and pedometer to further improve dead reckoning. Through case studies on 15 volunteers for the indoor and outdoor scenarios, we show iLoom is a non-infrastructure and low-training complexity indoor positioning approach that achieved a localization accuracy of 0.28-0.51 meter in multiple scenarios.

*This work was supported in part by National Science Foundation grant no. CNS–1320561*
Abstract: Clustering face images according to their identity has two important applications: (i) grouping a collection of face images when no eternal labels are associated with images, and (ii) indexing for efficient large scale face retrieval. The clustering problem is composed of two key parts: face representation and choice of similarity for grouping faces. In this research, we first propose a new representation based on the ResNet which has been shown to perform very well in image classification problems. Given this representation, we propose a new clustering algorithm which computes the similarity measure between images by directly optimizing the adjacency matrix. We formulate the problem as a Conditional Random Field (CRF) model and use Loopy Belief Propagation to find an approximate solution. Experiment results on two benchmark face databases (LFW and IJB-A) show that our algorithm outperforms well known clustering algorithms such as k-means and spectral clustering. Additionally, our algorithm can naturally incorporate pairwise constraints to obtain a semi-supervised version that leads to improved clustering performance.

Abstract: Makeup can be used to alter the facial appearance of a person. Previous studies have established the potential of using makeup to obfuscate the identity of an individual with respect to an automated face matcher. In this work, we analyze the potential of using makeup for spoofing an identity, where an individual attempts to impersonate another person’s facial appearance. In this regard, we first assemble a set of face images downloaded from the internet where individuals use facial cosmetics to impersonate celebrities. We next determine the impact of this alteration on two different face matchers. Experiments suggest that automated face matchers are vulnerable to makeup-induced spoofing and that the success of spoofing is impacted by the appearance of the impersonator’s face and the target face being spoofed. Further, an identification experiment is conducted to show that the spoofed faces are successfully matched at better ranks after the application of makeup.

Abstract: The large pose discrepancy between two face images is one of the key challenges in face recognition. The conventional approach to pose-robust face recognition either performs face frontalization on, or learns a pose-invariant representation from, a non-frontal face image. We argue that, it is more desirable to perform both tasks jointly to allow them to leverage each other. To this end, this paper proposes Disentangled Representation Learning-Generative Adversarial Network (DR-GAN) with three distinct novelties. First, the encoder-decoder structure of the generator allows DR-GAN to learn the identity representation for each face image, in addition to image synthesis. Second, this representation is explicitly disentangled from other face variations such as pose, through the pose code provided to the decoder and pose estimation in the discriminator. Third, DR-GAN can take one or multiple images as the input, and generate one integrated representation along with an arbitrary number of synthetic images. Quantitative and qualitative evaluation on both constrained and unconstrained databases demonstrate the superiority of DR-GAN over the state of the art.

This work was supported in part by National Geospatial-Intelligence Agency (NGA)

Abstract: Compromised accounts are a common problem faced by social media users. A 2014 Pew Research study found 21% of online adults experienced having their email or social media account compromised. The focus of this research is to understand and detect compromised accounts using data mining approaches. To increase our understanding of compromised accounts, we answer the following research questions. First who is compromising...
social media accounts; e.g. spammers or acquaintances of the user? Second, what type of content does the hacker post? Third, what features best distinguish compromised accounts from non-compromised accounts? This poster presents an unsupervised learning framework to detect compromised accounts. The first stage of proposed framework utilizes multimodal non-negative matrix factorization of tweet terms, sentiment, location, and source to learn users' behavior patterns. The second stage applies Hotelling’s statistic to identify anomalous behavior. Due to the high false positive rate of anomaly detection, the third stage examines the anomalous tweets to verify the account was compromised.

Poster Number: CSE-45  
Authors: Ding Wang, Pang-Ning Tan 
Title: A Framework for Mining Spatio-temporal Data from Multiple Sensors 

Abstract: Advances in sensing technology have enabled organizations to collect real-time spatio-temporal data from multiple sensors for various applications. In this project, we propose to develop techniques for detecting and locating surrounding vehicles from multiple scans generated by LIDAR sensors (Ibeo and Velodyne) installed on a moving vehicle. Specifically, we consider the spatio-temporal data from each sensor as providing a separate view for the detection task and develop techniques for fusing data from multiple sensors to improve the overall detection accuracy. We present preliminary evidence demonstrating the limitations of using data from a single source in the vehicle detection problem. We then propose a multi-view learning framework to effectively combine the data from different sensors.

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Poster Number: CSE-46  
Authors: Qi Wang, Mengying Sun, Liang Zhan, Paul Thompson, Shuiwang Ji, Jiayu Zhou 
Title: Multi-modality Disease Modeling via Collective Deep Matrix Factorization 

Abstract: Alzheimer’s disease (AD), one of the most common causes of dementia, is a severe irreversible neurodegenerative disease that results in loss of mental functions. The transitional stage between the expected cognitive decline of normal aging and AD, mild cognitive impairment (MCI), has been widely regarded as a suitable time for possible therapeutic intervention. The challenging task of MCI detection is therefore of great clinical importance, where the key is to effectively fuse predictive information from multiple heterogeneous data sources collected from the patients. In this paper, we propose a framework to fuse multiple data modalities for predictive modeling using deep matrix factorization, which explores the non-linear interactions among the modalities and exploits such interactions to transfer knowledge and enable high performance prediction. Specifically, the proposed collective deep matrix factorization decomposes all modalities simultaneously to capture (non-linear) structures of the modalities in a supervised manner; and learns a modality specific component for each modality and a modality invariant component across all modalities. The modality invariant component serves as a compact feature representation of patients that has high predictive power. The modality specific components provide an effective means to explore imaging genetics, yielding insights into how imaging and genotype interact with each other non-linearly in the AD pathology. Extensive empirical studies using various data modalities provided by Alzheimer’s Disease Neuroimaging Initiative (ADNI) demonstrate the effectiveness of the proposed method for fusing heterogeneous modalities.

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Poster Number: CSE-47  
Authors: Wei Wang, Kevin J. Liu 
Title: SERES: Sequentially Resampled Support Measures for Multiple Sequence Alignment 

Abstract: A multiple sequence alignment (MSA) aligns biological sequences into a data matrix that captures sequence homology and other relationships. MSAs are used as input to a wide range of computational problems in computational biology and bioinformatics, including phylogenetics, protein structure prediction, and automated genome annotation. MSAs are typically inferred using computational methods. It is well understood that downstream analyses are highly dependent on the accuracy of upstream MSA inference. There is therefore a great need to
evaluate the quality of inferred MSAs. However, the non-parametric techniques that are widely used to evaluate support throughout the natural sciences (e.g., bootstrapping and jackknifing) typically ignore the sequential nature of biomolecular sequence data, which is an essential aspect of the computational problem of MSA inference. To address the need for sequence-aware non-parametric support estimation in this context, we introduce SERES, a novel computational method to estimate statistical support for MSA inference based upon a sequentially resampling process. We demonstrate the performance of SERES using a validation study that incorporates both synthetic and empirical data.

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Poster Number: CSE-48
Authors: Liyang Xie, Inci M. Baytas, Kaixiang Lin, Jiayu Zhou
Title: Privacy-preserving Distributed Multi-task Learning with Asynchronous Updates

Abstract: Many data mining applications involve a set of related learning tasks. Multi-task learning (MTL) is a learning paradigm that improves generalization performance by transferring knowledge among related tasks. The research of MTL has attracted extensive efforts in the community, and various MTL algorithms have been successfully developed. Recent advances in distributed MTL have enabled MTL to learn from data that is distributed in different physical locations. However, significant challenges remain as the privacy in the data could be at stake in such distributed framework, when MTL is applied to build models from sensitive data. In this paper, we propose a novel privacy-preserving distributed multi-task Learning framework to address these challenges. Specifically, we present a privacy-preserving proximal gradient algorithm to solve a general class of MTL formulations, which update models of learning tasks asynchronously that is robust against network delays, and provides differential privacy guarantees through carefully designed perturbation. We have conduct extensive experiments to demonstrate the effectiveness and correctness of the proposed algorithm and its theoretical properties.

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Poster Number: CSE-49
Authors: Xi Yin, Xiaoming Liu
Title: Multi-task Learning for Face Recognition

Abstract: This paper explores multi-task learning (MTL) for face recognition. We answer the questions of how and why MTL can improve the face recognition performance. First, we propose a multi-task Convolutional Neural Network (CNN) for face recognition where identity recognition is the main task and pose, illumination, and expression estimations are the side tasks. Second, we develop a dynamic-weighting scheme to automatically assign the loss weight to each side task. Third, we propose a pose-directed multi-task CNN by grouping different poses to learn pose-specific identity features, simultaneously across all poses. We observe that the side tasks serve as regularizations to disentangle the variations from the learnt identity features. Extensive experiments on the entire Multi-PIE dataset demonstrate the effectiveness of the proposed approach. To the best of our knowledge, this is the first work using all data in Multi-PIE for face recognition. Our approach is also applicable to in-the-wild datasets and achieves comparable or better performance than state of the art on LFW, CFP, and IJB-A.

Poster Number: CSE-50
Authors: Shuai Yuan, Pang-Ning Tan, Kendra S. Cheruvelil, C. Emi Fergus, Nicholas K. Skaff, Patricia A. Soranno
Title: Learning Hash-based Features for Incomplete Continuous-valued Data

Abstract: Hash-based feature learning is a widely-used data mining approach for dimensionality reduction and for building linear models that are comparable in performance to their nonlinear counterparts. Unfortunately, such an approach is inapplicable to many real-world data sets because they are often riddled with missing values. Substantial data preprocessing is therefore needed to impute the missing values before the hash-based features can be derived. Biases can be introduced during this preprocessing because it is performed independently of the subsequent modeling task, which can result in the models constructed from the imputed hash-based features being suboptimal. To overcome this limitation, we present a novel framework called H-FLIP that simultaneously estimates the missing
values while constructing a set of nonlinear hash-based features from the incomplete data. The effectiveness of the framework is demonstrated through extensive experiments conducted using both synthetic and real-world data sets.

This work was supported in part by National Science Foundation under grant #EF-1065786 and #IIS-1615612

Poster Number: CSE-51
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 amount 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 stations 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.

Poster Number: CSE-52
Authors: Zejia Zheng, Juyang Weng
Title: Mobile Device Based Outdoor Navigation Using Video

Abstract: Vision is challenging with its dynamic environments and huge appearance variances. Traditional autonomous navigation systems use laser range scanners to perform collision avoidance and 3D local driving scene reconstruction. Existing image-based navigation methods, on the other hand, do not consider spatiotemporal visual contexts because these methods usually miss attention mechanisms, especially top-down attention. We developed a brain-inspired framework DN (Developmental Network) as an emergent Turing Machine. The emergent Turing Machine has clearly understandable context and invariances that existing neural network models lack. This work applied DN to a well-known challenging AI task: outdoor autonomous navigation for a pedestrian using a computational resource limited mobile device. Although GPS is available, the vision supplied behavior that integrates GPS signal is a long-standing, unsolved AI problem that faces the conflicts between high-level goals and low-level sensory signals. The network successfully navigated in regular long-duration testing in novel settings and blindfolded testing under sunny and cloudy weather conditions.

Poster Number: CSE-53
Authors: Zhiwei Wang, Tyler Derr, Jiliang Tang
Title: Understanding and Predicting Weight Loss with Mobile Social Networking Data

Abstract: It has become increasingly popular to use mobile social networking applications for weight loss and management. Users not only can create profiles and maintain their records but also can perform a variety of social activities that shatter the barrier to share or seek information. Due to the open and connected nature, these applications produce massive data that consists of rich weight-related information which offers immense opportunities for us to enable advanced research on weight loss. In this paper, we conduct the initial investigation to understand weight loss with a large-scale mobile social net- working dataset with near 10 million users. In particular, we study individual and social factors related to weight loss and reveal a number of interesting findings that help us build a meaningful model to predict weight loss automatically. The experimental results demonstrate the effectiveness of the proposed model and the significance of these factors in weight loss.
Poster Number: CSE-54
Authors: Yaohui Ding, Arun Ross
Title: An Ensemble of One-class SVMs for Fingerprint Spoof Detection Across Different Fabrication Materials

Abstract: A fingerprint recognition system is vulnerable to spoof attacks, where a fake fingerprint can be used to circumvent the system. To counter such attacks, researchers have developed automated spoof detectors that are used to distinguish fake fingerprints from real fingerprints. Most spoof detectors adopt a machine learning approach, where a classifier is trained to distinguish between "spoof" and "live" samples. Such an approach requires training samples from both classes. However, there are two fundamental concerns. Firstly, the number of spoof samples available during the training stage is typically much less than the number of live samples, resulting in imbalanced training sets. Secondly, the spoof detector may encounter spoofs fabricated using materials that were not previously "seen" in the training set, thereby failing to detect them.

In order to alleviate some of these concerns, we adopt a One Class Support Vector Machine (OC-SVM) approach that predominantly uses training samples from only a single class, i.e., the live class, to generate a hypersphere that encompasses most of the live samples. The goal is to learn the concept of a "live" fingerprint, and reject all other prints as being fake. The boundary of the generated hypersphere is refined using a small number of spoof samples. The proposed method uses an innovative ensemble of such OC-SVMs for spoof detection. Experimental results on the LivDet2011 database show the advantages of the proposed ensemble of OC-SVMs for detecting spoofs generated from previously "unseen" materials.

This work was supported in part by NSF Center for Identification Technology and Research.
**Electrical Engineering**

**Poster Number:** ECE-01  
**Authors:** Yasir Al-Nadawi, Xiaobo Tan, Hassan Khalil  
**Title:** A Robust Adaptive Conditional Servocompensator Design for Nanopositioner Stage Control

**Abstract:** In this work, we address the design of robust adaptive control for a piezoelectric nanopositioner to track periodic desired trajectories. The nanopositioner is modeled with a linear system proceeded by a hysteresis operator, which in turn is represented by a Modified Prandtl-Ishlinskii (MPI) operator. It is assumed that the system is subjected to periodic exogenous signals, generated by a neutrally stable exosystem. For compensating these periodic disturbances, we propose to use an adaptive conditional servocompensator, which accommodates a sufficient number of harmonics, in conjunction with an approximate MPI inverse operator. The adaptation law, which is equipped with a smooth parameter projection for robustness assurance against matched disturbances, is initiated only, when the trajectory driven by a continuous sliding mode control (SMC), enters a boundary layer around its sliding manifold. To reduce the conservativeness of the continuous SMC law, we analytically derive the hysteresis inversion error, which is found to satisfy certain growth condition on the desired control action. Considering the derived inversion upper bound, the SMC control law is designed to ensure that the trajectory converges to the boundary layer without the need to tune all the controller parameters. Our analysis shows that if the hysteresis inversion error is small enough, and under certain conditions, the closed-loop system admits an asymptotically stable, periodic solution. Experiments conducted on a commercially nanopositioner confirm our theoretical analysis, and demonstrate the efficacy of the proposed controller compared to the case of a nonadaptive continuous SMC.

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**Poster Number:** ECE-02  
**Authors:** Mehmet Akif Alper, Luan Tran, Daniel Morris  
**Title:** Automatic Contactless Limb Tremor Measurement System

**Abstract:** Tremor measurement is an important component of quantifying the severity of diseases that cause them, such as Parkinson’s disease, and provides a feedback measure for medications enabling dosage adjustments to appropriately treat the disease. Here we propose a system for automatic tremor detection suitable for home or clinic settings that does not require wearable sensors. Rather our system uses the Kinect 2 for contactless measurements. While the in-built person pose estimation can provide rough limb motions, we show that its accuracy can be too poor to quantify small tremors. Thus we add an additional level of limb tracking that resolves limb pose to a higher precision. Using this we are able to obtain automatic tremor detection and measurement.

**Poster Number:** ECE-03  
**Authors:** Mohammed Al-Rubaiai, Xiaobo Tan  
**Title:** An LED-based Optical Communication System with Active Alignment Control

**Abstract:** While acoustic modems have long been the dominant wireless communication method for underwater applications, they incur high cost and large power, and can only deliver low data rates. Recently, light-emitting diode (LED)-based optical communication has emerged as a promising approach to low-power, high-rate data transfer underwater over short-to-medium distances. However, LED-based communication relies on a close-to-line-of-sight link between the transmitter and the receiver, which presents significant challenges in its underwater robotic applications, where the underlying robots undergo constant motions due to propulsion and/or disturbances. We propose a novel and compact LED-based communication system with active alignment control, which maintains the communication link despite the underlying platform movement. Details on the system design and implementation are provided. The prototype is able to communicate at 115,200 bps over at least 23 m in swimming pool tests. Experiments involving a stationary transmitter and a mobile receiver mounted on a terrestrial robot are conducted to demonstrate the performance of the alignment maintenance system.

*This work was supported in part by National Science Foundation (IIS 1319602)*
**Poster Number:** ECE-04  
**Authors:** Portia Banerjee, Oleksii Karpenko, Mahmood Haq, Lalita Udpa, Yiming Deng  
**Title:** Impact-Damage Growth Estimation in Composites using Particle Filter Based Prognostics

**Abstract:** With increasing use of fibre reinforced polymer (FRP) composites in several industries such as aviation, automotive and construction, structural health monitoring (SHM) and prognosis of composites have become an extremely critical task in recent years. Despite outstanding qualities such as light-weight, high specific stiffness and strength, components made of composite materials are often vulnerable to damages caused due to fatigue or external impacts which compromises their performance and hence propels the need for robust health monitoring techniques. Overall accurate health prognostic is critical for condition-based-maintenance (CBM) and for reducing life-cycle costs by taking full advantage of the remaining useful life (RUL) of the equipment. In this paper, delamination growth due to repeated low-velocity impact introduced by drop-weight tests on GFRP composite samples was monitored. An integrated prognostics framework for estimation of damage propagation was proposed which utilizes both physical model based on Paris law and CBM data obtained from optical transmission scans of GFRP specimens. A Bayesian method based on particle filtering was implemented to estimate model parameters using damage-sensitive features extracted from measurements. Moreover, delaminations in GFRP samples have distinguishing characteristics unlike crack growth in metals. As a result, applying piecewise Paris-Paris model to our data reduced error in estimation of damage growth path. Additionally, material and model uncertainties were taken into account during update of model parameters and RUL of the GFRP samples. Results demonstrate feasibility and potential of the proposed approach as a robust SHM technique of GFRP composites.

**Poster Number:** ECE-05  
**Authors:** Atri Bera, Nga Nguyen, Saleh Almasabi, Joydeep Mitra  
**Title:** Optimal Power Flow based on Frequency Security Constraint

**Abstract:** The objective of this research is to reduce production cost while satisfying requirement of system frequency stability in addition to other operating constraints. The system frequency is required to be maintained within a safe limit, thus indicating the balance between generation and consumption. Hence, the solution for optimization of power flow should not only give a minimum cost of generation within the operating conditions, but also ensure frequency stability. In order to obtain this solution, the requirement of frequency stability is introduced as a new constraint of the power dispatch problem and is represented by the maximum frequency deviation limit. This new constraint is constructed as a non-linear function of system inertia and the frequency regulation constant, since frequency deviation is highly sensitive to these factors. A genetic algorithm is utilized in implementing the power flow optimization problem. The IEEE 30-bus test system is used to demonstrate the proposed idea.

**Poster Number:** ECE-06  
**Authors:** Connor Boss, Joonho Lee, Jongeun Choi  
**Title:** Model Uncertainty and Disturbance Estimation for Quadrotor Control

**Abstract:** This poster proposes a discrete-time, multi-time-scale estimation and control design for quadrotors in the presence of external disturbances and model uncertainties. The control scheme controls all six degrees of freedom, resulting in a strategy that can track trajectories in three-dimensional space, with desired pose. Sample-data Extended High-Gain Observers are used to estimate model uncertainties and external disturbances. Discretized dynamic inversion utilizes those estimates and deals with an uncertain principal inertia matrix. In the plant dynamics, the proposed control forces the rotational dynamics to be faster than the translational dynamics. The proposed estimation and control strategy is verified through numerical simulations and experimental flight. During experimental flight tests, all sensing and computation is performed on board the vehicle.

*This work was supported in part by National Science Foundation, CAREER award CMMI-0846547*

**Poster Number:** ECE-07  
**Authors:** Jennifer Byford, Premjeet Chahal  
**Title:** 3D Printing Ultra-wideband Hybrid Substrate Integrated Ribbon Waveguides

**Abstract:** A new wave guiding structure and fabrication technique is introduced for high speed, low loss, ultra-wideband interconnects. It is a hybrid between a dielectric ribbon and a substrate integrated waveguide design. In
this structure, a high dielectric constant valued core is surrounded by a low dielectric constant valued cladding which in turn is surrounded by a metal layer. Both cylindrical and rectangular waveguide designs are presented. Simulation and measurement results show that ultra-wide band interconnects with low-dispersion can be designed using this hybrid approach. Fabrication of the cladding layer was carried out using 3D plastic printing. Simulated and measured results are discussed as well as fabrication techniques.

**Poster Number:** ECE-08  
**Authors:** Le Cai, Suoming Zhang, Jinshui Miao, Zhibin Yu, Chuan Wang  
**Title:** Fully Printed Stretchable Thin-film Transistors and Integrated Logic Circuits  
**Abstract:** We present intrinsically stretchable thin-film transistors (TFTs) and integrated logic circuits that are directly printed on elastomeric polydimethylsiloxane (PDMS) substrates. The printed devices utilize carbon nanotubes and a type of hybrid gate dielectric comprising PDMS and barium titanate (BaTiO3) nanoparticles. The BaTiO3/PDMS composite simultaneously provides high dielectric constant, superior stretchability, low leakage, as well as good printability and compatibility with the elastomeric substrate. Both TFTs and logic circuits can be stretched beyond 50% strain along either channel length or channel width directions for thousands of cycles while showing no significant degradation in electrical performance. This work may offer an entry into more sophisticated stretchable electronic systems with monolithically integrated sensors, actuators, and displays, fabricated by scalable and low-cost methods for real life applications.

*This work was supported in part by National Science Foundation under Grant No. ECCS-1549888*

**Poster Number:** ECE-09  
**Authors:** Maria L. Castano, Anastasia Mavrommati, Todd Murphey, Xiaobo Tan  
**Title:** Trajectory Planning and Tracking of Robotic Fish Using Ergodic Exploration  
**Abstract:** In recent years, underwater robots that propel and maneuver themselves like real fish, often called robotic fish, have emerged as promising mobile sensing platforms for freshwater and marine environments. For these active monitoring applications, efficient exploration along with economical locomotion is highly important, in order to optimize sensing coverage and guarantee long field operation time. As a result, optimization of the sensing trajectory and energy saving tracking of the planned trajectory are of interest. In this paper we adopt an ergodic exploration method to calculate an optimal sensing trajectory for a tail-actuated robotic fish, and propose a nonlinear model predictive control (NMPC) approach for tracking the generated trajectory. A high-fidelity, averaged nonlinear dynamic model is used for trajectory planning and control. In particular, the bias and amplitude of the tail-beat pattern are treated as the control inputs, and their physical bounds and the constraints on their changing rates are properly accounted for in the optimization process. Finally, simulation results are presented to illustrate the effectiveness of the proposed approach.

*This work was supported in part by National Science Foundation (DGE 1424871, IIS 1319602, CCF 1331852, ECCS 1446793)*

**Poster Number:** ECE-10  
**Authors:** Dhrubajit Chowdhury, H. K. Khalil  
**Title:** Fast Consensus in Multi-agent Systems Using High Gain Observers  
**Abstract:** We address the consensus problem of multi-agent systems for a static undirected communication topology. It is known that for a static undirected graph, the convergence rate of the consensus protocol depends on the second smallest eigenvalue of the graph Laplacian also known as the algebraic connectivity of the graph. The fastest convergence rate can be achieved when the given communication topology is complete which is referred to as a complete graph i.e., every agent is connected to every other agent which is costly in terms of the required number of communication links. On the other hand the star topology is quite ubiquitous in nature but the convergence rate of the consensus protocol with this topology is slower than the complete graph. In this paper we show that by adding observers to each of the nodes except the root node of a given star topology, the convergence rate of the consensus protocol with the star topology approaches the convergence rate of the consensus protocol achieved with a complete graph for sufficiently small $\varepsilon$, which is a high-gain observer parameter. The observers estimate the missing connections and hence the star topology with the observers acts as if the network topology was complete.
Furthermore we show that for sufficiently small $\epsilon$, the trajectories of the agents with the star topology approach the trajectories of the agents with the virtual complete graph.

**Poster Number:** ECE-11  
**Authors:** Michael Craton, Jennifer Byford, Vincens Gjokaj, Premjeet Chahal, John Papapolymerou  
**Title:** 3D Printed High Frequency Coaxial Transmission Line Based Circuits

**Abstract:** Coaxial transmission lines are among the most elementary high frequency transmission constructions. Their use is ubiquitous in RF and high frequency design and instrumentation, favored for their superior signal isolation. Furthermore, many microwave circuit components are easily implemented using coaxial structures. Filters can be designed with higher Q-factors using coaxial transmission lines as opposed to planar structures (e.g. microstrip). Since the advent of 3D printing, many microwave circuits have been demonstrated, but a coaxial transmission line has not yet been exhibited for high frequency transmission. Current implementations of coaxial transmission lines typically require a dielectric to support the signal conductor. This limits the performance of the waveguide—higher order propagating modes can appear in smaller diameter structures than equivalent air-dielectric geometries. Other implementations use more expensive subtractive manufacturing techniques. For many high frequency designs, it is impractical to use coaxial transmission lines, thus limiting the designer’s flexibility. Semi-rigid coax requires additional tooling and other available coaxial transmission lines can very quickly become prohibitively expensive. 3D printing allows for flexible designs and quick design cycles while also providing an inexpensive design solution. This poster demonstrates a 3D printed coaxial transmission line structure using polyjet printing technology and its implementation in the design of filters for operation up to 10GHz. The unique benefits that 3D printing technology provides make it well suited to address some of the current limitations of coaxial transmission line construction. These techniques provide a template for a coaxial transmission line implementation where it would otherwise not be possible.

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

**Poster Number:** ECE-12  
**Authors:** Zane Crawford, Jie Li, Andrew Christlieb, Shanker Balasubramaniam  
**Title:** Advancements in the Mixed Finite Element Method for Electromagnetics

**Abstract:** The mixed finite element method (MFEM) for electromagnetics use curl-conforming basis functions to represent fields and divergence conforming basis functions to represent fluxes. Previous work on MFEM includes work on solving the coupled Maxwell equations, namely Faraday's and Ampere's law, for the electric field and magnetic flux density. However, the choice of a leapfrog scheme to represent the time derivatives in the coupled Maxwell equations causes CFL-like restrictions on the maximum time step size. Furthermore, a non-uniform spatial grid will cause the time step size to be smaller than needed to resolve the highest frequency content supported by the spatial grid. This can cause a bottleneck for examining wave phenomena, especially in the presence of charged particles, as more time steps must be taken than necessary to see behavior. Recent work has developed alternate time-stepping algorithms for MFEM for the coupled Maxwell equations that have different stability and accuracy properties. More importantly, in this work, we present a MFEM formulation with an unconditionally stable time-stepping algorithm for the coupled Maxwell equations. Additionally, we compare the stability and accuracy properties between leapfrog, Newmark-Beta, and predictor-corrector methods and preliminary work to extend the method to higher order spatial discretizations.

*This work was supported in part by DOE CSGF, grant number DE-FG02-97ER25308*

**Poster Number:** ECE-13  
**Authors:** Thassyo Pinto, Le Cai, Chuan Wang, Xiaobo Tan  
**Title:** CNT-based Sensor Arrays for Local Strain Measurements in Soft Pneumatic Actuators

**Abstract:** Soft robotics is a recent trend in engineering that seeks to create machines that are soft, compliant, and capable of withstanding damage, wear and high stress. Soft pneumatic actuators (SPAs) are the key elements of soft robots, and their elastomeric substrate enables generation of sophisticated motion with simple controls. Although several methods for fabrication, material selection, and structure design have been investigated for the construction of SPAs, limited attention has been paid to the integration of distributed sensors for performing localized...
measurement. Carbon nanotubes (CNTs) are molecular-scale tubes of carbon atoms with remarkable mechanical and electronic properties, showing potential application in sensing devices. In this paper, we present the design, fabrication, and testing of a novel type of CNT-based sensor array combined with silver nanowires (AgNWs) for measuring localized strain along the bottom layer of a SPA. Simulation and experimentation have been performed in order to analyze the soft actuator deformation during bending. The results demonstrate the promise of the proposed SPA with integrated strain sensing, which lays groundwork for a myriad of applications in grasping, manipulation, and bio-inspired locomotion.

This work was supported in part by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) under the Science Without Borders program (BEX-13404-13-0); National Science Foundation (DBI-0939454 and ECCS-1549888)

Poster Number: ECE-14
Authors: Osama Ennasr, Xiaobo Tan
Title: Distribute Tracking of a Moving Target with Time-difference-of-arrival Measurements

Abstract: Localization and tracking of a moving target has been established as a key problem in wireless sensor networks, with many algorithms being proposed in this area. In particular, time-difference-of-arrival (TDOA) localization is considered to be a cost-effective and accurate localization technique. However, traditional TDOA algorithms rely on a central node that produces an estimate of the target's location by gathering measurements from all other nodes in the network. In this work, we look at the problem of distributed localization and tracking of a moving target using TDOA measurements. Specifically, we examine the communication topologies among a network of agents that ensure successful localization of the target's position. In a centralized scheme, estimation is only possible if the central node has 3 or more TDOA measurements. However, in our distributed approach, we employ a networked extended Kalman filter (NEKF) and show that it is possible for the entire network to estimate the target's position without any agent having 3 neighbors, and therefore 3 TDOA measurements. For tracking the target's movement, control strategies for all agents in the network are devised to enhance the distributed filter's performance. Finally, we show that employing such a distributed architecture is more robust to communication dropouts with lower communication costs when compared to the centralized approach.

This work was supported in part by NSF

Poster Number: ECE-15
Authors: Vincens Gjokaj, John Doroshewitz, Premjeet Chahal
Title: Design and Fabrication of Multi-frequency Antenna Using Genetic Algorithms for 5G Applications

Abstract: Under on design approach, fifth generation wireless network will converge together most of the available wireless network. To be able to converge all of these bands in a single platform would require multiple antennas placed in close proximity to each other in a highly dense electronic environment. This is not practical and thus design of single antennas that can work at all these frequencies is necessary. Here we propose a patch antenna design that will incorporate most of these bands in a single antenna. To design such an antenna is complex and to overcome the design challenge, in this paper genetic algorithm is utilized to design antenna for design frequency bands and also to achieve high gain, especially at higher frequencies. For the first design, one antenna that can operate in Wi-Fi, Bluetooth, and 4G LTE bands and operate with high gain at all those frequencies is investigated. For the design process, a patch antenna that can operate at the middle frequency band provides the starting point. By pixelating the antenna and then removing certain pixels help provides other bands. Designs that can provide high gain at all frequency bands are determined through multi-objective optimization technique. This paper will present the design of antennas for 5G application using Matlab to run the Genetic algorithm and to control ANSYS High Frequency Structure Simulator that carried out detailed electromagnetic simulations of different antenna structures. Several antenna designs are fabricated and characterized over a wide-band and their performance is compared to simulated results.
**Poster Number:** ECE-16  
**Authors:** Jason N. Greenberg, Xiaobo Tan  
**Title:** LED-based Localization of Mobile Robots  

**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 (IIS 1319602, CCF 1331852, ECCS 1446793)*

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**Poster Number:** ECE-17  
**Authors:** Kalyanmoy Deb, Rayan Hussein, Proteek Roy, Gregorio Toscano  
**Title:** Metamodeling Methodologies for Multi-objective Optimization  

**Abstract:** In many practical optimization problems, evaluation of objectives and constraints often involve computationally expensive procedures. To handle such problems, a meta-model-assisted approach is usually used to complete an optimization run in a reasonable amount of time. A meta-model is an approximate mathematical model of an objective or a constraint function which is constructed with a handful of solutions evaluated exactly. However, when comes to solving multi-objective optimization problems involving numerous constraints, it may be too much to meta-model each and every objective and constraint function independently. The cumulative effect of errors from each meta-model may turn out to be detrimental for the accuracy of the overall optimization procedure. In this paper, we propose a taxonomy of various metamodeling methodologies for multi-objective optimization and provide a comparative study by discussing advantages and disadvantages of each method. The first results presented in this paper are obtained using the well-known Kriging meta-modeling approach. Based on our proposed taxonomy and an extensive literature search, we also highlight new and promising methods for multi-objective meta-modeling algorithms.

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**Poster Number:** ECE-18  
**Authors:** Daniel Morris, Saif Imran  
**Title:** Leaf Segments from Depth Images  

**Abstract:** Automatically segmenting leaves in imagery of dense foliage in a challenging task. This paper proposes a method to segment leaves and leaf-parts in depth images of foliage. The method relies on locally defined pixel affinities and does not require prior leaf shape models. As a result it is general enough to work on a wide variety of leaves. We develop a novel approach to expanding affinities beyond adjacent pixels which we call Shortest Path Affinity. These Shortest Path Affinities lead to improved segmentation when used by normalized cuts. We also incorporate them in a hierarchical segmentation method that creates superpixels and then groups superpixels recursively. This new method greatly speeds up segmentation computation while obtaining similar performance to normalized cuts. The result is an effective leaf segmentation method for depth images.
Poster Number: ECE-19
Authors: Ameer Janabi, Kellen Hilton, Bingsen Wang
Title: Variable Mode Model Predictive Control for Minimizing the Thermal Stress in Electric Drives

Abstract: A control scheme based on variable mode model predictive control is proposed. By augmenting the conventional model predictive controller with a variable cutoff-frequency/order low pass filter, an additional degree of the objective function allows for optimal trade-off between the thermal stress reduction and the harmonic performance. Both the simulation and experiment results have validated the effectiveness of the proposed method.

Poster Number: ECE-20
Authors: William Jensen, Shanelle Foster, Elias Strangas
Title: Online RUL Estimation of Stator Winding Insulation using Transient Peak Detection

Abstract: Wide bandgap semiconductor devices in machine drive topologies are becoming more prevalent. These devices improve efficiency and can operate at higher switching frequencies. However, higher switching frequencies will increase the electrical stress applied to the insulation of the machine. Electrical stress, excessive heating, mechanical vibrations, and environmental contamination are leading factors that contribute to insulation degradation. Breakdown of the insulation will lead to a short circuit fault between two conductors. Short circuit faults can quickly propagate and lead to catastrophic failure. This project proposes a method to predict the remaining useful life (RUL) of the stator insulation by monitoring a trend in the leakage current. As the insulation degrades, the magnitude of the overshoot in the transient response of the leakage current exponentially decreases. An analog peak detection circuit is used to acquire this magnitude in lieu of expensive high frequency sampling. An Extended Kalman Filter is applied to predict the RUL of the insulation. The proposed strategy will improve machine reliability, especially when using wide bandgap devices, and will eliminate system failures and unplanned shutdowns caused by short circuits.

This work was supported in part by James Dyson Foundation Fellowship

Poster Number: ECE-21
Authors: Saranraj Karuppuswami, Harikrishnan Arangali, Premjeet Chahal
Title: A Hybrid Electrical-mechanical Wireless Magnetoelastic Sensor for Liquid Sample Measurements

Abstract: This poster presents a hybrid passive wireless resonant electrical and mechanical sensor for enhanced sensitivity and specificity. Mechanical resonance measures the viscosity and electrical resonance measures the dielectric properties of liquid samples. The sensor is composed of two magnetoelastic (amorphous ferromagnetic ribbons) strips placed in parallel that are separated with a dielectric spacer forming a capacitor. An inductive coil is attached in parallel to this capacitor leading to an electrical resonant inductive-capacitive (L-C) tank. Both mechanical and electrical resonance frequencies are wirelessly measured using a single pickup coil connected to an impedance analyzer. Several liquid samples, including food items, having different viscosity and dielectric properties are measured and key advantages of this sensor are demonstrated. This sensor can be used in food quality monitoring and can be integrated with passive RFIDs.

This work was supported in part by Midland Research Institute for Value Chain Creation

Poster Number: ECE-22
Authors: Aqeel Madhag, Guoming Zhu
Title: Estimating Slow Varying Sensor Noise Covariance using a Modified Adaptive Filter

Abstract: Modern control systems heavily rely on sensors for feedback control. Degradation of sensor performance due to sensor aging affects the closed-loop system stability, reliability, and performance. This paper proposes an algorithm used to identify the time-varying sensor noise covariance online based on system sensor measurements. The covariance-matching technique, along with the adaptive Kalman filter, utilizes the information about the quality of weighted innovation sequence to estimate the time-varying sensor noise covariance. The covariance-matching of the weighted innovation sequence improves the prediction accuracy and reduces the computational load, which makes it suitable for online applications. The sequential manner of the proposed algorithm leads to significant reduction of the computational load. The convergence proof of the proposed algorithm is demonstrated. In addition, the upper and lower bounds of the
estimation window length are derived such that the convergence of the proposed algorithm is guaranteed. Simulation results show that the proposed algorithm is capable of estimating the time-varying sensor noise covariance for MIMO systems with white noise whose covariances vary linearly or exponentially. Furthermore, the proposed estimation algorithm demonstrates a reasonable convergence rate.

**Poster Number:** ECE-23  
**Authors:** Yaqub Mahnashi, Fang Z. Peng  
**Title:** Smart Solar Cell: Concept and Design

**Abstract:** Wireless sensor nodes (WSN) and implantable biomedical devices require constant battery maintenance which is costly and sometimes invasive. Solutions to prolong the battery life is highly desirable. Solar cells is considered a very powerful energy source for these applications and many others. However, the open circuit voltage ‘Voc’ of a regular solar cell is highly dependent on the light intensity. To overcome this problem, solar cells with regulated output voltage feature is presented which we call a smart solar cell. In this paper, the smart solar cell concept is introduced. A case study of miniaturized smart solar cell with 300~600mV open circuit voltage and 1.5V regulated output voltage is discussed. Simulation results are conducted and discussed to show the effectiveness of the smart solar cell compared to the regular counterpart.

*This work was supported in part by Ministry of Education of Saudi Arabia through King Fahd University of Petroleum and Minerals (KFUPM)*

**Poster Number:** ECE-24  
**Authors:** Yaqub Mahnashi, Fang Z. Peng  
**Title:** Variable Fibonacci Switched-capacitor Converter Synthesis

**Abstract:** Synthesizing the switched-capacitor (SC) converter to perform certain voltage conversions is considered a challenge in SC converter design and usually is done in ad-hoc way. This paper presents a systematic approach to synthesize an optimal SC converter for multiple voltage-gain-ratio (VCR) applications using Fibonacci SC topology. The optimization methodology is based on the minimum number of components count. This approach exploits the Fibonacci SC canonical model and extends it to variable converter implementation. In addition, using the method presented in this paper, the controller circuit of the designed SC converter is greatly simplified. Case studies are presented to show how different SC converters can be synthesized. Results of different designs are compared to some proposed converters in the literature which shows the versatility and simplicity of the design using proposed method.

*This work was supported in part by Ministry of Education of Saudi Arabia through King Fahd University of Petroleum and Minerals (KFUPM)*

**Poster Number:** ECE-25  
**Authors:** Jinshui Miao, Bo Song, Zhihao Xu, Le Cai, Suoming Zhang, Lixin Dong, Chuan Wang  
**Title:** Infrared Photodetector and Camera Using Layered Black Phosphorus

**Abstract:** Few-layer black phosphorus (BP) is an emerging two-dimensional semiconducting material which is of great interest for applications, mainly in high performance electronics, optoelectronics, and chemical sensors. BP nanoflake has a moderate bandgap of around 0.3 eV and high carrier mobility, which lead to transistors having high on-state current and on-off ratios. Here, we demonstrate the infrared photodetector and camera using layered black phosphorus. The BP photodetector shows respectable responsivity up to ~ 100 A/W. We integrated a BP photodetector in a single-pixel camera based on compressive sensing. We proposed a system for calibrating the optoelectrical properties of micro/nano photodetectors based on digital micromirror devices (DMD), which changes the light intensity by controlling the number of individual micromirrors. The calibration sensitivity is driven by the sum of all micromirrors of the DMD. The single-pixel imaging system with the BP photodetector was used to recover a static image to demonstrate the feasibility of the single-pixel imaging system.

*This work was supported in part by Michigan State University*
**Poster Number:** ECE-26  
**Authors:** Nicholas Miller, John Albrecht, Matt Grupen  
**Title:** Large-signal RF Simulation and Characterization of Power Amplifiers using Fermi Kinetics Transport

**Abstract:** Wireless communications is an ever-growing research area in the information age. Commercial applications include cellular telephones, wireless local area network (WLAN) and Wi-Fi, and global positioning system (GPS). A critical component of all wireless systems is the radio frequency (RF) and microwave amplifier. As bandwidth and efficiency criteria evolve with more sophisticated technology, so too must the underlying transistors which comprise the RF amplifiers. RF power amplifiers (PAs) are an important sub-component of TRX modules. GaN HEMTs are a popular PA transistor technology choice due to their high electron saturation velocity, large semiconductor band-gap, high 2D electron gas (2DEG) density in the channel, and high electron mobility. Design of RF PAs is significantly more involved than the design of other types of amplifiers. Basic requirements of these PAs include high gain, high power added efficiency (PAE), and higher linearity. Once the device technology, the type of PA, and the operating point is selected, design of the PA requires measured and/or simulated load-pull (LP) data. Simulated LP data is typically generated with standard commercial software, including Keysight's Advanced Design System (ADS). This requires, however, circuit models of the underlying transistors in order to simulate the PA and generate LP data. The purpose of this abstract is to utilize a TCAD framework called Fermi Kinetics Transport (FKT), which captures hot-electron and full-wave effects, to extract X-Parameter models of state-of-the-art GaN HEMT technology. These X-Parameter models will be imported into ADS to generate simulated LP data.

*This work was supported in part by AFOSR (#17RYCOR495); AF STTR program (FA8650-16-C-1764); SMART scholarship program*

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**Poster Number:** ECE-27  
**Authors:** Mohd Ifwat Mohd Ghazali, Saranraj Karuppuswami, Amanpreet Kaur, Premjeet Chahal  
**Title:** 3D Printed Air Substrates for the Design and Fabrication of RF Components

**Abstract:** This paper presents the fabrication and characterization of RF and microwave passive structures on an air substrate using additive manufacturing (3-dimensional, 3D, printing). The air substrate is realized by 3D printing RF structures in two separate pieces and snapped together face to face using a LEGO-like process. Spacers printed on the periphery provides the desired air substrate thickness. Metal patterning on non-planar printed plastic structures is carried out using a damascene-like process. Various RF structures such as low dispersion transmission line, T-line resonator, high gain patch antenna, slot antenna and cavity resonator are demonstrated using this process. Good performance is achieved; for example, measured 50Ω transmission line shows low loss of 0.17 dB/cm at 4 GHz and a patch antenna (center frequency of 4.5 GHz) shows gain and bandwidth of 7.6 dBi and 0.2 GHz, respectively. Details of both measured and simulation results are presented.

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**Poster Number:** ECE-28  
**Authors:** Matthias Muehle, Jes Asmussen, Michael Becker, Thomas Schuelke  
**Title:** High quality SCD synthesis with microwave plasma assisted CVD at pressures between 300 and 400 Torr

**Abstract:** Fabricating single-crystalline diamond (SCD) wafers exceeding 1" dimensions, requires serious synthesis effort. For example, with typical growth rates of 30 µm/hour it takes about 2000 hours of growth time to make a 3 cm by 3 cm diamond plate. Stable CVD SCD growth processes for such long deposition times have not yet been demonstrated. Thus, it is very desirable to significantly increase the growth rate, while maintaining or improving the SCD quality. The recent development of new growth reactor technology increased the safe and efficient diamond synthesis process window toward higher pressures up to 300 Torr [1]. The main motivation of increasing the process pressure is to achieve higher SCD growth rates while reducing defects [2]. However, any further increase in process pressure resulted in unstable plasma conditions due to the use of a microwave power supply pulsed at 120 Hz. In this poster, we report on further increasing process pressures to 400 Torr, which is possible with a power supply that can be switched between continuous and pulsed excitation. In this study, we demonstrate high quality SCD synthesis in the so-far unexplored pressure region between 300 and 400 Torr. The effects of several parameters of the multidimensional parameter space are discussed. The samples were analyzed for growth rates, film morphology, optical absorption, birefringence and nitrogen content. References [1] Lu et al., Diamond and Related Materials 37 (2013), 17-28; [2] Silva et al., Diamond and Related Materials 18 (2009), 683-697
**Poster Number:** ECE-29  
**Authors:** Asad Nawaz, Cagri Ulusoy  
**Title:** A 1W SiGe Power Amplifier

**Abstract:** High-speed silicon-based transistors suffer from low breakdown voltages (~2VCEO). Generation of high output power without degrading the reliability is still a major design challenge. This paper presents a watt-level X-band power amplifier realized in silicon-germanium 0.13um HBT technology. The proposed PA cell consists of modified cascode stage with base-degenerated CB transistor. Base degeneration increases amplifier reliability by sharing the voltage stress between both CE and CB transistors. Higher current swings are achieved by sizing CB transistors three time as big as CE transistors, this helps reducing output impedance while maintaining input impedance constant. Emitter and base ballasting have been included to provide thermal stability. The PA cell is biased in class-B and achieves 30dBm output power with 50% PAE. This is the state-of-art performance ever achieved from silicon-based transistors power cell.

*This work was supported in part by IHP Microelectronics*

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**Poster Number:** ECE-30  
**Authors:** Nga Nguyen, Joydeep Mitra  
**Title:** Effect of Wind Power on Load Frequency Control

**Abstract:** The integration of wind power into power systems has been gaining momentum in the global energy industry due to its environmental benefits and abundance of supply. However, the natural intermittent and non-dispatchable features of wind negatively impact the system’s frequency regulation capability. Wind power not only injects additional fluctuations to the already variable nature of frequency deviation, it also decreases frequency stability by reducing the inertia as well as the regulation capability. This reduction causes the decrease of overall system frequency response characteristic. These effects of wind integration will be examined closely in this paper. In addition, the effect of wind power on tie-line power flows and area control error will be investigated. The analytical and simulation model of load frequency control are utilized to show the impact of wind on system frequency regulation. Additionally, a range of wind penetration levels is considered to determine the maximum wind power penetration level given a frequency deviation limit.

*This work was supported in part by US Department of Energy under award no. DE-OE0000625*

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**Poster Number:** ECE-31  
**Authors:** Christopher Oakley, Jennifer A. Byford, Amanpreet Kaur, Premjeet Chahal  
**Title:** Aerosol Jet Printing of THz Passive Components

**Abstract:** Terahertz systems offer a convenient, non-invasive platform for biomedical imaging, remote sensing, substance detection, communications systems and material characterization. Due to the high cost of system components needed for proper operation such as mixers, filters, polarizers, and amplifiers, large-scale deployment of these systems has not been realized. Additive manufacturing has recently been demonstrated to provide a viable path towards low-cost, rapid fabrication of lenses, waveguides, probes and power splitters for operation in this frequency spectrum. These methods offer many advantages over traditional micromachining and lithographic techniques by reducing the need for a skilled operator, as well as eliminating hazardous waste traditionally generated as a by-product of these fabrication techniques. Aerosol jet printing of materials allows for a non-contact, direct-write methodology to fabricate structures with feature sizes as small at 10 micrometers, with layer thicknesses of as little as 300 nanometers. Metals, polymers and other materials can be deposited on non-planar surfaces, allowing for the integration of filters and other structures with other components of interest. The goal of this poster is to demonstrate viability of aerosol jet printing of passive terahertz filters on thin organic substrates. Performance of both band-pass and band-stop printed filters will be compared to similar structures fabricated using traditional lithographic techniques, over several frequency bands.
**Poster Number:** ECE-32  
**Authors:** Thang Pham, William Jensen, Shanelle Foster  
**Title:** Stator Incipient Fault Identification in Short Secondary Linear Permanent Magnet Synchronous Machines  

**Abstract:** Failures in linear permanent magnet synchronous machines (LPMSMs), especially those used in transportation and mining applications, can be catastrophic. Quick detection and location of incipient stator winding faults during normal operation provides time to deploy mitigation methods that slow the propagation of the fault and prolong the post-fault life of the machine; however, little has been done to locate the position of the fault in the winding while the machine is operating. In this work, a technique is proposed to detect and locate incipient turn-to-turn faults in short-secondary linear permanent magnet synchronous machines using voltage variations. The dynamic behavior of the circulating fault current generated by the permanent magnets introduces a unique signature voltage that is used to locate the fault. Identifying the faulty slot during normal operation provides additional flexibility for post-fault operation of short-secondary LPMSMs.

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**Poster Number:** ECE-33  
**Authors:** Jubaid Qayyum, John Papapolymerou, Ahmet Ulusoy  
**Title:** A System-on-package Dielectric Sensor using Additively Manufactured Interconnects  

**Abstract:** In this paper, the authors present an on-chip dielectric sensor based on six-port architecture. The designed sensor, integrated on-chip with the six-port reflectometer (SPR), 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 SPR, yield a responsivity of 5123 V/W at 94 GHz based on simulation results. 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. A system-level simulation using ADS (Advanced Design System) has been conducted to analyze and evaluate the reflectometer performance and the chip layout is done using Cadence Virtuoso. The chip occupies an area of 1179-μm × 404-μm and the reflectometer itself consumes 6.75 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.

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**Poster Number:** ECE-34  
**Authors:** Mohammad R. Rawashdeh, Lalita Udpa, S. Ratnajeewan H. Hoole, Yiming Deng  
**Title:** Subregion Finite Element Method based Defect Detection and Characterization using Eddy Current Techniques  

**Abstract:** A novel study of using Subregion Elastic Finite Element Method is presented. The idea of minimizing processing time and saving memory especially for large scale and complicated practical problems is one of the major problems that researches and engineers are facing. A practical example of detecting hidden cracks in infield military vehicles damaged by Improvised Explosive Devices is presented where subregion method is used to isolate defect region from the entire domain. This will lead to tangibly computational cost minimization. Then Finite Element solution has been developed to each region separately, next, to the affected region alone by using the Elastic mesh generation technique that improved in order to apply mathematical inverse problems techniques on this selected affected region alone then recombine solution with the entire solution of the existing problem. A flexible and elastic mesh generating scheme is developed in order to change the defect preselected design parameters each iteration. This meshing technique adds the specialty for using subregion method in such FEM inverse problems where the presented mesh generation process will go through this elastic algorithm so element numbering can be saved inside and outside defect region. In order to characterize the hidden cracks, both of Genetic Algorithm and Simulated Annealing optimization techniques are used. An excellent agreement between our results and others using different techniques. The CPU simulation process was minimized by 90% after using Subregion FEM instead of classical FEM, while an accuracy of 98% was achieved by reconstructing the original defect.

*This work was supported in part by NDEL*
**Poster Number:** ECE-35  
**Authors:** Montassar Aidi Sharif, Xiaobo Tan  
**Title:** Modeling and Fabrication of a Bio-inspired Canal Lateral Line System

**Abstract:** It is of interest to exploit the insight from the lateral line system of fish for flow sensing applications. Biological lateral lines consist of arrays of so-called neuromasts formed with hair cells encased by a gel-like structure named cupula. There are two types of neuromasts, superficial neuromasts and canal neuromasts. In this work we investigate the modeling, design, and fabrication of an artificial lateral line system with canal neuromasts. The canal is filled with viscous fluid to match the biological counterpart. The artificial neuromast is made by embedded an ionic polymer-metal composite (IPMC) sensor within a soft molded cupula structure. The displacement of the cupula structure under an oscillatory flow is studied using both an analytical solution in the literature and finite-element computation with COMSOL 5.1 Multiphysics and fluid structural interaction (FSI) module. The effect of material stiffness and fluid viscosity on the device sensitivity is examined. The sensing response of the IPMC-based canal neuromast is experimentally characterized. Ongoing work aims to estimate the system parameters and validate the modeling analysis with experiments, followed by model-based design optimization to maximize the sensing performance.

*This work was supported in part by Office of Naval Research (Grant N000141512246)*

**Poster Number:** ECE-36  
**Authors:** Hongyang Shi, Xiaobo Tan  
**Title:** Bio-inspired Design of Sea Lamprey Robot Based on the Suction and Swimming Behavior of Sea Lamprey

**Abstract:** Sea lampreys utilize attachment by suction and swim by rhythmic lateral undulations of the body axis. The goal of this study was first to understand the seal mechanism of the oral disc, the pressure creation within the sea lamprey mouth during the suction, and the neural control of swimming. Inspired from the biological mechanisms, a robotic sea lamprey would be designed. Then, we would test the suction efficiency of the robotic sea lamprey attached to some surfaces with different textures, and the swimming test would also be conducted separately to verify the neural control method. After that, we would like to conduct swimming and suction experiment in a higher flow environment, which would drive us to design a robotic sea lamprey with better suction efficiency and swimming performance.

**Poster Number:** ECE-37  
**Authors:** Pratap Bhanu Solanki, Xiaobo Tan  
**Title:** Extended Kalman Filter based Active Alignment Control for LED Optical Communication

**Abstract:** Light-emitting diode (LED)-based optical communication is emerging as a low-power, low-cost and high-data rate alternative to acoustic communication for underwater applications. However, it requires a close-to-line-of-sight link between the transmitter and the receiver to achieve an efficient communication link. Alignment for maintaining line-of-sight (LOS) is challenging due to the constant movement of the underlying mobile platform that is caused by unwanted disturbances and/or the propulsion. In this paper we propose a novel and compact LED-based communication system with active alignment control using a single receiver, which maintains the LOS link despite the underlying platform movement. The system design and implementation is discussed. An Extended Kalman Filter-based algorithm is proposed, which uses light intensity measurements from the single receiver photo-diode and a scanning technique to estimate the relative orientation between the receiver and the transmitter. This estimated orientation is used to adjust the receiver's orientation accordingly. The proposed algorithm is verified in simulation and experiments. The algorithm outperforms simpler algorithms like hill-climbing and three-point-averaging under noisy environment.

*This work was supported in part by National Science Foundation (IIS 1319602, ECCS 1446793)*
Poster Number: ECE-38
Authors: Samer Sulaeman, Joydeep Mitra
Title: A Direct Method to Calculate Capacity Value of Variable Energy Resources

Abstract: This work proposes a direct method to calculate the capacity value of variable energy resources (VERs) in probabilistic adequacy planning studies. The capacity value is used to measure the contribution of VERs such as wind power, to the adequacy of generation systems. Iterative methods are traditionally used to calculate the capacity value of VERs. However, iterative methods are computationally demanding even for power system planning studies. The proposed method is based on augmenting the cumulative distribution function (CDF) of the generation reserve margin (prior to adding VERs) to include the output power of VERs. From the augmented CDF of the generation reserve margin, the capacity value is analytically determined without performing iterations. The proposed method reduces modeling complexity and the computational burden associated with calculating the capacity value of VERs. The proposed approach considers the correlation with system load, output variability and forced outages of generation units in the evaluation process. Furthermore, using the proposed method, the optimal penetration level of VERs in terms of their capacity value can be determined with greater ease than with iterative methods. The proposed method is demonstrated on the IEEE Reliability Test System (IEEE RTS) and used to calculate the capacity value of wind power.

Poster Number: ECE-39
Authors: Yuting Tian, Mohammed Benidris, Samer Sulaeman, Salem Elsaiah, Joydeep Mitra
Title: Optimal Feeder Reconfiguration and Distributed Generation Placement for Reliability Improvement

Abstract: This work presents a methodology to determine the optimal distribution system feeder reconfiguration and distributed generation (DG) placement simultaneously, and is optimal in that the system reliability is maximized. An important consideration in optimal distribution system feeder reconfiguration is the effect of the variable output of intermittent resources. The work presented in this paper considers the stochastic behavior of variable resources, and open/close status of the sectionalizing and tie-switches as variables in determining the optimal DG locations and optimal configuration that enhance system reliability. Genetic algorithm (GA) is applied to search for the optimal solution. The proposed method is demonstrated on a 33-bus radial distribution system, which is extensively used as an example in solving the distribution system reconfiguration problem.

Poster Number: ECE-40
Authors: Haojun Wang, Chaojian Hou
Title: Self-assembly Nano Robot Carrier

Abstract: During recent years, a substantial development on precisely controlled drug delivery technology has changed medical treatments in improving patient conformity and accessibility. However, strategies, even for those most advanced, cannot eliminate side effects, especially when considering both control veracity and compatibility. Improving biocompatibility comes at the expense of reduced controllability, which has an unacceptable side effect due to carriers may interact with untargeted body cells. In favor of controllability may sacrifice the harmony between carriers and biological cells. Side effects have restricted further progress in clinical practice. Here, our Automation & Robotics Laboratory introduce a new way striking a balance between both sides, which is named Self-Assembly Nano Robot Carrier. Self-assembly nano robot carrier is made up of a certain amount of nanoparticles. Aggregation or disassembly follow scientists’ inclinations. Assembled nano-robot can be directed to areas of the body affected by a disease, such as cancer, tumor or neurodegenerative disease. Disassembled nanoparticles can be easily metabolized due to its nanoscale sizes. This controllable nano drug carrier offers a historical solution for clinicians to overcome cellular barriers and negative effects.

Poster Number: ECE-41
Authors: Tongyu Wang, David Torres, Chuan Wang, Felix Fernandez, Nelson Sepulveda
Title: Maximizing Performance of Photothermal Actuators by Combining Vanadium Dioxide and Single-wall Carbon Nanotubes

Abstract: The development of photothermal actuators has been hindered by failing to solve the unavoidable trade-offs between performances such as high energy density, speed, deflection, power efficiency, and sensitivity. Improving some of these parameters often implies deterioration of others. Vanadium dioxide (VO2)-based actuators...
have demonstrated great performance in terms of strain energy density, speed, reversible actuation, programming capabilities, and large deflection. The relative low phase transition temperature of VO2 (~68 °C) gives this technology an additional advantage over typical thermal actuators in terms of power consumption. However, VO2’s low optical absorption still limits its application in photothermal devices. Here we report a VO2-based actuator technology that incorporates single-wall carbon nanotubes (SWNTs) as an effective light absorber to reduce the photothermal energy required for actuation. It is demonstrated that the chemistry involved in the process of integrating SWNT films with VO2-based actuators does not alter the quality of the VO2 film, and that the addition of such film enhances the actuator performance in terms of speed and responsivity. More importantly, the results show that the combination of VO2 and SWNT thin films is an effective approach to increase the photothermal efficiency of VO2-based actuators. Furthermore, by utilizing SWNT films with different chirality distribution, wavelength selective VO2 based photothermal actuators have been demonstrated. These devices response to selected optical spectra based on the chirality of SWNT coatings, which enables the future development of micro-robots, mechanical logic gates and electronic devices that are triggered by optical radiation from different frequency bands.

Poster Number: ECE-42
Authors: Suoming Zhang, Le Cai, Jinshui Miao, Zhibin Yu, Chuan Wang
Title: Patterning Silver Nanowires on Various Substrates using a Direct Printing Method for Stretchable Conductors and Sensors

Abstract: we have developed a direct printing process for additively patterning AgNWs with length up to ~ 40 µm on various substrates. Well-defined and uniform AgNW features could be obtained by optimizing the printing conditions like nozzle size, ink formulation, surface energy, substrate temperature, and printing speed. Systematic characterizations were performed to investigate the electrical and electromechanical properties of the printed features with different nanowire lengths. By printing the AgNWs on a bi-axially pre-stretched PDMS substrate, we have realized a stretchable conductor that could maintain stable conductance under an areal strain of up to 156% (256% of the original area). Additionally, using the printed parallel AgNW lines as electrodes, we have fabricated an ultrasensitive capacitive pressure sensor array and a high resolution PLEC display on flexible substrates, implying the great potential of this unique additive patterning method. Furthermore, the same strategy can be applied to other material platforms like semiconducting nanowires, which may offer a new entry to various nanowire-based mechanically compliant sensory and optoelectronic systems.
Environmental Engineering

Poster Number: ENE-01
Authors: Zachary Curtis, Shu-Guang Li, Hua-Sheng Liao, Hassan Abbas
Title: General Groundwater Flow Processes Underlying Michigan Fens - A Multi-Scale Data-Driven Modeling Study

Abstract: Fens are groundwater-dependent ecosystems that provide critical habitats to many rare plant and animal species, resulting in the investment of substantial resources for their protection. Our recent process-based modeling of the underlying groundwater systems at a few different sites demonstrates that fens receive groundwater from multiple groundwater source areas, including distant regional groundwater recharge areas. In this study, we applied data-driven groundwater modeling of a large, contiguous region of Lower Michigan with 150 fen occurrences to generalize the groundwater processes important to these critical habits. In particular, groundwater source areas were investigated by developing and applying steady-state mean groundwater flow models at different spatial scales (basin-wide, regional, sub regional, and local). The approach directly filters, processes, and analyzes water well records and surface water elevations to estimate groundwater flow using a non-stationary kriging spatial interpolation technique. Major findings include: (1) most fens are located around or at the foot of several large groundwater "mounds" occurring across the intersection of major watersheds; (2) groundwater flow patterns in the regional source water areas are complex and most fens are recharged from multiple sources; (3) conversion of surface water to groundwater that ultimately discharges to a nearby fen – a "cascading connection" - is a robust delivery mechanism; and (4) the contributing groundwater source areas (groundwatersheds) of fens are much larger than their surface water catchments. These findings highlight that fens are key "nodes" in a complex, highly interconnected groundwater system that supports many ecosystems and groundwater resources of Lower Michigan. Because of this connectivity and the fact that groundwater mounds are critical regional source water areas for aquifer systems, fens, and other groundwater-dependent ecosystems, a few "smart" actions in key locations could yield high ecological returns.

Poster Number: ENE-02
Authors: Hien T. T. Dang, Volodymyr V. Tarabara
Title: Kinetics of Bacteriophage MS2 Deposition onto Polyelectrolyte-coated Surfaces

Abstract: Kinetics of bacteriophage MS2 deposition onto polyelectrolyte-coated surfaces
Hien T. T. Dang, Volodymyr V. Tarabara
Department of Civil and Environmental Engineering, Michigan State University, East Lansing, MI 48824 USA
Adhesion to surfaces plays an important role in determining pathogen transport and fate in the environment. Countertops, hospital walls, hair and skin are examples of surfaces of particular interest. While bacterial adhesion is relatively well understood, less is known about interactions of viruses with surfaces of different charges, hydrophobicities and morphologies. In this study, the attachment of bacteriophage MS2 onto negatively and positively-charged polyelectrolyte-coated surfaces were studied by using quartz crystal microbalance with dissipation (QCM-D). Each surface coating was designed by assembling a polyelectrolyte multilayer (PEM) via alternate deposition of the negatively-charged poly(styrene-4-sulfonate) (PSS) and positively-charged poly(dimethyl diallyl ammonium chloride) (PDADMAC) on a QCM-D sensor. The PEM deposition solutions were of either high or low ionic strength (100 mM and 10 mM NaCl background electrolyte, respectively) yielding the total of four different coating types. The surface charge of the PEMs ranged from -7.5 mV to 27.5 mV. Each of the four designed surfaces was tested in two QCM-D experiments wherein MS2 was deposited on the surface from either a high ionic strength solution (100 mM NaCl) or a low ionic strength solution (10 mM NaCl). MS2 deposition onto the negative surface was more significant from the high ionic strength solution. This is consistent with the hypothesis that electrostatic repulsion controls the MS2-surface interaction. Predictions by the Derjaguin-Landau-Verwey-Overbeek (DLVO) theory corroborated the hypothesis. MS2 deposition onto the positive surfaces, however, was less favorable from 10 mM NaCl than from 100 mM NaCl background electrolyte, in disagreement with the hypothesis and the DLVO theory. The extended DLVO (XDLVO) was then employed to account for hydrophobic interactions. XDLVO theory showed that the hydrophobic interaction between MS2 and the positively-charged surface was significant but still failed to explain the experimental results. The discrepancy was attributed to differences in the coating morphologies as witnessed by atomic force microscopy (AFM) images of the surfaces under wet conditions. The AFM showed that when the PEMs immersed in a higher ionic strength solutions are characterized by significantly higher roughness, which may explain the more favorable adhesion of MS2 in 100 mM NaCl background electrolyte. The preliminary results obtained in this study will be used to design surfaces that resist virus adhesion. Specialty polymeric coatings and paints with a modified formulation should help reduce human exposure to viruses.

This work was supported in part by National Science Foundation Partnerships for International Education and Research program (grant IIA-1243433)

Abstracts of the 2017 Engineering Graduate Research Symposium, Michigan State University 61
**Poster Number:** ENE-03  
**Authors:** Farshid Felfelani, Yadu N. Pokhrel  
**Title:** Impacts of Irrigation on Terrestrial Water Storage Variations in the Community Land Model: A Case Study of Overexploited Aquifers in the US

**Abstract:** This study uses the Community Land Model (CLM) to examine the impacts of irrigation on the variations of terrestrial water storage (TWS) in the High Plains and Central Valley aquifers in the US. The Community Land Model (CLM), a state-of-the-art land surface model (LSM), simulates the land hydrology by solving the water and energy balances at the land surface. CLM has been recently enhanced by incorporating human impacts modules with crop and irrigation representation. In this study, we use the latest version of CLM to conduct two sets of simulations with and without irrigation and crop modules (hereafter IRRIG and CNTRL simulations respectively). The results from the IRRIG and CNTRL simulations are compared to assess the impacts of irrigation on total TWS with emphasis on the changes in soil moisture (SM) content. Further, two simulations are compared to the observations from the Gravity Recovery and Climate Experiment (GRACE) satellite mission to evaluate whether the incorporation of crop and irrigation modules adds any improvements in model results at regional scale. It is found that the irrigation extensively alters the spatio-temporal patterns of SM content over highly irrigated areas. Our results underscore the need to further improve the representation of irrigation and crop in hydrological models to more realistically capture the spatial and temporal variability in TWS.

**Poster Number:** ENE-04  
**Authors:** Shardula Gawankar, Imen Zaabar, Nizar Lajnef  
**Title:** Remote Detection and Characterization of Field Aging of Asphalt Pavement

**Abstract:** The oxidation of asphalt is the primary cause of binder hardening in pavements, which in turn leads to various forms of pavement failures. Oxidation is one of the principal factors responsible for the aging phenomena. When asphalt is exposed to oxygen, a slow autoxidation occurs. As binders oxidize, carbonyl groups are formed increasing the polarity of their host compounds and making them much more likely to associate with other polar compounds. As they form these associations, they create less soluble asphaltenes materials. This composition change, results in orders-of-magnitude increases in both the asphalt's viscous and elastic properties. This results in a material that increases its stress greatly with deformation and simultaneously cannot relieve the stress by flow, leading to a pavement that is very brittle and susceptible to fatigue and thermal cracking. Current techniques do not allow for the detection of asphalt aging levels in the field. Most of the experimental techniques are limited to laboratory settings, thus leading to erroneous simulation predictions compared to actual observed degradation levels in the field. The objective of this project is a proof-of-concept for a sensing system that is easy to install and implementable in the field. The process is based on the inclusion of chemical compounds into the material. These engineered compounds also contain fluorescent elements which exhibit a varying fluorescence emission spectrum depending on concentration levels of oxygen. Then, these engineered materials were aged and tested in the lab using Confocal Laser Scanning Microscopy. Preliminary results showed that the fluorescence intensity decreased with an increase in asphalt aging.

*This work was supported in part by US Department of Transportation University Center for Highway Pavement Preservation*

**Poster Number:** ENE-05  
**Authors:** Charifa A. Hejase, Jia Wei Chew, Anthony G. Fane, Volodymyr V. Tarabara  
**Title:** Deoiling Saline Emulsions by Porous Membranes: A Direct Visualization Study

**Abstract:** Large volumes of oily wastewaters are produced in various industrial operations by petroleum refineries, petrochemical plants, and food processing industries. If not properly treated, these wastewater streams can pose significant environmental risks. Membrane filtration is the most cost-effective technology capable of removing oil droplets smaller than 10 microns, often a prerequisite for meeting environmental regulations. However, membrane fouling by oil has been a disadvantage limiting the broader acceptance of this technology. In this study, we investigated the impacts of emulsion salinity and membrane's surface chemistry on oil droplet behavior during crossflow filtration. Direct Observation Through the Membrane (DOTM) technique was employed to visualize the droplets in real time on the surface of three optically transparent membranes: ultrafiltration membrane (Anopore; = 0.02 micron) and two nanofiltration membranes (Anopore coated with polyelectrolyte multilayer films) with opposite surface charges. Visualization by DOTM was complemented by quartz crystal microbalance with dissipation (QCM-D) experiments to gain quantitative understanding of oil droplets deposition on various surfaces. Hexadecane-in-water
emulsions (0.1% v/v) were prepared and stabilized by sodium dodecyl sulfate (0.1 mM) in the presence of sodium chloride (8.5 mM or 103 mM or 171 mM). Emulsions were characterized in terms of interfacial tension and droplet size distribution. The results indicate that membrane fouling by emulsified oil is governed by interfacial tension, electrostatic droplet-membrane interaction, membrane's wettability by oil, and salinity of the dispersed phase. Membrane fouling by oil can be mitigated by promoting droplet coalescence where oil droplets reach a critical size and then are swept off the membrane surface by the crossflow shear.

This work was supported in part by Environmental Science Policy Program (ESPP) doctoral fellowship; Partnerships for International Research and Education (PIRE)

Poster Number: ENE-06
Authors: Dipti Kamath, Stephen Christy, Kelsey Goss, Annick Anctil
Title: Environmental Benefits of Second Use of EV Batteries for Fast Charging: A Life Cycle Assessment Approach

Abstract: With a gradual increase in the number of Electric Vehicles (EVs) on the road today, a similar trend is seen in the use of Lithium Ion Batteries (LIBs) for these EVs. However, LIBs are only considered suitable for vehicle application up to a capacity fade of 20%. Once such a capacity fade occurs, these LIBs are discarded, leading to a significant problem in waste management. However, even with this capacity fade, these End-of-Life (EOL) LIBs can be considered useful for other applications, especially stationary applications. This work aims at evaluating the second life potential and environmental benefits of EOL LIBs for a particular photovoltaic (PV) application. The premise is that the remaining capacity of the EV battery after its in-vehicle life phase may offer the perfect complement to the intermittent renewable energy source at low cost and high net environmental benefit. The application involves using the EOL batteries as an Energy Storage System (ESS) for high rate charging of an EV. This scenario would consider a grid connected PV system for charging the ESS and high rate discharge from the ESS to charge an EV. The secondary battery lifetime capacity and performance over time is simulated through various models. The environmental benefits of the second life usage was compared to recycling processes using life cycle assessment (LCA) and focused on greenhouse gases emissions and energy demand.

This work was supported in part by Ford Motor Company (Project: Potential for second life battery in PV systems)

Poster Number: ENE-07
Authors: Yogendra Kanitkar, Robert Stedtfeld, Paul Hatzinger, Syed Hashsham, Alison Cupples
Title: The Application of Loop Mediated Isothermal Amplification (LAMP) for Rapid Detection of vcrA and tceA in Groundwater Samples

Abstract: A number of quantitative PCR (qPCR) protocols to enumerate Dehalococcoides spp. reductive dehalogenase (RDase) genes, such as vcrA, tceA and bvcA, are available. However, there can be significant costs associated with both approaches (e.g., a thermal cycler for qPCR can be $20K). In this study, we developed an alternative method to qPCR for the detection of RDase genes. The approach involves loop mediated isothermal amplification (LAMP) and requires only low-cost laboratory equipment. In addition, the analysis time and cost per sample are lower than currently used methods. The method was tested with groundwater samples from 35 monitoring wells at five different sites. Finally, optimization experiments were then carried out to eliminate false positives caused because of carryover-aerosolized quantification by incorporating a Uracil N-Glycolase protocol widely used with qPCR. To establish that LAMP was comparable to qPCR for DNA extracted from groundwater, the first stage of the research involved a comparison of LAMP to qPCR for tceA and vcrA using a real time thermal cycler. Following this, experiments were conducted to optimize the sample concentration approach, so that the DNA extraction step could be removed. Finally, optimization experiments were carried out by completely replacing deoxythymidine triphosphate (dTTP) with deoxyuridine triphosphate (dUTP) to establish the amount of UNG needed to eliminate false positives while maintaining a minimum acceptable detection limit of 10^5 vcrA gene copies/reaction. A final method was developed which only requires low cost equipment (bench top centrifuge and a water-bath) for RDase detection. When qPCR and LAMP were compared using DNA extracted from groundwater, the results of both methods were almost identical (R^2=0.991) over a range of approximately 10^4 to 1010 gene copies/L for tceA and 10^5 to 10^10 gene copies/L for vcrA. Although amplification from cell templates resulted in lower values compared to DNA extracts, a strong correlation was obtained between the two sets of data. The final approach (using LAMP/SYBR green and a waterbath) to detect RDase genes, without DNA extraction or a thermal cycler, was successful to 1.8 X 10^5 gene copies per L for vcrA and 1.3 X 10^5 gene copies per L for tceA. Both values are below the threshold recommended for effective in situ dechlorination.

This work was supported in part by Strategic Environmental Research and Development Program (SERDP)
**Poster Number:** ENE-08  
**Authors:** Eunsang Lee, Cameron Jacob Andrews, Annick Anctil  
**Title:** Methodology to Evaluate the Impact of Fine Chemicals Manufacturing: An Example from Organic Photovoltaic Materials  

**Abstract:** Fine chemicals are complex, single, and pure chemical substances for certain applications. There is a challenge in their production since they are produced in plants producing many other chemicals and require multistep processes. In this work, we use metal phthalocyanine (M-Pc) as a case study of applying sustainability methodology. M-Pcs are common electron donors and fullerenes are used as electron acceptors in organic photovoltaic. M-Pcs synthesis release polychlorinated biphenyls (PCBs) when chlorinated benzenes are used as a reaction media. For solar applications, high purity is required for high efficiency, but the purification process is energy intensive. Our sustainability methodology combines environmental, health and economic impact combining life cycle assessment (LCA) and green chemistry metrics to identify significant contributor and reduce the impact of fine chemicals synthesis. LCA is used to assess cumulative environmental, health, and cost impacts from cradle to gate. Since LCA is time intensive, green chemistry metrics is used to supplement LCA. Chloroaluminum phthalocyanine (ClAlPc) was synthesized using various precursors and solvents under heating mantle and microwave. Material flows were recorded, and by-products were identified to calculate life cycle toxicity. Preliminary data indicates that the alternative reaction media, 2,4-dichlorianisole, requires toxic chemicals in its upstream process and consequently results in higher health impact than the conventional reaction media. These results highlight the importance of the life cycle assessment approach that can effectively identify unintended consequences from the prior chemical process. The methodology can also be applied to other fine chemicals, and results from fullerene purification will be presented.

*This work was supported in part by A green chemistry approach to organic and transparent photovoltaic material synthesis and device fabrication (NSF-1511098)*

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**Poster Number:** ENE-09  
**Authors:** Xiaoyan Li, Selett Allen, Alyssa Rose, Rebecca Lahr  
**Title:** Low Cost Drinking Water Analysis using the “Coffee Ring” Effect  

**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. 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 (Wong, Chen et al. 2011) (Deegan, Bakajin et al. 1997). Paired with chemical analysis, the coffee ring effect has previously been used to quantify cyanotoxin contamination in surface water (Halvorson and Vikesland 2011) and evaluate signs of ocular damage in human tear fluid (Filik and Stone 2008). These detection protocols have relied upon chemical analysis (Raman spectroscopy) to quantify one species in the sample at a time. Photographs of the residue patterns themselves have not previously been used to document overall water composition.

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**Poster Number:** ENE-10  
**Authors:** Camille McCall, Mariya Munir, Terance Marsh, Irene Xagoraraki  
**Title:** Comparative Study of Sequence Aligners for Detecting Antibiotic Resistance on a Metagenomic Scale  

**Abstract:** In this study, we aim to compare the results of two sequence aligners, BWA-MEM and Bowtie2, when aligning bacterial DNA against two nucleotide antibiotic resistant gene reference databases, CARD and ARG-ANNOT. We used high-throughput sequencing paired with alignment algorithms to obtain annotated results of resistant genes in wastewater samples extracted directly after the disinfection process of two sewage treatment facilities. In general, BWA-MEM mapped with greater base coverage and sequencing depth when aligned against the larger reference genome, CARD, while alignment results against the smaller reference genome, ARG-ANNOT, were more comparable between sequence aligners. Alignment with BWA-MEM and Bowtie2 suggests the presence of macrolide, effamycin, sulfonamide, beta-lactam, and aminoglycoside resistance in both samples. To our knowledge, this is the first study to suggest effamycin resistance in wastewater samples using metagenomic analysis. Results indicate that when operating under the aligner’s default conditions, the size of the reference database may influence the potential for mapping in both Bowtie2 and BWA-MEM alignments. To our understanding, this is the first study to
Abstracts of the 2017 Engineering Graduate Research Symposium, Michigan State University

provide sequence alignment results of real, whole-genome bacterial DNA mapped against two different size nucleotide antibiotic resistant gene references using Bowtie2 and BWA-MEM.

Poster Number: ENE-11
Authors: Joyce Mujunga Nakyazze, Huiyun Wu, Evan O'Brien, Noah Kiwanuka, John Kaneene, Irene Xagoraraki
Title: Waterborne Viruses in Southwest Kampala, Uganda

Abstract: The prevalence of waterborne viral diseases is still a major problem in developing countries like Uganda. However, little is known of the viral pathogens that cause disease. This research was conducted to study waterborne viruses; Adenoviruses, Rotaviruses, Enteroviruses and Hepatitis A viruses in the southwest region of Kampala, Uganda. Fifteen samples were collected from five sampling locations that include: Wastewater Treatment Plant (WWTP) both influent and effluent, Nakivubo channel (upstream and downstream of the WWTP) and Nakivubo swamp. Virus samples were collected with electropositive cartridges. Viruses were recovered by elution using beef extract, DNA and RNA extraction followed. DNA viruses were quantified using quantitative Polymerase Chain Reaction method and RNA viruses were detected by Reverse Transcription Polymerase Chain Reaction method. The concentration of the viruses varied between Log 1.7- 7.8 copies/L. Rotavirus concentrations varied between Log 1.7 – 4.3 copies/L, with WWTP effluent rotavirus concentration varying greatly compared to those at other sampling locations. For Hepatitis A, the maximum concentration (Log 4.1 copies/L) was observed at the channel after WWTP. The channel before WWTP had more consistent Enterovirus concentration (range 0.4) compared to other locations. Adenovirus concentrations were relatively high, Log 5.1 – 7.1 copies/L at all the sampling locations. Human exposure to such pathogens through consumption of contaminated water and food can be harmful. This data is paramount for estimating the risk from exposure to microorganisms.

This work was supported in part by Department of Civil and Environmental Engineering MSU-internal; College of Veterinary Medicine, MSU- external; MasterCard Foundation Scholars Program, MSU-external

Poster Number: ENE-12
Authors: Evan O'Brien, Joyce Nakyazze, Huiyun Wu, Noah Kiwanuka, John Kaneene, Irene Xagoraraki
Title: Viral Diversity of Wastewater in Kampala, Uganda

Abstract: Viral diversity of wastewater influent from a wastewater treatment utility in Uganda was explored using metagenomic analyses on a preliminary sample in preparation for a full-scale project. Samples were collected from the influent of the Bugolobi Wastewater Treatment Plant in Kampala, Uganda. Samples were processed to concentrate viral particles and sequenced using an Illumina platform. Sequencing files were then analyzed to assess viral diversity of these samples. Sequence were aligned to the NCBI reference genome of viral sequences using the BWA-MEM aligner. Results show high coverage of several human waterborne viruses, including enteroviruses, rotaviruses, and hepatitis viruses. Low levels of genome coverage were observed for other human viruses, including influenza, polyomavirus, papillomavirus, herpesvirus, and astrovirus, as well as low levels of coverage for certain endemic viruses such as Chikungunya virus, Dengue virus, hantavirus, and Nipah virus. Numerous animal and plant viruses also showed high coverage in the sequencing sample. These results indicate the ability of next-generation sequencing to offer a full viral diversity profile of an environmental sample for the detection and characterization of human viruses present in the environment. Future work will analyze samples from multiple locations to better assess the ability of metagenomic analyses to detect hazardous viruses in the environment and the impact of wastewater effluent discharge on the viral diversity of surface waters.

Poster Number: ENE-13
Authors: Han Qiu, Jie Niu, Mantha S. Phanikumar
Title: Modeling Nitrogen Fate and Transport in Agricultural Basins in the Great Lakes Region Using a Process-based Hydrologic Model

Abstract: Nitrogen loading and transport in river basins are closely related to several environmental issues such as eutrophication. In this work, we describe an operator-splitting-based approach for multi-component reactive transport modeling of nitrogen fate and transport in agricultural basins in the Great Lakes region. This work provides a watershed-scale framework of nitrogen transport and reactions originating from multiple sources with interactions between the domains of soil, groundwater, overland and river networks. User-defined reaction modules make it possible to manipulate individual processes, evaluate the impacts of point sources, and to understand the evolving
roles of nitrogen species in different domains. The modeling framework was tested on agricultural watersheds such as the Kalamazoo River watershed (5,200 km2) in Michigan. Our results are expected to aid in the management of water resources, and in evaluating the impacts of agricultural activities.

**Poster Number:** ENE-14  
**Authors:** Vidhya Ramalingam, Alison M. Cupples  
**Title:** The Development of Enrichment Cultures Capable of Anaerobic Biodegradation of the Groundwater Contaminant 1,4-Dioxane

**Abstract:** The solvent stabilizer 1,4-dioxane is a common groundwater contaminant especially at contaminated sites where it was used as a stabilizer for the chlorinated solvents. It is a possible human carcinogen and exposure leads to liver, kidney and nervous system damage. Further, this chemical is highly hydrophilic and mobile, which makes groundwater remediation particularly challenging. To date, 1,4-dioxane biodegradation has only been observed under aerobic conditions. However, aerobic biodegradation may not be useful at sites that use reductive dechlorination for remediation, since the site will have reducing conditions. Therefore, the primary objective of this work is to develop anaerobic cultures capable of 1,4-dioxane biodegradation under iron reducing, sulfate reducing, nitrate reducing and methanogenic conditions. Experiments, thus far, have involved the development of enrichment cultures using four agricultural soils. The experimental set up involved triplicates and controls for each reducing condition and for each soil. A method was developed to analyze 1,4-dioxane in these samples using a gas chromatograph flame ionization detector (GC-FID). Data will be collected over the next few months to determine if significant removal has occurred in the samples compared to the controls. Future plans for enrichment cultures illustrating 1,4-dioxane biodegradation include high throughput sequencing to identify the dominant microorganisms in these cultures.

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

**Poster Number:** ENE-15  
**Authors:** Hang Shi, Irene Xagoraraki, Kristin N. Parent, Merlin L. Bruening, Volodymyr V. Tarabara  
**Title:** Recovery of Human Adenovirus 40 from Tap and Surface Water by Crossflow ultrafiltration

**Abstract:** Prevention of waterborne disease outbreaks relies on the efficient detection of pathogens in drinking and recreational water. Development of sample concentration technology that ensures fast and high recovery of pathogens from aquatic samples is crucial for reliable detection. This study examines the recovery of enteric adenovirus HAdV 40 by crossflow ultrafiltration from several water matrices (deionized water, tap water and surface water) and interprets recovery data by elucidating the physicochemical mechanisms that control virus adhesion on surfaces. Membranes were either blocked by calf serum (CS) or coated with a polyelectrolyte multilayer (PEM) to minimize virus adsorption on the membrane surface. In accordance with predictions from the extended Derjaguin-Landau-Verwey-Overbeek theory, pre-elution recovery of HAdV 40 from deionized water was higher with the PEM-coated membranes ($r_{pre}^{PEM}= 74.8 \pm 9.7\%$) than with CS-blocked membranes ($r_{pre}^{CS}=54.1 \pm 6.2\%$). With either membrane type, the total virus recovery after elution was high in both deionized water ($r_{post}^{PEM}= 99.5 \pm 6.6\%; r_{post}^{CS}= 98.8 \pm 7.7\%$) and tap water ($r_{post}^{PEM} = 89 \pm 15\%$ and $r_{post}^{CS}= 93.7 \pm 6.9\%$). The nearly 100% recoveries suggest that sodium polyphosphate and tween 80 in the eluent effectively disrupt electrostatic and hydrophobic interactions between the virus and the membrane. For surface water, addition of ethylenediaminetetraacetic acid to the eluent greatly improves the elution efficacy ($r_{post}^{PEM}= 88.6 \pm 4.3\%; r_{post}^{CS}= 87.0 \pm 6.9\%$) even when organic carbon concentration in the water is high (9.4 ± 0.1 mg/L), possibly by eliminating cation bridging between viruses and particles in the feed water matrix or the fouling layer on the membrane surface. This suggests that the eluent composition is the most important factor for achieving high virus recovery for complex water matrices.

*This work was supported in part by National Science Foundation Partnerships for International Education and Research program under grant IIA-1243433*

**Poster Number:** ENE-16  
**Authors:** Jean-Rene Thelusmond, Alison Cupples, Timothy Strathmann  
**Title:** Biological Transformation of Two Common Pharmaceuticals in Agricultural Soils and Identification of the Responsible Microorganisms
Abstract: Pharmaceuticals and personal (PPCPs) care products are being released into the environment because of their poor elimination during the wastewater treatment process. The release of such contaminants into the environment will probably continue as wastewater effluents and biosolids are being increasingly utilized to irrigate and amend farms. The presence of PPCPs in the soils is concerning due to the risk of the underlying groundwater contamination and the uptake into plants. To abate the risks posed by these contaminants, their removal from the soils is quite warranted. The use of the soil microbial communities can be a safe and inexpensive way of removal. This study elucidates the biodegradability of diclofenac (DCF) and carbamazepine (CBZ) in agricultural soils. The experimental procedure consisted in establishing laboratory microcosms with agricultural soils and adding 50 ng/g of DCF or CBZ. The pharmaceuticals were extracted periodically using a modified QuEChERS followed by solid phase extraction and liquid chromatography tandem mass spectrometry. DNA was also extracted from all the samples except the abiotic controls. High throughput sequencing was performed on the extracted DNA prior to processing the output through Mothur, PICRUSt and STAMP. The initial results demonstrate that DCF is readily degradable under aerobic conditions with DCF exhibiting 55%, 80.5%, 100%, and 98.1% decrease in soils A, B, C, and D, respectively, on day 3. On day 7, over 99% of the added drug was biotransformed in all the soils. Data on CBZ degradation are still being collected. The microorganisms responsible for the removal of DCF and CBZ are still under investigation.

This work was supported in part by USDA

Poster Number: ENE-17
Authors: Xiaoyu Wang, Simon Davies, Susan Masten
Title: Energy Cost Analysis of Catalytic Ceramic Membrane Ozonation Filtration System

Abstract: Membrane fouling is one of the main factors that limiting the application and increasing the operational costs of membrane technologies. It can be reduced through shear stress generated by cross-flow at the membrane surface. Moreover, previous work has shown that presence of ozone can reduce membrane fouling. In this work the effect of ozonation and cross-flow on membrane fouling on ceramic membranes was studied. The effect of ozone dosage on membrane fouling was studied in both cross-flow and dead-end configurations. The performance of a manganese oxide coated membrane was compared with that of uncoated titanium oxide membrane. Membrane fouling decreased with increasing ozone dosages in the manganese oxide coated catalytic membrane, although increasing the dosage beyond 10-15 μg/s yielded limited improvement.

Poster Number: ENE-18
Authors: Chelsea Weiskerger, Richard Whitman, Mantha Phanikumar
Title: Anatomy of “Wicked” Problem: Approaching Long-term Recreational Water Quality Trends with Multiple Causal Hypotheses

Abstract: With the prevalence of “wicked” problems in natural sciences – problems that are complex and poorly understood, such as climate change, environmental justice, etc. – it is vital that researchers approach these issues with multiple hypotheses regarding their causes. But wicked problems are not limited to worldwide problems; these types of issues arise in regional and local contexts as well. An example is an observed mid- to long-term decrease in E. coli contamination of recreational waters on Lake Michigan. Researchers contend that there are four main hypotheses that could explain these decreases: municipal changes to sewer and wastewater management, bird harassment at beaches, climatic changes including prevailing winds and temperature alterations, and effects of invasive, filter-feeding mussels. Hypotheses are systematically analyzed, in terms of feasibility, spatial and temporal scale matching, and statistical correlation with E. coli trends. While all four hypotheses have merit, after the analyses, researchers are left with one, “most likely” explanation for the mid- to long-term decreases in E. coli. The most probable explanation involves an increase in water clarity and light inactivation of bacteria due to filter feeding. This highlights the importance of thinking about all potential causes of environmental phenomena prior to drawing causal conclusions when studying “wicked” environmental problems.

Poster Number: ENE-19
Authors: Maggie Williams, Robert Stedtfeld, Tiffany Stedtfeld, James Tiedje, Syed Hashsham
Title: Influence of Dioxin Exposure on the Communication between the Host Immune Response and Gut Microbiome through Ileal microRNAs

Abstract: The gut microbiome is thought to have co-evolved with the host to perform essential functions including immune system modulation, resulting in a complex and dynamic symbiotic relationship. As small, non-coding molecules, microRNAs regulate gene expression post-transcriptionally by targeting the 3’ untranslated region on
mRNAs, thereby blocking protein synthesis and degradation of mRNAs. Differential expression of microRNAs is observed in the gut when certain gut members are present. More recently it has been shown that the host may be regulating its own gut microbiome through microRNAs, which are taken up by bacteria and associate with DNA. Exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) can cause disruption of the immune system which can be modulated by the microbiome and microRNAs. In this study, we hypothesized that microRNAs involved in these immune responses would have altered expression following TCDD dosing. Mouse treatment groups of mono-associated (SFB), di-associated (Clostridia and B. fragilis), tri-associated (SFB, Clostridia and B. fragilis), and germ-free, were dosed with 30 µg/kg of TCDD. Ileum tissue samples were collected and microRNA expression levels were characterized using nCounter. MicroRNA expression results were compared with mRNA expression results to provide insight into gene expression regulation. The influence of association (colonized vs. germ-free; vehicle only) was more significant than the influence of TCDD exposure with 36 differentially expressed microRNAs of which the most differentially expressed microRNAs were present in the SFB mono-colonized group (n=24). A total of 3 microRNAs were differentially expressed when comparing B. fragilis colonized to germ-free mice and 9 microRNAs were significant when comparing the SFB co-colonized group to germ-free. The influence of dioxin on ileal microRNA expression was determined by comparing the TCDD-treated to vehicle controls within each associated group. The most differentially expressed microRNAs (log2FC > |0.59|, adjusted p value < 0.05 after ANOVA screening) were in the SFB mono colonized group (n=27), the majority of which were downregulated (n=16). Based on potential gene targets of these microRNAs, pathways affected by TCDD included inflammatory responses, which is a known response to TCDD. These findings reflect the comprehensive effort necessary to understand the complex relationship between the gut microbiome, environmental contaminants, and host.

This work was supported in part by National Institute of Environmental Health Sciences Superfund Basic Research Program (NIEHS SBRP P42ES04911) with contributions from Project 1, 4, 5, and Core B

Poster Number: ENE-20
Authors: Huiyun Wu, Amira Oun, Thomas Voice, David Long, Irene Xagoraraki
Title: First Flush Evaluation of Bacterial Indicators in Red Cedar River, MI

Abstract: First flush refers to the initial surface runoff of a hydrological event. It raises significant issues due to its high concentration of contaminants. Studies of first flush phenomena have been primarily focused on chemicals. The objective of the study is to evaluate first flush phenomena for microbial contaminants during the periods of spring snowmelt and summer storms. Samples were collected in Red Cedar River in Michigan and were analyzed for three fecal contamination indicators: E.coli, Bovine-associated bacteroides (BoBac) gene marker, and Human-associated bacteroides (HuBac) gene marker. E.coli and BoBac showed flush effect in the summer rainfall events, E.coli showed first flush effect in spring snowmelt events. The occurrence of first flush phenomena of fecal indicators in both summer rainfall events (2013) and spring snowmelt (2014) in the Red Cedar River confirmed the watershed was under a high risk of microbial contamination. A surface water runoff management and watershed protection plan for Red Cider River watershed should be considered to control human and animal pollution.
**Materials Science**

**Poster Number:** MSE-01  
**Authors:** David Hernández Escobar, Hakan Yilmazer, Carl J. Boehlert  
**Title:** High-pressure Torsion as a Novel Technique for Processing Zn-based Cardiovascular Stents  

**Abstract:** High-pressure torsion (HPT) is a severe plastic deformation (SPD) technique in which a disc sample is subjected to torsional shear strain under a high hydrostatic pressure simultaneously. HPT, firstly documented in 1935, has recently gained popularity in the biomaterials field as it provides the potential for achieving nanograined microstructures that can significantly improve mechanical material properties such as microhardness and tensile strength. A satisfactory combination of bioabsorption, biodegradability and mechanical properties are some of the challenging requirements for cardiovascular stents that have not been recorded yet for current Fe and Mg alloys used in these applications. Therefore, alternative materials have to be considered in order to fully satisfy all design constraints. There are numerous reasons for considering metallic Zn a great candidate for bioabsorbable metal stents. It is an essential element for basic biological functions and shows strong antiatherogenic properties that enhance endothelium stabilization. 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 have been chosen. Scanning electron microscopy (SEM) was used to analyze the grain features along the radius of the disk-like samples as well as to compare the distribution of Zn and Mg phases at different number of turns. Energy dispersive spectroscopy (EDS) combined with SEM was also used for chemical composition analysis of the present phases.

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

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**Poster Number:** MSE-02  
**Authors:** Kwang Jin Kim, James Wortman, Sung-Yup Kim, Yue Qi  
**Title:** Atomistic Structural Evolution and Li Trapping Due to Delithiation Rates in Si Electrodes  

**Abstract:** To minimize the irreversible capacity loss and enhance the long-term capacity retention of Si anode, it is important to gain fundamental understanding of the intrinsic response of Si upon delithiation with different rates. In this study, we developed a new continuous delithiation algorithm based on ReaxFF-MD simulations by utilizing a lithiated Al2O3 coating layer on fully lithiated Si to generate a driving force for Li to naturally diffuse out of the a-LixSi. Specifically, we investigate the mechanism of irreversible structural changes and its consequences on subsequent lithiation process. The delithiation rate is considered to be “slow”, with respect to the size of Si and the diffusion rate, when Li can completely diffuse out of Si (the residual Li in Si is less than Li0.2Si) and the Si exhibits negligible amount of isolated inner-pore. However, upon fast delithiation (10 times faster), Li concentration gradient with higher Li concentration in the center of Si and lower Li concentration near the surface is formed which ensembles a cage-like structure with locally dense Si network near the surface. As we have demonstrated before that Li diffusion in Si increases with Li concentration, this concentration gradient leads to significant amount of Li trapped inside Si. As a result, at the end of fast delithiation process, a- Li1.2Si with non-uniform Li concentration distribution shows 141 % volume inflation. Meanwhile, during fast delithiation, isolated inner-pores continuously collapse and reform, and eventually, agglomerates into a large pore with severe coating delamination. However, irreversible structure change was discovered even during the slow delithiation process, where the delithiated a-Li0.2Si remains 44 % inflated with uniform Li concentration at the end of slow delithiation. This is due to the loss of directly bonded Si-Si pairs, which makes the delithiated a-Li0.2Si exhibit faster lithiation rate in the next cycle.

*This work was supported in part by NEES (Nanostructures for Electrical Energy Storage)*

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**Poster Number:** MSE-03  
**Authors:** Matthew Klenk, Niina H. Jalarvo, Sydney Boeberitz, Wei Lai  
**Title:** Lithium Diffusion Dynamics through Quasi-elastic Neutron Scattering and Molecular Dynamics  

**Abstract:** Critical to the prospect of a clean energy future, battery technology will need to develop to a point where large scale grid storage, electric vehicles, and low cost personal battery systems become ubiquitous in society. To
avert the inherent safety issues with today’s liquid electrolytes, proposals for safer all-solid-state batteries are gaining traction in the literature. The solid electrolyte Li7-xLa3TaxZr2-xO12 (LLZT) has been shown to be a promising substitute for conventional electrolyte systems exhibiting room temperature conductivity approaching 1E-3 S/cm and stability to a range of anode and cathode materials.

In the present study LLZT is investigated using quasi-elastic neutron scattering (QENS), classical molecular dynamics (MD), and density functional theory (DFT) to better understand the phase transformation behavior, lithium diffusion mechanism, and effects of dopant concentration on lithium distribution in the crystal. We see that lithium diffusion is mostly carried out through collective hopping with its neighbors maximized at compositions between 0.3 < x < 0.5. Within this range lithium is optimally distributed increasing the number of repulsive Li-Li interactions driving diffusion. We show that it is possible to use lithium site occupancy and lithium sub-lattice excess entropy as descriptors for the observed maximum in the conductivity. To verify our simulations QENS was performed to calculate the self-diffusivity, residence time, and jump length distribution for the end member composition LLT (x=2). The dynamic structure factor S(Q,E) is calculated and compared to the intermediate scattering factor I(Q,t) calculated through velocity autocorrelation of the MD simulations.

This work was supported in part by Ceramics Program of National Science Foundation (DMR-1206356)

Poster Number: MSE-04
Authors: Junchao Li, Wei Lai, Donald T. Morelli
Title: First-principle Study of Atomic Dynamics in Tetrahedrite Thermoelectrics
Abstract: Tetrahedrite are high-performance thermoelectrics which contain earth-abundant and environmentally friendly elements. At present, the mechanistic understanding of their low lattice thermal conductivity remains limits. This work applies first-principle molecular dynamics simulations, along with extended X-ray absorption fine-structure (EXAFS) experiments, to study the incoherent and coherent atomic dynamics in tetrahedrites materials, in order to deepen our insight into mechanisms of anomalous dynamic behavior and the origin of low lattice thermal conductivity.

This work was supported in part by Thermal Transport Processes Program of National Science Foundation

Poster Number: MSE-05
Authors: Yuanchao Liu, David P. Hickey, Jing-Yao Guo, Erica Earl, Sofiene Abdellaoui, Ross D. Milton, Matthew S. Sigman, Shelley D. Minteer, Scott Calabrese Barton
Title: Multi-scale Simulation on Substrate Channeling
Abstract: Nature has a very efficient metabolic pathway to produce energy within the cell, through a series of chemical reactions. In this one-pot multi-step catalysis, carbohydrates are oxidized on sequential enzymatic active sites. Although the cell has a very complicated chemical environment, these superamolecular complexes are able to maintain a high reaction efficiency and prevent unproductive side reactions. To mimic these cascade reactions, a key factor is found to be substrate channeling [1], where the reaction intermediates are directly transported to a downstream active site without first equilibrating with bulk media. We simulate substrate channeling at multiple scales to study the effect of electrostatic pathways on the channeling of charged intermediates [2]. Specifically, molecular dynamics (MD) elucidates the surface interaction between negative intermediate molecules and cationic peptide surfaces, revealing a surface diffusion mode. Based on MD and experimental results, a coarse-grained Kinetic Monte Carlo (KMC) method is used to quantify the overall cascade kinetics, bridging the gap between molecular-level interaction and experiment. KMC reveals rate limiting steps that can be further studied to improve cascade design. 1. I. Wheeldon, S. D. Minteer, S. Banta, S. C. Barton, P. Atanassov and M. Sigman, "Substrate channelling as an approach to cascade reactions", Nature Chemistry, 8, 299–309 (2016). doi:10.1038/nchem.2459. 2. Y. Liu, D. P. Hickey, J.-Y. Guo, E. Earl, S. Abdellaoui, R. D. Milton, M. S. Sigman, S. D. Minteer and S. C. Barton, "Substrate Channeling in a Cross-Linked Enzyme Complex: A Molecular Dynamics Blueprint for an Experimental Peptide Bridge", ACS Catalysis, Revision, (2017).

This work was supported in part by Army Research Office MURI (#W911NF1410263) via The University of Utah
Abstract: A Multi-Beam Optical Stress Sensor (MOSS) provides a contact free, in-situ technique to measure stress based on the curvature of the sample. Originally, this technique was used to measure the film stress during deposition. However, when combined with special sample design and experimental setup, it can be used to measure the physical properties of thin film materials. In this work, the oxygen surface exchange coefficients (kchem) of thin film material were measured when combining MOSS with curvature relaxation technique; thermal expansion coefficient (CTE), chemical expansion coefficient (CCE) and biaxial modulus (M) were measured when combining the MOSS with dual substrates technique. Praseodymium doped ceria was chosen as the film material in order to validate the feasibility of curvature relaxation and dual substrate techniques for measuring kchem, CTE, CCE and M values. The results showed that: (1) Curvature relaxation is able to measure kchem accurately and reproducibly (2) the Dual substrate technique is capable of measuring CTE, CCE and M of a mixed ionic electronic conductor (3) kchem, CTE, CCE and M can all be measured within the same curvature measurement platform.

This work was supported in part by Department of Energy under Award Number DE-FE0023315
non-sized CFs. This research is an effective approach to increase interfacial properties in CF-epoxy composites, and potentially also be utilized for interfacial optimization in biobased natural fiber composites.

This work was supported in part by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) through the Science Without Borders program (BEX: 13655-13-2)

Poster Number: MSE-09
Authors: David Smiadak, Alex Zevalkink
Title: Scintillator Candidate Compounds Grown by the Micro-pulling Down Method

Abstract: Crystals with composition MgTa2O6 and Ce:LuAG were synthesized using the micro-pulling-down method. The crystals were prepared from powdered oxides and the results were characterized with x-ray powder diffraction, x-ray luminescence, scanning electron microscopy, and energy-dispersive x-ray spectroscopy. Analysis confirmed single crystal growths of Ce:LuAG while two phases were identified in the MgTa2O6 growths. Production parameters for these crystal growths are detailed. Further development is required in the case of MgTa2O6 as growth results did not produce detectable emission spectra required of scintillators. The growth of single crystal Ce:LuAG was confirmed and the spectral analysis matched those of published values. Ce:LuAG was confirmed to be an appropriate scintillator material that can be grown with in-house equipment at Lawrence Berkeley National Laboratory. Scanning electron microscopy and energy-dispersive x-ray spectroscopy testing were performed at Michigan State University.

This work was supported in part by Michigan State University; Lawrence Berkeley National Laboratory; Department of Energy; Department of Homeland Security’s Domestic Nuclear Detection Office

Poster Number: MSE-10
Authors: Erik Stitt, Markus Downey, Mahmood Haq, Lawrence Drzal
Title: Enhancing Multi-material Bond-strengths via Plasma Surface treatment of Thermoplastic Adhesives

Abstract: Multi-material adhesive joining is gaining attention in automotive applications as a means to enhance light-weighting, fuel-efficiency and reduce greenhouse emissions. Specifically, reversible adhesives comprising of thermoplastics embedded with conductive graphene nanoplatelets (GnP) enable ‘selective heating’ of the adhesive while exposed to electromagnetic radiation; thereby allowing for rapid assembly, re-assembly and repair. The efficiency of an adhesive joint is dependent on sufficient and excellent transfer of stresses from the substrates to the adhesive. This requires adequate compatibility to create a good bond between surfaces of the adhesive and substrate.

In this work, efficiency of multi-material joints made of carbon fiber reinforced polymer (CFRP) and Aluminum (Al) substrates bonded with high-impact polystyrene (HIPS) thermoplastic adhesive was experimentally evaluated. The HIPS films were surface treated with O2-Plasma exposure and its efficacy was compared with similar joints without surface treatments. Additionally, the GnP concentration was varied and its effect on joint behavior was evaluated. Preliminary results indicate enhancement is both ultimate loads and displacements with O2-plasma treated joints. Structure-property relationships, improvements in wettability of HIPS due to O2 surface treatment and the path forward will be presented.

This work was supported in part by Department of Energy

Poster Number: MSE-11
Authors: Spencer L. Waldrop, Donald T. Morelli
Title: Effect of Non-stoichiometry on the Thermal and Electrical Properties of Polycrystalline PtSb2 at Low Temperature

Abstract: In narrow bandgap materials non-stoichiometry can dramatically change the measured electrical and thermal properties below room temperature. The work here attempts to examine the effects of non-stoichiometry on the low temperature properties of polycrystalline PtSb2. It was found that at antimony deficiencies of only 1% a change in the sign of the Seebeck coefficient was observed from 80 to 120 K. Further reduction of the antimony content resulted in a negative Seebeck for all temperatures measured. Antimony excess was found to retain positive values in the Seebeck coefficient, but with a reduction in the magnitude. The electrical resistivity was found to vary
largely at low temperature, however converged to similar values at room temperature. These results show the importance of stoichiometry in narrow bandgap materials at low temperature.

This work was supported in part by Air Force Office of Scientific Research under the Multi-University Research initiative (MURI), “Cryogenic Peltier Cooling,” Contract No. FA9550-10-1-0533

Poster Number: MSE-12
Authors: M. Wang, D. Kang, P. J. Lee, A. A. Polyanskii, C.C. Compton, T.R. Bieler
Title: Investigation of the Effect of Strategically Selected Grain Boundaries on Superconducting Properties of SRF Cavity Niobium

Abstract: High purity Nb is the most used material for the fabrication of SRF cavities due to its high critical temperature and ease of formability. However, microstructural defects such as dislocations and grain boundaries in niobium can serve as favorable sites of pinning centers for magnetic flux that may degrade SRF cavity performance. In this study, bi-crystal Nb samples with strategically selected grain boundaries were designed, and their effect on magnetic flux behavior was investigated. Grain boundaries with different orientations were chosen to favor specific slip systems, which can be activated during tensile deformation and generate dislocations with special angles with respect to the grain boundaries. Laue X-ray and EBSD-OIM crystallographic analyses were used to characterize grain orientations and orientation gradient, while Electron Channeling Contrast Imaging (ECCI) was performed to investigate the dislocation structures. Cryogenic Magneto-Optical Imaging (MOI) was used to directly observe the penetration of magnetic flux into Nb at about 5-8 K, and relationships between flux penetration and grain boundary structures were identified.

This work was supported in part by DOE/OHEP (contract number DE-FG02-09ER41638 at MSU and DE-SC0009960 at FSU); State of Florida

Poster Number: MSE-13
Authors: Daniel Weller, Donald Morelli
Title: Thermoelectric Performance of Tetrahedrite Synthesized by a Modified Polyol Process

Abstract: Tetrahedrite, a promising thermoelectric material composed of earth-abundant elements, has been fabricated utilizing the rapid and low energy modified polyol process. Synthesis has been demonstrated for Cu12Sb4S13 and Cu11ZnSb4S13 on the gram scale requiring only 1 hour at 220 °C. This method is capable of incorporating dopants and producing particles in the 50-200 nm size regime. For determination of bulk thermoelectric properties, powders produced by this solution-phase method were densified into pellets by spark plasma sintering. Thermopower, electrical resistivity, and thermal conductivity were obtained for temperatures ranging from 323 to 723 K. Maximum ZT values at 723 K were found to be 0.66 and 1.09 for the undoped and zinc-doped tetrahedrite samples, respectively. These values are comparable to or greater than those obtained using time and energy intensive conventional solid-state methods. Consolidated pellets fabricated using nanomaterial produced by this solution-phase method were found to have decreased thermal conductivity, increased electrical resistivity, and increased thermopower. Exceptionally low total thermal conductivity values were found (below 0.7 Wm-1K-1 for undoped tetrahedrite and 0.5 Wm-1K-1 for zinc-doped tetrahedrite), with both having lattice thermal conductivities below 0.4 Wm-1K-1. This study explores how nanostructuring and doping of tetrahedrite via a solution-phase polyol process impacts thermoelectric performance.

This work was supported in part by NSF-CBET-1507789; U.S. Dept. of Education GAANN program

Poster Number: MSE-14
Authors: Jared B. Williams, Spencer Mather, Alexander Page, Ctirad Uher, Donald T. Morelli
Title: Increasing the Power Factor of Ge17Sb2Te20 by Adjusting the Ge to Sb Ratio

Abstract: The ever increasing energy demands of humans show no signs of stopping. Unfortunately the majority of this energy is produced by means which are nonrenewable and detrimental to the environment. In response to this issue researchers from a myriad of fields have looked for new reliable energy sources such as solar, wind, geothermal, or even nuclear. However, perhaps a more important issue to tackle is the fact the efficiency by which we use the energy we generate is approximately 40%. The majority of this unused energy is expelled as thermal energy. Thermoelectric materials possess the unique ability to convert thermal energy to electrical energy, and could
therefore improve how effectively we use energy. The efficiency of thermoelectric power generation is, however, is dependent on the Carnot efficiency and the unitless parameter, ZT. The ZT of a material is dependent on the electrical and thermal properties of the material. However, to achieve a high ZT, and therefore high efficiency, novel materials science must be used to overcome the contraindicated property relations of ZT, namely: high Seebeck coefficient and electrical conductivity, and low thermal conductivity. In this work, the carrier concentration of Ge17Sb2Te20, a thermoelectric compound from the phase change material family, was tuned in order to optimize the thermoelectric power factor. This was achieved by altering the stoichiometry of Ge and Sb, and therefore does not require additional foreign elements during synthesis. The result was a more than 30% increase in the power factor of the material.

This work was supported in part by Department of Energy; Michigan State University Distinguished Fellowship

Poster Number: MSE-15

Authors: Yubo Zhang, Jason D. Nicholas

Title: Barium Oxide (BaO) Infiltrated Lanthanum Strontium Manganese Oxide (LSM)-Gadolinium Doped Ceria (GDC) Solid Oxide Electrochemical Reduction Cells for Reduced Diesel NOx Emissions

Abstract: Diesel engines are widely used in automobiles for their high fuel efficiency, low carbon monoxide emissions, and low hydrocarbon emissions. Unfortunately, due to their lean-burn operating environment, diesel engines emit higher amounts of NOx than gasoline engines. Although NOx Storage and Reduction (NSR) and Selective Catalytic Reduction (SCR) technologies have been commercialized and offer high deNOx (i.e. NOx decomposition) efficiency, they suffer from a loss of fuel efficiency during catalyst regeneration and a need for large-volume, on-board ammonia storage and replenishment, respectively. Further, expensive precious metal catalysts are needed to enable deNOx chemical reactions in these conventional technologies. In contrast, Solid Oxide Electrochemical Reduction Cells (SOERCs) utilizing an external bias to electrochemically drive NOx decomposition promise precious-metal-free operation without the need for catalyst regeneration or large-volume, on-board storage. Here, the deNOx performance of barium oxide (BaO) infiltrated lanthanum strontium manganese oxide (LSM)-gadolinium doped ceria (GDC) SOERCs were measured as a function of operating temperature, AC amplitude, and AC frequency. The BaO-LSM-GDC SOERCs tested here displayed better low-temperature NOx conversion efficiencies than those previously reported in the literature; achieving 22% at 350C compared to the 3% reported in literature. The application of an AC electric bias was found to produce higher BaO-LSM-GDC NOx conversion efficiencies than a DC bias of the same magnitude and BaO-LSM-GDC SOERCs exhibited current and thermodynamic efficiencies of a few percent, and a few tenths of a percent, respectively.
MECHANICAL ENGINEERING

Poster Number: ME-01
Authors: Fatemeh Afzali, Brian F. Feeny
Title: Vibrational Analysis of Vertical Axis Wind Turbine Blades Containing Time Varying Damping Coefficient

Abstract: The derivation of a vibration model for an H-rotor/Giromill blade is investigated. The blade is treated as a uniform straight elastic Euler-Bernoulli beam under transverse bending and twisting deformation. The derivation of the energy equations for the bending and twisting blade and a simplified aerodynamic model is issued. Lagrange's equations are applied to assumed modal coordinates to obtain nonlinear equations of motion for bend and twist. A single quasi-steady airfoil theory is applied to obtain the aeroelastic loads. The behavior of the linearized equation for bend only is examined. We study the response of a linear differential equation, for an oscillator 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. Eventually, the stability and the response of the damped system for a set of parameters are shown.

Poster Number: ME-02
Authors: Ali Al-Hajjar, Ali Al-Jiboory, Shan Min Swei, Guoming George Zhu
Title: Aircraft Flutter Suppression

Abstract: Aircraft flutter is a dangerous and catastrophic instability phenomena which results as the interaction between the structural dynamics and aerodynamics. This interaction will cause unstable oscillation and failure. There are many methods used to suppress this phenomena. Some methods suggests to fortify the aircraft structure, but this will increase the mass of the aircraft which is strongly undesirable in the aerospace applications. The active flutter suppression is the best way to suppress the flutter without increasing the mass of the aircraft. In this work we do an active flutter suppression to aircraft, which effectively enhance the stability and performance of the aircraft.

Poster Number: ME-03
Authors: Sheng Chen, Sara Roccabianca
Title: Effect of Storage Condition, Orientation, Location and Gender on Rat Back Skin Mechanical Properties

Abstract: The determination of biomechanical properties of soft tissues like skin involves mechanical tensile test. In practice, skin samples cannot always be tested right after removal from the subjects. The purpose of this work is to determine the storage protocol that preserves skin mechanical properties the most by evaluating mechanical characteristics on five parameters: initial slope, maximum slope, rupture strain, ultimate tensile strength (UTS), and toughness. Also, the differences due to orientation, location and gender are studied in this work. Sixteen Sprague Dawley rats, eight males and eight females, aged between 10 to 12 weeks were used in the study. Skin samples from rat back skin went through quasi-static uniaxial tensile test. ANOVA results show that there are no statistically significant (5%) differences between four storage protocols on five evaluated parameters, while Protocol III (flash frozen at -78.5°C, stored at -80°C, and thawed at 4°C for 6h before testing) is the one that preserves the stress-stretch curve characteristics the most in both cyclic loading and rupture loading curves, compared with the control group Protocol I. The study reports no differences between male and female animals, but statistically significant differences on orientation and location. This work is valuable for people who need a proper protocol to store their soft tissue samples for further mechanical tensile test.
**Poster Number:** ME-04  
**Authors:** Amber R. Cussen, Gail A. Shafer, Tamara R. Bush  
**Title:** Device Design and Development to Measure Carpometacarpal Joint Force Application: Preliminary Results  

**Abstract:** Osteoarthritis (OA) of the carpometacarpal (CMC) joint is a debilitating and prevalent disease affecting nearly 50% of U.S. adults over 55. While OA of the CMC joint is characterized by waning grip strength, minimal research has investigated the individual thumb muscle actions that correlate to this reduced function and no device is currently capable of measuring the applied force of the CMC joint during thumb motion. In this study, we built a thumb CMC joint apparatus that attaches to a multi-axis load. The device is capable of measuring forces applied during flexion (palmar abduction), extension, (radial) abduction, and adduction. Our goals for device design included: 1) adjustable to accommodate varying hand size, 2) hand placement is consistent and measures are repeatable, 3) isolates CMC joint action, 4) can detect force magnitude and direction, and 5) is durable to accommodate numerous patients. To meet these objectives, a palmar hand support and a connected structure that allowed for mounting of the load cell were machined out of aluminum. Both pieces are adjustable to accommodate varying hand sizes. Thumb forces are applied to a customized circular ring connected to the load cell to allow for symmetrical thumb movements and bilateral testing. This portable apparatus is designed to be placed on an adjustable table top and is designed to be used with a standard adjustable office chair. Each CMC joint action can be measured independently. Pilot testing suggests that our apparatus can be used with both OA and asymptomatic subjects.

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**Poster Number:** ME-05  
**Authors:** Amber R. Cussen, Tony Trier, Laura Bix, Tamara R. Bush  
**Title:** Development of a Methodology to Evaluate the Biomechanics Associated with Aseptic Presentation of Sterile Medical Pouches  

**Abstract:** Hospital-acquired infections (HAIs) are a significant cause of in-patient morbidity and mortality. Although many contributors to HAIs are carefully surveilled, sterile package opening and guideline compliance evaluations are lacking. Additionally, only a portion of aseptic presentation guidelines are evidence-based. In this pilot study, we developed a method using motion capture to evaluate the movements associated with aseptic package opening. Nine health professionals trained in sterile package opening and scrub procedures were recruited to open two chevron-style package sizes while wearing 13 reflective markers to detect movement. Participant movement was then evaluated for compliance to aseptic presentation guidelines. No participant was able to present both packages of either size without crossing the sterile field. When opening large sized packages, participants pulled open to a greater degree (larger pull distance), performed more repetitive motions and spent more time handling the packages. In this study, we show motion capture methods are sufficient to detect human factors associated with aseptic package guideline compliance, and participants have more difficulty abiding to best practice guidelines when opening large sized packages. Our methodology can be used to identify handling behaviors that depart from established guidelines. In combination with contamination data collection, our method can also be used to relate specific handling behaviors to contamination risk, thus providing healthcare providers with an evidence basis for training and improved opening techniques.

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**Poster Number:** ME-06  
**Authors:** Joshua Drost, Tamara R. Bush  
**Title:** Modeling Changes to Force and Function of the Hand Due to Osteoarthritis  

**Abstract:** Currently, the methods used to assess functional changes in hand function are primarily surveys, pain scales and radiological exams which are all subjective. A model that maps both the force and motion abilities will allow clinicians to objectively compare changes in hand function throughout rehabilitation and treatment. Recently, we modeled the changes in the range of motions of the hand caused by arthritis. The goal of this work was to determine forces associated with the index finger and create a predictive model of the force abilities of participants over their range of motion for participants with and without reduced hand functionality. Sixteen “Healthy” participants and fifteen “Arthritic” participants were included in this study. Maximum forces were measured in nineteen trials over the range of motion. After collection, the data were analyzed in terms of the position (x,y,z coordinate), direction and magnitude of the force applied. A linear mixed effect model was used to create predict to full force abilities for the healthy and arthritic participants. Future work will include the measurement of forces for all fingers and for a larger subject group. Clinically, this model is highly innovative and useful: measures of motion and force will be gathered for individuals to assess the difference as compared to an average healthy individual. Also the individual can be measured multiple times throughout treatment to track improvement to hand function.
**Poster Number:** ME-07  
**Authors:** Masumeh Gholamisheeri, Elisa Toulson  
**Title:** Experiments and CFD Modeling of a Homogeneously Charged Turbulent Jet Ignition (TJI) System

**Abstract:** Advanced ignition systems can be effective approaches to reduce NOx emissions and improve efficiency in automotive applications. Prechamber ignition systems such as the Turbulent Jet Ignition (TJI) system are modern technologies that improve engine efficiency while lowering fuel consumption through low temperature combustion. TJI enables fast burn rates that allow for increased levels of dilution and lean burn combustion. In the presented research, transient jet ignition of a homogeneous methane air mixture in a TJI system is studied computationally using Large Eddy Simulation (LES) and Reynolds averaged Navier-Stokes (RANS) turbulent models. In TJI a turbulent jet discharges from a prechamber into the main chamber via one/multiple orifice(s) and provides a distributed ignition source. The effect of orifice size and stoichiometry is studied through simulations performed with the Converge CFD code. A reduced chemical kinetic mechanism is used for combustion modeling along with a zero-equation Smagorinsky sub-model and RNG k-ε model for turbulence modeling. The computed pressure traces are compared with experimental data measured in the Rapid Compression Machine (RCM) experimental tests. The comparison indicates that the CFD results are in acceptable agreement with the experimental data during compression and the early stage of combustion, however, an over-prediction of peak pressure was reported. Pressure traces are scaled and CFD temperature contours for various nozzle orifices and air-fuel ratios are compared in order to achieve deeper insight into the TJI combustion process in the RCM combustion cylinder.

*This work was supported in part by NSF-DOE*

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**Poster Number:** ME-08  
**Authors:** Jun Guo, Rigoberto Burgueño  
**Title:** Tailoring the Elastic Postbuckling Response of Cylindrical Shells under Axial Compression

**Abstract:** Buckling has traditionally been considered as a failure limit and thus a condition to avoid, but recently it has been recognized as a promising response phenomenon to design smart applications, such as energy harvesting, frequency tuning, sensing, actuation, etc. Cylindrical shells are considered a good prototype for smart applications since they have advantages over other structural forms in their ability to attain multiple buckling events in their elastic postbuckling response. Yet, to design smart applications from cylindrical shells requires that their elastic postbuckling response be controllable, tailored and be relatively less sensitive to imperfections. The postbuckling behavior of axially-compressed cylindrical shells with a uniform stiffness distribution has been extensively studied. Conversely, the response of cylindrical shells with non-uniform stiffness distribution, mainly used to increase their load-carrying capacity, has caught little attention. The study presented here shows, through numerical simulations and experiments, that the design of varied stiffness distributions on the surface of axially-compressed shells can tailor their elastic postbuckling response. The shell surface was discretized into cells and some of them were thickened with respect to the baseline uniform shell thickness. By introducing the non-uniform thickness distribution, the number, sequence, and location of local buckling events in the far elastic post-buckling response can be tailored. In addition, the shell’s elastic postbuckling response type (i.e., softening, sustaining of stiffening) can be controlled and is expected to show reduced sensitivity to random initial imperfections.

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**Poster Number:** ME-09  
**Authors:** Patrick Hammer, Ahmed Naguib, Manoochehr Koochesfahani  
**Title:** Lift on a Low Reynolds Number Steady Airfoil in Uniform Shear Flow

**Abstract:** Two-dimensional computations have been performed on a steady NACA 0012 airfoil at zero angle of attack and chord Reynolds number of 12,000 in a uniform-shear approach flow. It is found that the average lift coefficient has an opposite sign to the inviscid solution for the same airfoil, while having a lower magnitude. It is hypothesized that this different sign of lift is caused by a slight camber towards the low-speed side of effective shape of the airfoil, created by asymmetry in the boundary layer displacement thickness. Analysis of the computed flow pattern around the airfoil supports this hypothesis.

*This work was supported in part by AFOSR grant number FA9550-15-1-0224*
**Poster Number:** ME-10  
**Authors:** Tianyi He, Ali Khudhair Al-Jiboory, Sean Shan-Min Swei, Guoming G. Zhu  
**Title:** Switching State-feedback LPV Control with Uncertain Scheduling Parameters

**Abstract:** This paper presents a new method to design Robust Switching State-Feedback Gain-Scheduling (RSSFGS) controllers for Linear Parameter Varying (LPV) systems with uncertain scheduling parameters. The domain of scheduling parameters are divided into several overlapped subregions to undergo hysteresis switching among a family of simultaneously designed LPV controllers over the corresponding subregion with the guaranteed $\mathcal{H}_\infty$ performance. The synthesis conditions are given in terms of Parameterized Linear Matrix Inequalities that guarantee both stability and performance at each subregion and associated switching surfaces. The switching stability is ensured by descent parameter-dependent Lyapunov function on switching surfaces. By solving the optimization problem, RSSFGS controller can be obtained for each subregion. A numerical example is given to illustrate the effectiveness of the proposed approach over the non-switching controllers.

*This work was supported in part by NASA ARMD Convergent Aeronautics Solutions (CAS) Project*

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**Poster Number:** ME-11  
**Authors:** Alexander Ho, Alborz Izadi, Rebecca Anthony  
**Title:** Conformal Deposition of Nanocrystals onto Surfaces

**Abstract:** Nanocrystals can be incorporated into a variety of applications due to their tunable optical and electronic properties. There are various applications that require structures with an irregular geometry. Here a method for conformal deposition of luminescent nanocrystals onto surfaces of varying geometries and materials is investigated. In a single reactor, silicon nanocrystals were synthesized in a nonthermal plasma and deposited directly onto substrates held in the plasma by a stand. The confirmation of conformal coatings onto the substrates was verified through the use of scanning electron microscopy. Preliminary results indicate conformal coatings and suggest that insulating surfaces exhibit greater nanocrystal agglomeration than conductive surfaces whose distribution shows greater uniformity. For the nanocrystals to exhibit the desired optical and electrical properties they must be crystalline: control of the crystallinity is accomplished by adjusting gas flow rates and the power to the plasma. Part of our current work is synthesizing and verifying that the coatings consist of crystalline nanocrystals and measuring the thickness of the deposited coatings. Ongoing work also includes studying the effects of thermal and electrical properties, and surface complexity on the degree of conformality.

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**Poster Number:** ME-12  
**Authors:** Alborz Izadi, Mayank Sinha, Sara Roccabianca, Rebecca Anthony  
**Title:** Silicon Nanocrystal Mechanical Property Investigations

**Abstract:** Flexible electronics have attracted a lot of interest in recent decades. To our knowledge there are few to no basic studies based on the mechanical properties of nanomaterials on flexible substrates, and the resulting opto-electric properties. In this study we will focus on fabrication of nanocrystals and deformable substrates. Silicon nanocrystals (SiNCs) will be produced and deposited onto flexible substrates, opening a new level of understanding of instabilities formed by nanomaterials. This work will help us to revolutionize next generation of photovoltaics, LEDs and other optoelectronic devices. We use a low-pressure plasma reactor excited using radiofrequency (RF) power to deposit SiNCs on polydimethylsiloxane (PDMS) as an elastomer substrate. The substrate is going to be pre-stretched underneath the orifice where the SiNCs accelerate and form a film on top of the PDMS. In order to focus on mechanical properties of SiNCs we apply stress on one direction and raster the substrate beneath the orifice in the same direction to provide uniform deposition of luminescent SiNCs on PDMS. We then relax the PDMS and preliminary results show that the NC films exhibit wrinkling patterns in a manifestation of surface instabilities. Since PDMS and films of SiNCs both have highly non-linear behavior, we will apply uniaxial tensile tests and nanoindentation to investigate the material properties of the bilayer depending on the geometrical characteristics of the NC films and PDMS substrates.

*This work was supported in part by NSF under CBET Grant 1561964*
**Poster Number:** ME-13  
**Authors:** Hussam Hikmat Jabbar, Ahmed Naguib  
**Title:** Computational Study of a Vortex Ring Interacting with a Constant Temperature Heated Wall

**Abstract:** In this research, a computer simulation is conducted using ANSYS-Fluent to investigate the unsteady heat transfer resulting from the interaction of an axisymmetric vortex ring with a heated flat wall. The overarching goal of the research is to develop and experimentally characterize active flow control methodology to enhance the heat transfer rates in impinging jets. The present work isolates a fundamental feature of these flows; that involving the interaction of the jet vortices with the wall. This simplification facilitates understanding of the fundamental connection(s) between the flow features and thermal transport at the surface through simultaneous examination of the vorticity and the temperature fields, the hydrodynamic and the thermal boundary layers, and the Nusselt number. Ultimately, this understanding will be used to devise open-loop and adaptive flow control strategies to enhance the overall heat transfer rates from/to the wall.

**Poster Number:** ME-14  
**Authors:** Sina Jahangiri Mamouri, Andre Benard  
**Title:** Modeling Oil-water Separation Using Membranes

**Abstract:** Oil-water separation is a critical aspect of operating an oil well and also constitutes a unit process critical for the success of oil spill cleanup. In the US, an average of 7 to 8 barrels of contaminated water are produced for one barrel of oil [1]. This so called produced water has oil concentrations of typically 100 to 5,000 mg/L [2]. These waters cannot be directly discharged into the environment if the oil concentration is less than the allowable concentration [3-6].

Deoiling of produced or impaired water represents a significant challenge for companies, communities, state and federal agencies. Centrifugation, air flotation, and hydrocyclone separation are the current methods of oil removal from produced water, however the efficiency of these methods decreases dramatically for droplets smaller than approximately 20 µm. More effective separation of oil-water mixtures into water and oil phases is a key technology that has potential to both decrease the environmental footprint of the oil and gas industry and improve human well-being in regions such as the Gulf of Mexico.

New technologies, enabled by recent breakthroughs in membrane separation processes and design of systems with advanced flow management offer tremendous potential for improving oil-water separation efficacy. In this project, the behavior of oil droplets and their interaction with membrane surfaces is studied using computer simulations; experiments are already available to validate the results. The behavior of a single and multiple droplets interacting with pores on the surface, with each other, and with the flowing stream is modeled (impingement, coalescence, pore entry, and removal). The information gathered from such models is used to develop population balance models for droplets on surfaces so as to improve the design and effectiveness of separation devices.

*This work was supported in part by Fellowship from James Dyson Foundation; MSU Sustainability office fellowship; NSF partnership for international research and education (PIRE)*

**Poster Number:** ME-15  
**Authors:** Xue(Zoe) Jiang, Peter B. Lillehoj  
**Title:** Pneumatic Microvalves Fabricated by Multi-material 3D Printing

**Abstract:** We report an innovative and simple approach for fabricating pneumatic microvalves via an assembly-free 3D printing technique. These valves are based on monolithic elastomeric valves fabricated by multilayer soft lithography but circumvents the need for specialized layering, alignment and bonding. 3D printed microfluidic devices containing flow channels and pneumatic valves were fabricated and tested for functionality. Using these devices, we successfully demonstrate valve actuation for precise liquid flow control and on/off operation. The speed and simplicity of this approach make it a promising technique for rapid prototyping and manufacturing of 3D printed microfluidic devices with fully integrated components.

*This work was supported in part by Bill and Melinda Gates Foundation*
Poster Number: ME-16
Authors: Nilay Kant, Ranjan Mukherjee, Hassan K. Khalil
Title: Swing-up of Inertia Wheel Pendulum using Impulsive Control

Abstract: Inertia Wheel Pendulum (IWP) is an underactuated system. It consists of a planar pendulum with a rotating disc at the end attached to a motor. The torque applied by the motor causes a reaction torque on the pendulum link which is unactuated. We look at the problem of swing-up control of the inertia wheel pendulum from vertically downward equilibrium configuration to the upright equilibrium configuration using impulsive control and then switching the swing-up controller to a local stabilizing controller. As compared to previous studies of swing-up control of IWP that uses a continuous controller based on energy methods, the swing up time using our controller is much less. It has also been reported that global stabilizing controller that do not rely on switching tend to aggressively stabilize the equilibrium and require extremely high torque input to accomplish. Based on the dynamics of the system, we also present the reason for such behavior which was previously not known. Impulsive control is implemented using high gain feedback and a generalized approach is presented for reduction of peak impulses with respect to increase in the number of impulsive torques.

This work was supported in part by National Science Foundation

Poster Number: ME-17
Authors: Ali Kharazmi, Harold Schock
Title: Three Dimensional Analysis of the Gas Flow in Piston Ring Pack

Abstract: A 3D model of the piston assembly is introduced to analyze the flow between the cylinder liner and the piston. A new program is developed to link between the conventional 1D models and Commercial CFD solvers. The effect of ring twist on mass flow rate and pressure across the piston is calculated using the introduced model.

Poster Number: ME-18
Authors: Ehsan Kharazmi, Mohsen Zayernouri
Title: Operator-based Uncertainty Quantification (UQ) in Science and Engineering

Abstract: Mathematical models of physical phenomena contain design parameters, which are obtained from observable data. Stochastic fractional differential equations generalize the standard PDE models to those of fractional orders, and they offer attractive possibilities for robust modeling of complex multi-scale physical problems. In such models, the fractional orders are obtained from experimental sets of data. However, due to the inherent incompleteness of the data, uncertainty quantification is required to assess the uncertainties, associated with the randomness in the parameters. Moreover, the behavior of fractional models is sensitive to the fractional orders, which motivates the sensitivity analysis in order to develop numerical solvers to obtain the parameters in an iterative fashion. In this work, we consider a fractional differential equation (FDE) and a fractional partial differential equation (FPDE). We use Monte Carlo method and probabilistic collocation method to obtain the standard deviation of the solution and quantify the uncertainties of parameters. Moreover, we derive the sensitivity equations, corresponding to the order of fractional derivatives and develop an iterative algorithm, which employ the sensitivity equations along with the original FDE/FPDE to iteratively obtain the fractional derivative orders.

This work was supported in part by AFOSR Young Investigator Program (YIP) award on: "Data-Infused Fractional PDE Modelling and Simulation of Anomalous Transport" (FA9550-17-1-0150)

Poster Number: ME-19
Authors: Ruixue Christine Li, Guoming George Zhu, Kevin David Moran, Ruitao Song
Title: In-cylinder Ionization Sensing with Ignition Coil Inductance Shorting

Abstract: An MSU patented technique to improve the frequency response of an in-cylinder ionization sensing circuit when used with a high energy (impedance) ignition coil on an internal combustion spark ignition engine. To be more specific, it is used to reduce the filtering effects of the ignition coil inductance by shorting the primary winding following the spark event and continuing through combustion process. The experimental results with improvement on engine knock detection will be presented.
**Poster Number:** ME-20  
**Authors:** Tung-Yi Lin, Sina Parsnejad, Linlin Tu, Trey T. Pfeiffer, Andrew J. Mason, Guoliang Xing, Peter Lillehoj  
**Title:** Finger-powered Microfluidic Electrochemical Assay for Point-of-care Testing

**Abstract:** Many point-of-care tests utilize microfluidics for liquid transport. However, two key challenges for microfluidic systems are systems integration and fluidic handling, which typically involves external components and/or power sources. Here, we demonstrate a finger-powered microfluidic electrochemical assay for rapid measurements of protein biomarkers. This device employs a valveless, piston-based pumping mechanism which utilizes a human finger for the actuation force. Liquids are driven inside microchannels by pressing on the pistons which generates a pressure-driven flow. Reagents are preloaded in microwells allowing for the entire testing procedure to be completed on chip. For proof-of-concept, this device was used to detect *Plasmodium falciparum* histidine-rich protein-2 (PfHRP2) in human plasma samples using a mobile phone detection platform. This device can measure PfHRP2 from 0.1 to 20 µg/mL with high specificity. Furthermore, each measurement can be completed in <= 6 min. Based on its simplicity, portability and excellent analytical performance, this device is a promising platform for point-of-care testing, particularly in remote and resource-limited regions.

*This work was supported in part by National Institutes of Health (R01AI113257)*

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**Poster Number:** ME-21  
**Authors:** Suihan Liu, Rigoberto Burgueño  
**Title:** Controlled Elastic Postbuckling of Bilaterally Constrained Non-prismatic Columns: Application to Enhanced Quasi-static Energy Harvesters

**Abstract:** Axially compressed bilaterally constrained columns, which can attain multiple snap-through buckling events in their elastic postbuckling response, can be used as energy concentrators and mechanical triggers to transform external quasi-static displacement input to local high-rate motions and excite vibration-based piezoelectric transducers for energy harvesting devices. However, the buckling location with highest kinetic energy release along the element, and where piezoelectric oscillators should be optimally placed, cannot be controlled or isolated due to the changing buckling configurations. This work proposes the concept of stiffness variations along the column to gain control of the buckling location for optimal placement of piezoelectric transducers. Prototyped non-prismatic columns with piece-wise varying thickness were fabricated through 3D printing for experimental characterization and numerical simulations were conducted using the finite element method. A simple theoretical model was also developed based on the stationary potential energy principle for predicting the critical line contact segment that triggers snap-through events and the buckling morphologies as compression proceeds. Results confirm that non-prismatic column designs allow control of the buckling location in the elastic postbuckling regime. Compared to prismatic columns, non-prismatic designs can attain a concentrated kinetic energy release spot and a higher number of snap-buckling mode transitions under the same global strain. The direct relation between the column’s dynamic response and the output voltage from piezoelectric oscillator transducers allows the tailorable postbuckling response of non-prismatic columns to be used as multi-stable energy concentrators with enhanced performance in micro-energy harvesters.

*This work was supported in part by U.S. National Science Foundation under grant number ECCS-1408506*

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**Poster Number:** ME-22  
**Authors:** Xiyuan Liu, Peter B. Lillehoj  
**Title:** Embroidered Biosensors on Gauze for Rapid Electrochemical Measurements

**Abstract:** We report a unique process for fabricating robust, flexible electrodes onto medical gauze and wound dressing via embroidery. Embroidered electrodes were utilized as electrochemical biosensors for measurements of wound-related biomarkers. Proof-of-concept was carried out by performing quantitative measurements of uric acid, a biomarker for wound healing, in simulated wound fluid. This gauze-based sensor exhibits high specificity and linearity from 0 µM to 800 µM. Additionally, this biosensor exhibits excellent resilience against mechanical deformation, making it a promising platform for noninvasive wound monitoring.

*This work was supported in part by National Science Foundation CAREER award (ECCS-135056)*
Title: How do Humans Exploit Mechanical Redundancy when Faced with Increasing Task Difficulty?

Abstract: Humans can successfully perform goal-directed movements, even in the presence of redundancy at multiple levels. How the nervous system uses this redundancy when learning remains an open question. The uncontrolled manifold hypothesis (UCM) postulates that the nervous system exploits redundancy by allowing variability in the "null space" of the task while controlling the variability in the task space. The aim of our study was to test this hypothesis by examining how participants exploit variability in the null space, when faced with tasks of different difficulty. Participants performed a bimanual tracing task of a complex trajectory made up of several sinusoidal segments, and we varied task difficulty by adjusting the width of the “track” they were permitted to stay within. The mechanical redundancy in this task arose from the fact that the cursor used for the tracing was defined as the average position of the two hands. Two groups of 8 subjects each were tested on two different track widths and each subject performed 124 trials each day on a two-day schedule. We measured how redundancy is exploited by measuring the variability in the null space of the task. Our preliminary results show that null space variance reduces with learning, and had no correlation to changing trajectory widths. These results provide better understanding of how our nervous system resolves interlimb redundancy when learning and promotes development of novel methods in upper limb neurorehabilitation.

Poster Number: ME-24
Authors: Yifan Men, Guoming Zhu
Title: Model-based Calibration of the Reaction-based Diesel Combustion Dynamics

Abstract: A control-oriented reaction-based combustion model is implemented and used to simulate the combustion process in a diesel engine. The model integrates a homogeneous thermodynamic system with a two-step chemical reaction mechanism that consists of six species. The accuracy of the model is evaluated by comparing with experimental data from a GM 6.6 L, 8 cylinder Duramax engine. The model is calibrated for different key points over the entire engine map as well as various injection timings and exhaust gas recirculation (EGR) ratio using an automated calibration algorithm. The reaction based model is shown to provide accurate predictions of in-cylinder pressure, temperature, mass-fraction-burned and heat release rate. As an alternative to Wiebe-based method, this approach could lead to a better model with less calibration effort. The improvement is due to the fact that the burn rate is online calculated based upon the dominated fuel chemical components and combustion chamber properties, such as temperature, oxygen and burned gas concentration, etc.

This work was supported in part by General Motors Company

Poster Number: ME-25
Authors: Yen Nguyen, Thomas Pence, Indrek Wichman
Title: Crack Formation and Propagation in an Elastic Medium Undergoing Thermal Pyrolysis

Abstract: A theoretical and numerical model for the degradation of solid materials in combustion is developed. As solid materials are heated by the flame, they undergo an internal thermo-chemical breakdown process known as pyrolysis. As the pyrolysis front propagates into the sample, a charring layer is left behind which contains voids, fractures and defects. Cracks propagate to release tensile stresses accumulated when the sample is losing its mass. The crack front may precede the pyrolysis front into the sample. Crack patterns and fracture behaviors may vary depending on material properties and heating condition. Cracks cause loss of material integrity, forming isolated loops or fragments. They also concentrate the stresses and reduce the ability to withstand external loads. Cracks expose uncharred materials to flame, accelerating combustion. The process is highly nonlinear: crack patterns display fractal behavior. Two heating conditions along with various values of material strength are examined: each combination yields different crack patterns for which its morphological statistics are calculated using image analysis (computational diagnostics). Fundamental theoretical principles are uncovered.
**Poster Number:** ME-26  
**Authors:** Kyle O'Shea, Rebecca Anthony  
**Title:** Surface Treatment of Silicon Nanocrystals at Atmospheric Pressure  

**Abstract:** Silicon Nanocrystals (SiNCs) show great potential in applications as LEDS and other optoelectronic devices; properties such as photoluminescence (PL) and reflectivity indicate how effectively a SiNC sample behaves as an LED. Here, we synthesize SiNCs using a non-thermal plasma reactor consisting of Argon (Ar), Silane (SiH4), and Hydrogen (H2) gases. In particular, this study investigates the use of a dielectric barrier discharge (DBD) radio frequency (RF) reactor to generate a non-thermal argon plasma at atmospheric pressure which is used for additional treatment of SiNC samples deposited on a copper substrate. Rather than utilizing one positive and one negative electrode around the perimeter of a glass tube to generate a plasma, a DBD reactor uses a coiled electrode around the outside of the glass and a grounded electrode that runs down the center of the tube. The current study seeks to discover how additional surface treatment of SiNCs with a DBD reactor impacts their optoelectronic properties.

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**Poster Number:** ME-27  
**Authors:** Raul Quispe-Abad, Norbert H. Mueller  
**Title:** Exergy Approach to Evaluate the Performance of Unsteady Expansion Process in Rotors with Curved Channels  

**Abstract:** The Wave Disc Engine (WDE) is a novel idea among the wave rotor technology. This new engine concept is a radial rotor in which the typical processes of an Internal Combustion Engine (Compression, Combustion, and Expansion) are realized. For the torque production, the unsteady expansion process of outflowing combusted gases is used. The evaluation of the performance of torque generation for conventional turbines typically considers only steady effects and the efficiency method is based on the energy approach. For the unsteady expansion process, an unsteady component is added to this conventional analysis and because of that a different method to evaluate the efficiency is required. This research is focused on the evaluation of the performance of the unsteady expansion process by using the criterion of the Second Law of Thermodynamic efficiency. The combination of Computational Fluid Dynamic analysis and the Exergy approach, the efficiency is evaluated. Two findings will be pointed out: The percentages of the efficiency based on this new approach and the potential option that is brought out to improve the torque extracted. The outcome of this research contributes to maximizing the work extraction of Wave Disc Engine (WDE) technology. This will be a step forward to a near future of the fabrication of the WDE for portable and residential scale power generation.

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**Poster Number:** ME-28  
**Authors:** Matt Ryerkerk, Ron Averill, Kalyanmoy Deb, Erik Goodman  
**Title:** Length Niching Selection Operator for Metameric Genetic Algorithms  

**Abstract:** In many optimization problems one of the goals is to determine the optimal number of analogous components to include in the 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. Genetic 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 BEACON (An NSF Center for the Study of Evolution in Action)
Poster Number: ME-29
Authors: Alireza Safaripour, Anton Ryabtsev, Shahram Pouya, Marcos Dantus, Manoochehr Koochesfahani
Title: A Novel Vorticity Measurement Technique Using Laguerre-Gaussian Laser Beams with Orbital Angular Momentum

Abstract: Vorticity is one of the most important dynamic flow variables and is fundamental to the basic flow physics of many areas of fluid dynamics, including aerodynamics, turbulent flows and chaotic motion. Vorticity characterizes twice the local rotation rate of a fluid particle and is mathematically defined as the curl of the flow velocity vector. The most common vorticity measurement techniques rely on determining the velocity gradients from a measured velocity field to estimate the spatially averaged vorticity over a small region. This work presents a novel technique to measure the vorticity of a fluid flow in a direct and non-intrusive fashion. This technique utilizes a superposition of Laguerre-Gaussian (LG) laser beams focused inside the flow as an optical probe and takes advantage of the Rotational Doppler Effect (RDE) from seed micron-sized particles going through the beam focal volume. Sample experiments are performed to measure the vorticity in a fluid flow with a well-characterized vorticity field and the results are in excellent agreement with the expected values. This method allows for localized real-time determination of vorticity in a fluid flow with three-dimensional resolution.

This work was supported in part by Air Force Office of Scientific Research (AFOSR) FA9550-14-1-0312

Poster Number: ME-30
Authors: Mehdi Samiee, Mohsen Zayernouri
Title: A Fractional PDE Approach to Turbulent Mixing

Abstract: It has been experimentally and theoretically shown that even in the most ideal cases of homogeneous and isotropic turbulence, the statistical distributions are asymmetric and heavy-tailed. Similar observations, in addition to high peaks, have been made in grid turbulence and atmospheric boundary layer. In the aforementioned problems, the skewness, as a measure of asymmetry, is non-zero and negative, also the flatness (kurtosis), as a notion of the tail heaviness in the distribution, significantly exceeds the Gaussian value 3, reflecting a strong non-Gaussianity. In this talk, we demonstrate that the existence of such anomalous characteristics e.g., heavy tails, asymmetric distributions, and high peaks can naturally put the phenomenology of Taylor, Richardson, and Kolmogorov in broader framework, where the generalizing fractional Brownian motions and stochastic Lévy jump processes (or Lévy flights), investigated in the context of fractional PDEs in the fluid limit, can physically and mathematically explain, hence, predict the notion of anomalously enhanced (sub-to-super) diffusion and self-similar features in passive scalar turbulence.

We propose a generalizing fractional order transport model of advection-diffusion kind with fractional time- and space-derivatives, governing the evolution of passive scalar turbulence. This approach allows one to incorporate the nonlocal and memory effects in the underlying anomalous diffusion i.e., sub-to-standard diffusion to model the trapping of particles inside the eddied, and super-diffusion associated with the sudden jumps of particles from one coherent region to another. For this nonlocal model, we develop a high order numerical (spectral) method in addition to a fast solver, examined in the context of some canonical problems.

Poster Number: ME-31
Authors: Ayse Sapmaz, Brian F. Feeny
Title: In-plane Blade-hub Dynamics of Horizontal-axis Wind Turbine with Mistuned Blades

Abstract: Understanding vibration of the wind turbine blades is of fundamental importance. This poster regards the effect of blade mistuning on the coupled blade-hub dynamics. Unavoidably, at any stage of the wind turbine, the set of blades will not be precisely identical due to the in-homogeneous material, manufacturer tolerances etc. This poster is based on blade-hub dynamics of a horizontal axis wind turbine with mistuned blade. The equations of motion are derived for the wind turbine blades and hub exposed to centrifugal effects, gravitational and cyclic aerodynamic forces. The equations are coupled. To decoupled them, the independent variable is changed from time to rotor angle. The blade equations include parametric and direct excitation terms. The method of multiple scales is applied to examine response of the system. This analysis shows that superharmonic and primary resonances exist. Resonance cases and the relations between response amplitude and frequency are studied.

This work was supported in part by National Science Foundation under grant CMMI-1335177; Republic of Turkey / Ministry of National Education
Poster Number: ME-32  
Authors: Justin Scott, Tamara R. Bush  
Title: Pressure Ulcer Prevention in High Risk Individuals

Abstract: Many people sit in a chair for part of their day, getting up and adjusting themselves without a thought. But there are those who experience the complications associated with sitting in a chair all day on a regular basis. Pressure ulcers (PU) are wounds that can penetrate to the bone and are caused by a lack of nutrients to tissue. Their long healing time means the average cost of a hospital visit to treat a PU is $48,000 [1]. This does not consider lost work or deterioration of quality of life. The constant load on the buttocks and backs of wheelchair bound individuals put them at a high risk for developing PUs. External pressure diminishes blood flow to loaded areas, resulting in malnourished tissue and eventually tissue death. The 282,000 people [2] with spinal cord injuries (SCI) in the United States are prone to PUs. Another factor with SCI patients is that they cannot feel pressure points. They cannot feel discomfort after long periods of loading, nor can they adjust without thinking, making the formation of an ulcer more likely. The work aims to shift loading from the ischial tuberosities, a PU prone region, using an articulating chair to move the body. Cyclically loading and unloading tissues should reduce the chance of a PU in a specific region, such as the ischial tuberosities. [1] National Spinal Cord Injury Statistical Center, 2016. [2] Brem, H., et al. American Journal of Surgery, 200(4): 473-477, 2010.

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

Poster Number: ME-33  
Authors: Sheikh Mohammad Shavik, Lik Chuan Lee  
Title: Assessment of Organ-scale Left Ventricular Mechanics and Physiology using a Cellular-based Active Contraction Model

Abstract: Left ventricular (LV) finite element (FE) models based on cellular descriptions of active contraction are used increasingly to model ventricular mechanics associated with normal and abnormal heart functions. As the active contraction models were developed using data from single cell experiments, it is unknown if they are able to reproduce physiological behavior observed at the organ level. The goal of this work is to assess organ-scale physiological behaviors that are derived from a cellular-based LV FE model. The electro-mechanical model of LV was developed by coupling the cellular electrophysiology model of Winslow et al. (1999) with the active tension development model of Rice et al. (2008). This model was coupled to a lumped parameter closed-loop circulatory model that takes into account atrial contractions. Different loading conditions were simulated and the model predictions of (1) pressure-volume (PV) loops, (2) myocardial oxygen consumption (mVO2) and mechanical work relationship, and (3) three-dimensional strain were analyzed. The results show that the model is able to reproduce a linear end-systolic pressure-volume relationship (ESPVR) and a curvilinear end-diastolic pressure-volume relationship (EDPVR) using the PV loops generated under different loading conditions. The model prediction agrees with the linear relationship between mVO2 and PVA as observed experimentally. Finally, our model predicts that changes in the loading conditions affect the longitudinal, circumferential and radial strain behavior over the cardiac cycle. However, interestingly, the peak longitudinal and circumferential strain are less sensitive to the loading conditions than the radial strain.

Poster Number: ME-34  
Authors: Mayank Sinha, Alborz Izadi, Shwan Al-Howrami, Rebecca Anthony, Sara Roccabianca  
Title: Mechanical Characterization and Modeling of the Behavior of Nanocrystals-PDMS Bilayers

Abstract: A new approach to engineer the microstructure of functional materials is to use the formation of mechanical instabilities to initiate or moderate the microscale ordering of materials. While semiconductor nanocrystals (NC) are beginning to be used in stretchable devices, to date there are few studies on the mechanical behavior of NC on stretchable surfaces. We want to characterize the mechanical behavior of a bilayer of PDMS and NCs by experimentally observing stress-strain behavior of both the components. Two types of experiments are to be performed, a uniaxial tensile test and a nanoindentation test, to calculate the material properties of the bilayer depending on the geometrical characteristics of the NC film. PDMS and NCs both have highly non-linear behavior, with the former being extensively studied over the past 50 years. PDMS is generally defined as an isotropic, homogeneous, hyperelastic and incompressible material, and is characterized by strain energy functions defined for rubber-like materials. For silicon NCs, we propose to adopt different strain energy functions which have proven to be descriptive of elasto-plastic materials to fit the results obtained from the nanoindentation and uniaxial tensile tests.

This work was supported in part by NSF Award 1561964
Poster Number: ME-35  
Authors: Ruitao Song, Guoming Zhu  
Title: Control-oriented Model for a Gasoline Turbulent Jet Ignition Engine

Abstract: A control-oriented engine model is necessary for developing and validating the associated engine control strategies. For engines equipped with the turbulent jet ignition (TJI) system, the interaction between the pre- and main-combustion chambers should be considered in the control-oriented model for developing control strategies that optimize the overall thermal efficiency in real-time. Therefore, a two-zone combustion model based on the newly proposed parameter-varying Wiebe function is proposed. Since the engine uses the liquid fuel, a pre-chamber air-fuel mixing and vaporization model is also developed. The model was validated using the experimental data from a single cylinder TJI engine under different operational conditions, and the simulation results show a good agreement with the experimental data.

*This work was supported in part by US National Science Foundation and Department of Energy under contract number CBET-1258581*

Poster Number: ME-36  
Authors: Yifeng Tian, Farhad Jaberi, Daniel Livescu, Zhaorui Li  
Title: Shock-capturing Simulations of Variable Density Shock-turbulence Interactions

Abstract: The interaction between an isotropic multi-fluid turbulence with a planar shock wave is studied using turbulence resolved shock-capturing simulations. This problem is an extension of the canonical Shock-Turbulence Interaction (STI), with the effects of strong density variations (from compositional changes) taken into consideration. To establish shock-capturing simulation as a reliable method for studying STI, LIA convergence tests are conducted to show that LIA limits can be approximated at relatively high Reynolds number and low turbulent Mach number, when the separation between numerical shock thickness and turbulent length scales is adequate. This agrees well with previous DNS study. When variable density effects are introduced, turbulence structure is modified more by the normal shock, with a differential distribution of turbulent statistics in regions with different densities, resulting in a strong mixing asymmetry in the post-shock region. Turbulence achieves similar axisymmetric two-dimensional local state right after the shock wave in the multi-fluid case, but has a faster return to three-dimensional isotropic structure when compared to the single-fluid case. The characteristics of post-shock thermodynamic fluctuations are also affected and are dominated by shock strength fluctuations that result from the compositional changes.

*This work was supported in part by Los Alamos National Laboratory*

Poster Number: ME-37  
Authors: Tyler Tuttle, Alex Tyckoski, Anthony Tomaski, Sara Roccabianca  
Title: Comparison of Mechanical Properties of the Urinary Bladder Wall in Apex-to-base and Circumferential Directions

Abstract: The urinary bladder (UB) is a musculomembranous hollow organ whose main function is to store and void urine in a controlled manner. As urine is collected in the bladder, the bladder enlarges so that the internal pressure remains relatively constant. Alterations to this cycle, or obstruction of the urethral outlet, can cause a number of storage or voiding disorders. The parameter that urologists use to diagnose loss of functionality in the bladder is compliance (change in volume over change in pressure during filling). Compliance values have a wide range of “normality” reported in the literature. We submit that measurement of stress in the UB wall could be a better predictor of normal functionality of the bladder. For this reason, the focus of this study is to experimentally measure the mechanical properties of the UB wall. Specifically, four intact pig UB were collected from the MSU Meat Laboratory, then cleaned of contents and adjacent tissues. Four samples from each UB were harvested along the apex-to-base axis from four anatomical regions (dorsal, ventral, trigon, and lower body). Specimens were either tested fresh, or stored following three different storage protocols before testing. Samples were subjected to a uni-axial tensile test. The collected data was modeled using the constrained mixture theory. The data indicated that the storage protocols yield results that are not significantly different, mechanical responses are reproducible across pigs, and differences exist between anatomical locations in pig bladders. The model showed good predictive capabilities in pig UB.
Poster Number: ME-38  
Authors: Miao Wang, Xinran Xiao  
Title: A Multiphysics Microstructure-resolved Model for Silicon Anode Lithium-ion Batteries  

Abstract: Silicon (Si) is one of the most promising next generation anode materials for lithium-ion batteries (LIB), but the use of Si in LIBs has been rather limited. The main challenge is its large volume change (up to 300%) during battery cycling. This can lead to the fracture of Si, failure at the interfaces between electrode components, and large dimensional change on the cell level. To optimize the Si electrode/battery design, a model that considers the interactions of different cell components is needed. This paper presents the development of a multiphysics microstructure-resolved model (MRM) for LIB cells with a-Si anode. The model considered the electrochemical reactions, Li transports in electrolyte and electrodes, dimensional changes and stresses, property evolution with the structure, and the coupling relationships. Important model parameters, such as the diffusivity, reaction rate constant and apparent transfer coefficient, were determined by correlating the simulation results to experiments. The model was validated with experimental results in the literature. The use of this model was demonstrated in a parameter study of Si nanowall|Li cells. The specific and volumetric capacities of the cell as a function of size, length/size ratio, spacing of the nanostructure, and the Li+ concentration in electrolyte were investigated.

This work was supported in part by NSF CMMI 1030821

Poster Number: ME-39  
Authors: Yingxu Wang, George Zhu  
Title: Control on Apple Tree Watering System  

Abstract: A new method of planting apple trees is deployed at the Michigan State University Clarksville Facility, where the apple trees are planned with very high density in a way similar to grape vineyard on the farm. A watering and pesticide spray system is developed along the tree columns with hundreds sprayers. For the purpose of monitoring spray results and automatic control the spray process, a drone is modified to be equipped with both conventional HD and IR cameras and used to monitor the spray results based on the images from both HD and IR cameras; and wireless flow sensing system are under development and it will be used to make the spray process automated.

This work was supported in part by United States Department of Agriculture

Poster Number: ME-40  
Authors: Wei Li, David Torres, Tongyu Wang, Chuan Wang, Nelson Sepulveda  
Title: Flexible and Biocompatible Polypropylene Ferroelectret Nanogenerator (FENG): On the Path Toward Wearable Devices Powered by Human Motion  

Abstract: Recently, there has been tremendous research efforts on the development of energy harvesters that can scavenge energy from ubiquitous forms of mechanical energy. The most studied mechanisms are based on the use of piezoelectric and triboelectric effects. Polypropylene ferroelectret (PPFE) is introduced here as the active material in an efficient, flexible, and biocompatible ferroelectret nanogenerator (FENG) device. PPFE is charged polymers with empty voids and inorganic particles that create giant dipoles across the material's thickness. Upon applied pressure, the change in the dipole moments generate a change of the accumulated electric charge on each surface of the PPFE film, resulting in a potential difference between the two electrodes of the FENG. The mechanical-electrical energy conversion mechanism in PPFE films is described by finite element method (FEM). Further investigation of the developed device shows that the magnitudes of the generated voltage and current signals are doubled each time the device is folded, and an increase with magnitude or frequency of the mechanical input is observed. The developed FENGs is sufficient to light 20 commercial green and blue light-emitting diodes (LEDs), and realize a self-powered liquid-crystal display (LCD) that harvests energy from user's touch. A self-powered flexible/foldable keyboard is also demonstrated.

This work was supported in part by National Science Foundation (NSF ECCS Award \#1139773 (NSF CAREER Award) and \#ECCS-1306311)
Abstracts of the 2017 Engineering Graduate Research Symposium, Michigan State University

Poster Number: ME-41
Authors: Ce Xi, Lee Lik Chuan
Title: Finite Element Implementation and Analysis of a Structural Three-dimensional Constitutive Law for the Passive Myocardium

Abstract: A three-dimensional constitutive law is implemented in the left ventricle FE geometry. Its formulation is based on a structural approach in which the total strain energy of the tissue is the sum of the strain energies of its constituents: the muscle fibers, the collagen fibers and the fluid matrix which embeds them. The material law accounts for the specific structural and mechanical properties of the tissue, namely, the spatial orientation of the comprising fibers, their waviness in the unstressed state and their stress-strain relationship when stretched. Material parameters are adjusted and varied to analyze their influence on stress distribution and myocardium tissue properties.

Poster Number: ME-42
Authors: Peng Xu, Thomas Bieler, Neil Wright
Title: Monte Carlo Simulation of the Lattice Thermal Conductivity of Superconducting Niobium Thin Films

Abstract: Understanding the scattering mechanisms is essential for modeling the thermal conductivity of Nb in bulk or in thin films. Such models improve the design process for developing the next generation of Superconducting Radio Frequency (SRF) particle accelerators. Thermal conductivity is composed of electron and lattice components. In superconductors, these components are of the same order of magnitude. The conventional model of thermal conductivity in superconductors requires estimating several parameters from experimental results. Here, an energy-based variance reduced Monte Carlo simulation is used to predict the lattice thermal conductivity of bulk superconducting Nb as well as Nb thin film by considering phonon-electron scattering and boundary scattering. The model was first verified by comparing the predicted thermal conductivity in bulk Si and Si nanowires with experimental data. When applied to Nb, predictions of the temperature dependent thermal conductivity due to boundary scattering agree well with a kinetic theory model and with the experimental data. Results also show that boundary scattering dominates for T smaller than 2K where the phonon mean free path is comparable to the size of the sample, and that phonon-electron scattering is important when T is greater than 2K. A local maximum in thermal conductivity (i.e., the phonon peak) appears at temperatures of approximately 2 K in appropriately heat-treated material.

Poster Number: ME-43
Authors: Shutian Yan, Xinran Xiao
Title: Characterization of the Through Thickness Mechanical Property of Thin Polymer Films

Abstract: Thin polymer films have a wide range of applications. The mechanical properties of the films play an important role to their performances and functions. For example, porous thin polymer films are often the choice of materials for separators in Li-ion batteries. The mechanical integrity of the separator is critical to the durability and the safety of the batteries. To improve the separator design, it is desired to know the stresses experienced by a separator in a battery under different charging-discharging cycles and in the events of impact. Such information can be estimated through numerical simulations using multiphysics models. The stress-strain response of the separator is a required input. The in-plane stress-strain behavior of a thin polymer film may be measured using common lab equipment. The characterization of the through thickness mechanical properties is far more challenging. The battery separator is usually 20~30 micron in thickness. To obtain the stress-strain behavior, the displacement measurement must have a submicron resolution. In this work, we investigate a capacitance based displacement measurement method. Our preliminary study shows that this method can achieve a resolution of <0.5 micron. As shown in previous studies, both the in-plane and the through thickness mechanical properties are lower when tested in electrolyte solutions. Therefore, the mechanical properties measured in electrolyte solutions are used to represent the material behavior in the battery environment. In this work, a special testing fixture with capacitance based displacement measurement has been designed and used for through thickness behavior characterization in solutions.

This work was supported in part by National Science Foundation and General Motors
Poster Number: ME-44  
Authors: Yaozhong Zhang, Junghoon Yeom  
Title: Development of Soft-based Micromotors for Water Decontamination

Abstract: The pollution crisis derived from scalable use of chemicals and biologicals has greatly affected humans’ health and global economy in past decades, whereas the conventional wastewater treatment plants have a hard time cleaning those emerged contaminants. In this circumstance photocatalytic degradation is developed as one promising approach to remove water contaminants caused by organic compounds. Although a large number of nanoparticle- or nanopowder-based photocatalysts have been fabricated, the challenges such as easy-agglomeration and poor recyclability impede their practical application. Recently, the immobilized photocatalytic system, especially the micromotor strategy attracts considerable attention because the extendable configuration may address the abovementioned issues. For example the multifunctionality enables the micromotor freely swimming while decontaminating in water, where the self-propelled movement renders photocatalysts the continuous separation and achieves rapid pollutant degradation. Up to now, with the assistance of template the micromotors are fabricated in reliability and cost-effectiveness. However the limitations such as complicated instruments and poor geometry diversity still remain. Here we report a novel fabrication technique to create pollutant-degrading, self-propelled, micro soft-robots whose surface is decorated with the high surface-area, photocatalytic ZnO nanowire array. TiO2 and ZnO are the preferable photocatalysts due to their remarkable degradability and stability. The proposed micromotor is based on a sub-millimeter, hierarchical, self-folded polymeric structure integrated with functional inorganic nanomaterials that confer desired functionalities such as photodegradation and self-propulsion. To our knowledge, this type of micromotor platform has never been published, and we believe it would provide us with an opportunity to incorporate multiple functionalities.

Poster Number: ME-45  
Authors: Wu Zhou, Dahsin Liu  
Title: Analyzing Dynamic Fracture Process in Fiber-reinforced Composite Materials with a Peridynamic Model

Abstract: A bond-based peridynamic model was developed to study in-plane dynamic fracture process in orthotropic composites. The peridynamic material constant was extended to a continuous micro-modulus $C_\theta$ for orthotropic materials. $C_\theta$ changes continuously from the fiber direction to the transverse direction with an effective orthotropy. Moreover, this model investigated the impact dynamic fracture process by inputting the in-situ crack velocity related dynamic toughness for the first time. Besides the final failure status, the fracture process and crack velocity can be predicted more accurately by using the in-situ dynamic fracture energy. The simulation was validated by comparison to the experimental results.

This work was supported in part by US Army Research Laboratory (ARL); Department of Mechanical Engineering, MSU

Poster Number: ME-46  
Authors: Yifeng Tian, Farhad Jaberi, Daniel Livescu, Zhaorui Li  
Title: Shock-capturing Simulations of Variable Density Shock-turbulence Interactions

Abstract: The interaction between an isotropic multi-fluid turbulence with a planar shock wave is studied using turbulence resolved shock-capturing simulations. This problem is an extension of the canonical Shock-Turbulence Interaction (STI), with the effects of strong density variations (from compositional changes) taken into consideration. To establish shock-capturing simulation as a reliable method for studying STI, LIA convergence tests are conducted to show that LIA limits can be approximated at relatively high Reynolds number and low turbulent Mach number, when the separation between numerical shock thickness and turbulent length scales is adequate. This agrees well with previous DNS study. When variable density effects are introduced, turbulence structure is modified more by the normal shock, with a differential distribution of turbulent statistics in regions with different densities, resulting in a strong mixing asymmetry in the post-shock region. Turbulence achieves similar axisymmetric two-dimensional local state right after the shock wave in the multi-fluid case, but has a faster return to three-dimensional isotropic structure when compared to the single-fluid case. The characteristics of post-shock thermodynamic fluctuations are also affected and are dominated by shock strength fluctuations that result from the compositional changes.

This work was supported in part by Los Alamos National Laboratory