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Please visit our website for information on the annual MSU Engineering Graduate Research Symposium, including the most recent version of these abstracts: [www.tinyurl.com/EGRS2016](http://www.tinyurl.com/EGRS2016)
Poster Number: BAE-01
Title: Multiscale Spatial and Temporal Climate Change Impact Assessment on Water Resources in Malawi
Authors: Umesh Adhikari; A. Pouyan Nejadhashemi; Matthew R. Herman

Abstract: Global warming has altered the hydrological cycle and resulted in spatial and temporal variation in precipitation and temperature. Changes in precipitation pattern and subsequent alteration in temperature directly impacts crop production and ultimately threatens food security, especially in rainfed agricultural systems. This study examines how climate change impacts the hydrological components within Malawi in order to identify the vulnerable areas and formulate adaptation measures. Malawi is a country in southeastern Africa and is characterized by a high degree of dependency on rainfed agriculture, low level of irrigation development, and low adaptive capacity due to the lack of adequate technological and financial resources. The Soil and Water Assessment tool (SWAT) model was used to assess the potential changes in evapotranspiration, water yield, surface runoff, and soil moisture. The country was divided into nine watersheds, and for each watershed calibration and validation were performed. Observed weather data were used to simulate the historical (1981-2000) conditions, whereas, outputs from six General Circulation Models were used to evaluate the future climate change scenarios for the mid-century (2041-2060). SWAT simulation results from the historical and future scenarios were analyzed to assess seasonal and annual impacts of climate change on the water resources at the country, watershed, and the subbasin levels.

This work was supported in part by the Global Center for Food Systems Innovation at Michigan State University and funded through Higher Education Solutions Network of the United States Department for International Development (USAID).

Poster Number: BAE-02
Title: A Traditional Ground-Based System for Woody Biomass Harvesting in Short Rotation Woody Crops (SRWC) Plantations
Authors: Zachary Carter; Fei Pan; Yingqian Lin; Raymond Miller; Ajit Srivastava

Abstract: Reconfigured forage harvesting equipment utilized for plantation biomass harvesting and processing is highly productive but is expensive and not yet widely used in short rotation woody crop (SRWC) production systems. Traditional timber harvesting equipment, on the other hand, has been widely used for decades and can be adapted for use in SRWC plantations. Productivity of these traditional systems is not well understood when they are used in SRWC plantations. Productivity and costs were evaluated for a feller-buncher, skidder, loader, and grinder (the traditional system) in a 7.5 acre small-diameter hybrid poplar plantation in Escanaba, Michigan. Operation cycle time predictive models were developed from a time-motion analysis. Operation productivity and costs were then compared with published data for a reconfigured forage harvesting system. Compared values between the two systems included: machine hourly rate, in dollars per productive machine hour ($/PMH), the production cost, in dollars per oven dry ton ($/ODT), and the system production rate, in oven dry tons.
per productive machine hour (ODT/PMH). The machine hourly rate and production cost of the traditional system were found to be $349.00/PMH, and $19.90/ODT, respectively, while the production rate was found to be variable between 11.07-30.31 ODT/PMH. Other analyses performed on the traditional system including: a sensitivity analysis to test the effect of machine utilization on production cost, ANOVA tests to determine the effect of spacing and tree size on felling productivity, and also a net energy analysis to determine the energy ratio between diesel fuel inputs with recoverable energy outputs.

**Poster Number:** BAE-03  
**Title:** Modeling the Effect of Product Temperature, Moisture, and Process Humidity on Thermal Inactivation of Salmonella in Pistachios  
**Authors:** Kaitlyn Casulli; Francisco Garces-Vega; Kirk Dolan; Linda Harris; Bradley Marks

**Abstract:** Some thermal processes, like pistachio roasting, are not well-characterized with respect to the impact of product and process variables on Salmonella lethality. The objective was to quantify effects of product temperature, product moisture, and process humidity on Salmonella lethality on in-shell pistachios. Pistachios were inoculated with Salmonella Enteritidis PT30, equilibrated in controlled-humidity chambers (0.45 or 0.65 aw), and, in some cases, exposed to a pure-water or 27% NaCl brining treatment for 30 s (0.95 and 0.75 aw, respectively) prior to thermal treatment. Samples (15 g) were heated in a laboratory-scale, moist-air convection oven, following a full-factorial experimental design (in duplicate) with process temperatures of 104.4 and 118.3°C, process humidities of ~3, 15, and 30% v/v (corresponding to dew points of ~24.4, 54.4, and 69.4°C, respectively), and air speed of 1.3 m/s. Salmonella survivors, moisture content, and aw were quantified at six time points during each treatment, targeting cumulative lethality of ~3-5 log. Inactivation rates were modeled as a function of time, product temperature, product moisture, and process dewpoint. Increasing product temperature or process dewpoint increased Salmonella inactivation rates (P<0.05). For unbrined and brined treatments, analyzed separately, initial product aw did not affect inactivation rates (P>0.05). However, when comparing unbrined against brined treatments, inactivation rates were greater (P<0.05) for brined pistachios. Product and process moisture both impact pathogen reduction in low-moisture products, and this project quantifies those impacts for Salmonella inactivation in pistachios.

*This work was supported in part by Center for Produce Safety*

**Poster Number:** BAE-04  
**Title:** An Evaluation of the Influenza Risk Reduction from Antimicrobial Spray Application of Porous Surfaces  
**Authors:** Alexandre Chabrelie; Jade Mitchell; Joan Rose; Duane Charbonneau; Yoshiki Ishida

**Abstract:** Antimicrobial spray products are used by millions of people around the world, for cleaning and disinfection of commonly touched surfaces. Influenza A is a pathogen of major concern, causing over 36,000 deaths and 114,000 hospitalizations annually in the United States alone. One of the proposed routes of transmission for Influenza A is by transfer from porous and non-porous surfaces to hands and subsequently to mucous membranes. Therefore, routine cleaning and disinfection of surfaces is an important part of the environmental management of Influenza A. While the emphasis is generally on spraying hard surfaces and laundering cloth and linens with high temperature machine drying, this study examines the impact using an antimicrobial spray on a porous surface has on reducing the risk of
infection. A Quantitative Microbial Risk Assessment (QMRA) for a single touch resulting in direct contact with a treated, contaminated, porous surface is analyzed to determine the reduction in Influenza A risk associated with the measured viral inactivation. A comparison of the risk of infection with and without the use of the antimicrobial spray product has been done. The analysis indicates that Influenza infection risks associated with a single touch to contaminated fabrics are relatively high especially considering the potential for multiple touches in a real world scenario. However, use of the antimicrobial spray product resulted in a 4 log risk reduction. Thus the results of this study inform and broaden the range of risk management strategies for Influenza A.

This work was supported in part by External funding source: from the private company Procter & Gamble

Poster Number: BAE-05
Title: Sensitivity Analysis of Climate Change Impact on Macroinvertebrate Communities in the Saginaw River Watershed
Authors: Fariborz Daneshvar; A. Pouyan Nejadhashemi; Mohammad Abouali; Matthew R. Herman

Abstract: Aquatic ecosystems are vulnerable to climate change. However, these impacts especially on macroinvertebrate communities are unknown. In this study, three macroinvertebrate communities indices including Benthic Index of Biotic Integrity (B-IBI), Hilsenhoff Biotic Index (HBI), and the total number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa, were used to evaluate stream health conditions. Saginaw River Watershed, the largest 6-digit Hydrological Unit Code (HUC) in Michigan was selected as the study area. The Soil and Water Assessment tool (SWAT) model was used to evaluate in-stream water quality and quantity of 13831 stream segments within the study area. The SWAT model outputs were used to develop stream health models capable of predicting three macroinvertebrates indices. Then the climate data obtained from the NASA Exchange Global Daily Downscaled Projections (NEX-GDDP) were used to evaluate the impacts of future climate scenarios on the macroinvertebrate communities.

Poster Number: BAE-06
Title: Drought Impacts and Stream Ecosystem Functions
Authors: Elaheh Esfahanian; A. Pouyan Nejadhashemi; Mohammad Abouali; Fariborz Daneshvar; Alireza Ameli Renani; Matthew R. Herman; Ying Tang

Abstract: Droughts are the world’s costliest natural disaster, affecting water supply, crop yield, habitats, ecosystems, and many other social and economic sectors. Numerous drought indices have been developed to assess the spatial and temporal extends of droughts. However, the majority of indices are only sensitive to drought impacts on crop production and loss, neglecting other aspects of environmental sustainability such as stream health. Droughts damage aquatic ecosystems by altering native biological communities such as fish assemblages. The goal of this study is to develop a new index that quantifies the impacts of drought on stream ecosystems. A hydrological model, the Soil and Water Assessment tool, was coupled with a regional-scale habitat sustainability model to investigate the drought condition at the watershed scale in the Saginaw River Watershed. The ReliefF algorithm was used as the variable selection technique to select the best variables. Two sets of predictive drought models were developed using partial least square regression to capture current and future drought severities. Forty-seven different climate scenarios were used to evaluate the performance of predictive drought model. Key words: Great Lakes; Stream Health; Climate Change; Risk
**Poster Number:** BAE-07  
**Title:** Evaluation of Water Content as a Convenient Metric in Thermal Inactivation Modeling for Low-Moisture Foods  
**Authors:** Francisco J. Garcés-Vega; Bradley P. Marks

**Abstract:** The Food Safety Modernization Act Preventive Controls Rules require validation of pathogen reduction steps in the food industry, which increases the importance of microbial modeling for process validations. Water activity (aw) has been the most commonly used metric for evaluating and modeling the effect of water on Salmonella inactivation in low-moisture foods. However, because of the nature of these products and processes, as well as the aw correlation with temperature, it may not be the most suitable metric. The objective was to compare the correlation of moisture content (%MC) and aw with D-values (i.e., thermal resistance), to evaluate the utility of %MC as a metric in inactivation models. D80°C for Salmonella Enteritidis PT30 were calculated by linear regression of isothermal inactivation data from multiple related studies (wheat flour, almonds, dates; 0.25, 0.45, 0.65 aw). Water activity and %MC were measured or calculated from moisture isotherms. Correlation coefficients were estimated between logD and aw and %MC. The D80°C values for the different products exhibited log-linear trends with aw, as well as with %MC. The correlation coefficients varied less than 5% when comparing aw and %MC vs. logD. The results suggest that %MC may be a suitable metric for the effect of water on inactivation process. When comparing the utility of aw vs. %MC for inactivation modeling or process validation, %MC has the advantage of being measurable (potentially real-time in dynamic processes). This is critically important to both monitoring and modeling inactivation processes in low-moisture foods.

*This work was supported in part by USDA-NIFA grant 2011-51110-30994*

**Poster Number:** BAE-08  
**Title:** Electrocatalytic Upgrading of Lignin Model Compounds Using Ruthenium on Activated Carbon Cloth to Produce Liquid Fuel Intermediates  
**Authors:** Mahlet Garedew; Leonardo Sousa; James E. Jackson; Christopher M. Saffron

**Abstract:** With current energy crisis and the implication of burning fossil fuels as one of the major contributors to climate change, the production of fuels from biomass has become a very important current topic. Biomass fast pyrolysis (BFP), which uses heat (400-600°C) without oxygen to convert biomass to bio-oil, biochar and combustible gas, offers an alternative to fossil fuels and a means to alleviate the environmental impact of fossil fuel use. The biochar co-product can be used for the removal of pollutants in the environment and has potential for use in soil amendment and carbon sequestration. The combustible gas co-product is typically burned for process heat needed by the pyrolysis system. The major product, bio-oil, has the potential to displace liquid hydrocarbon fuels; however, bio-oil is highly oxygenated, corrosive, low in energy content and unstable during storage. Electrocatalytic hydrogenation (ECH) is employed to reduce and deoxygenate reactive compounds and improve bio-oil properties. This study focuses on the electrocatalytic stabilization of compounds derived from the pyrolytic depolymerization of lignin. to date, several model monomers and dimers have been reduced to simpler compounds such as cyclohexanol and phenol using ruthenium on activated carbon (Ru/ACC) as a catalyst. Further studies in this area have also been conducted to improve catalyst performance and reusability. With the combination of pyrolysis and electrocatalysis, this process will maximize the yields of biomass conversion to fuels and value-added products.
This work was supported in part by Great Lakes Bioenergy Center (GLBRC) funded by the Department of Energy (DOE)

**Poster Number:** BAE-09  
**Title:** Using an Evolutionary Algorithm to Optimize Bioenergy Crop Selection and Placement Based on Stream Health  
**Authors:** Matthew Herman; Pouyan Nejadhashemi; Fariborz Daneshvar; Mohammad Abouali; Dennis Ross; Sean Woznicki; Zhen Zhang

**Abstract:** Greenhouse gas emissions continue to intensify the magnitude of global climate change. In order to reduce these emissions, focus has been put on the development of renewable energy sources, such as biofuels. And while the use of biofuels can reduce global net greenhouse gas emissions, their application can have negative impacts on water resources, such as increased sediment, nutrient, and pollutant loads. Therefore it is necessary to evaluate both the positive and negative impacts of bioenergy crop production when considering their application to a landscape. In this study, a new optimization technique is introduced that can be applied to any region to identify the best locations for bioenergy crop implementation while maintaining or improving stream health. This new technique links several hydrological models including the Soil and Water Assessment tool and Hydrologic Integrity tool to develop stream health predictor models using the Adaptive Neruro Fuzzy Inference System. The stream health models, based on the Index of Biological Integrity, can simulate the stream health scores for each river segment in a watershed. These health scores were used to guide a genetic algorithm to design watershed-scale bioenergy landscapes for the agricultural lands within the Flint River Watershed in Michigan.

*This work was supported in part by USDA National Institute of Food and Agriculture, Hatch project MICL02359*

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**Poster Number:** BAE-10  
**Title:** Detection of Fresh Bruises in Apples Using Structured-Illumination Reflectance Imaging  
**Authors:** Richard Li; Renfu Lu

**Abstract:** Apple bruise can cause a significant economic loss to the industry because consumers typically avoid buying bruised fruit and thus, the apples go to waste. Conventional machine vision is ineffective in detecting bruises on apples, especially those bruises that are within 24 hours old. In this research, structured-illumination reflectance imaging (SIRI) was developed for detecting tissue bruising in apples. SIRI provides the ability to control the depth to which light penetrates tissue through varying the spatial frequencies of the light illumination patterns. Light, medium and heavy impacts were applied to ‘Delicious’ and ‘Golden Delicious’ apples for inducing different levels of bruises. Under illumination of sinusoidal patterns at each spatial frequency of 0.1, 0.15 and 0.25 mm/cycle, three images were acquired from the bruised apples using phase shifts of 1200 0-1, 4-6 and 24 hours after initial impact, and they were then demodulated for each spatial frequency into direct and alternating components. Ratio images of demodulated alternating components and direct components were created to enhance bruise contrast. A circular Hough transform was then applied to detect bruised regions. SIRI achieved detection accuracies ranging from 85% to 100% on bruises aged 0-1 hours, 90% to 100% on bruises aged 4-6 hours and 75% to 100% in 24 hour old bruises, compared to 5% to 25% for conventional planar illumination. SIRI is promising as a novel and cost effective alternative to conventional machine vision.
technique for quality detection of agricultural and food products, and its full potential warrants further research.

This work was supported in part by U.S. Department of Agriculture Agricultural Research Service as an in house research project

Poster Number: BAE-11
Title: Moisture Equilibration and Product Fabrication Methods Affect Measured Thermal Resistance of Salmonella Enteritidis PT30 on/in Whole Almonds, Almond Meal, and Almond Butter
Authors: Pichamon Limcharoenchat; Michael James; Nicole Hall; Bradley Marks

Abstract: Recent work has suggested that changing the structure of low-moisture food products, with equivalent composition, may affect the thermal resistance of Salmonella in/on those products; however, the underlying effects of sample preparation (equilibration and fabrication) have not been systematically evaluated. The objective was to quantify the effect of product equilibration and fabrication on Salmonella thermal resistance on/in multiple almond products. Whole raw almonds were inoculated with Salmonella Enteritidis PT30 (~108 CFU/g) and equilibrated (3-10 days) to 0.25, 0.45, or 0.65 aw (triplicate tests). Inoculated and equilibrated almonds were individually vacuum-packed in plastic bags or fabricated into meal and butter that was loaded into aluminum test cells (~1 g samples). Samples were heated in an isothermal water bath (80°C), pulled at multiple intervals, cooled in an ice bath, diluted in peptone water, and plated on modified trypticase soy agar to enumerate survivors. Although aw of almonds appeared to reach equilibrium after 3-5 days (by aw meter readings), the moisture content (mc) of the meal and butter fabricated from that product were significantly (P < 0.05) lower or higher than the almond mc for adsorbing (0.65 aw) and desorbing (0.25 aw) conditions, respectively, indicating that full equilibration had not been achieved. However, for 0.25 aw, after 8-10 days of equilibration, the resulting meal and butter were at the same mc as the almonds, but aw was higher (P < 0.05) for meal (0.29) than butter (0.22) and almonds. Subsequently, the D80°C value on whole almonds (19.7 min) was lower (P < 0.05) than in meal (50.8 min) and butter (48.3 min). Equilibration state impacted aw changes in fabricated almond products, and product structure may be significantly important when applying inactivation parameters to process validations.

This work was supported in part by The U.S. Department of Agriculture, National Institute of Food and Agriculture, Award No. 2012-67005-19598

Poster Number: BAE-12
Title: Willow Harvesting Using A Small-Scale System in Michigan
Authors: Yingqian Lin; Fei Pan

Abstract: Electricity production from renewable sources has been steadily increasing in Michigan since 2009. The large areas of pasture and hayland available in Michigan present a unique opportunity for the potential development of Short Rotation Woody Crops (SRWC). For SRWC to be competitive with fossil fuels and other forms of renewable fuels, the machinery cost and harvesting productivity of reconfigured forage harvester must be evaluated. In this project, a small-scale harvesting system, including a John Deere 7330 tractor, a Ny Vraa JF192 willow harvester, and a Komatsu CK35-1 bobcat, was evaluated in a 3-year-old willow plantation in Michigan. The production rate of the harvesting system was determined to be 3.94 dry tons/hr. with an estimated hourly cost of $52.18/dry ton. The net

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energy ratio (calculated as recoverable heating value of the biomass over fossil fuel input) was calculated to be 18.43. Data envelopment analysis (DEA) will be used to measure the efficiency of this small scale harvesting system and to suggest the best direction for improving the harvesting systems efficiency.

This work was supported in part by Michigan State University

Poster Number: BAE-13
Title: Rapid Detection of Pathogenic Bacteria Using Affixed Carbohydrate-Functionalized MNP and Cyclic Voltammetry Detection
Authors: Leann Lerie Matta; Evangelyn C. Alocilja

Abstract: Protection against foodbourne outbreaks from pathogenic bacteria is an important consideration throughout the entire food supply chain. Early and reliable detection provides both consumer food security and supplier economic safety. Novel carbohydrate-functionalized magnetic nanoparticles (MNP-F#2) are able to selectively bind to pathogenic bacteria and quickly extract captured bacteria from solution through magnetic separation. Affixing these MNP-F#2 to plastic strips provides a stand-alone nano-biosensor which can rapidly quantify the bacteria. MNP-F#2 affixed to 1 cm x 5 cm plastic strips through a heat process were used to detect Salmonella Enteritidis (Se) thru submersion within 25 mL of spiked liquid or direct application of 100 uL culture onto the functionalized surface. Bacteria were quantified using cyclic voltammetry (CV) testing by laying the MNP-strip face down into 150 uL of a chemical mediator for five minutes before testing 75 uL of the activated chemical. Results show detection for as few as log 3 colony forming units per mL (log CFU/mL), showing a linear relation between log 3 to log 5 CFU/mL. Application of these self-contained nano-biosensors for real-time detection of pathogenic bacteria within our food supply would increase food security at minimal costs to the consumer.

This work was supported in part by MRIVCC

Poster Number: BAE-14
Title: Pasture Diversification to Combat Climate Change Impacts on Grazing Dairy Production
Authors: M. Melissa Rojas-Downing; A. Pouyan Nejadhashemi; Mohammad Abouali; Fariborz Daneshvar; Sabah Anwer Dawood Al Masraf; Matthew Herman; Timothy Harrigan; Zhen Zhang

Abstract: Livestock systems are being impacted by climate change, mainly due to the seasonal variability in temperature and precipitation. Among these systems, grazing livestock is likely to be the most impacted due to its dependency on feed quality and availability of pastureland. Therefore, adaptation strategies should be implemented to reduce the negative impacts of climate change. The goal of this study is to identify the best pasture composition for a representative grazing dairy farm in Michigan. The representative farm was established based on the results from several surveys that were performed in the Lower Peninsula regarding typical management strategies. Next the collected information was incorporated into the Integrated Farm System Model (IFSM) to evaluate the effectiveness of the adaptation strategy concerning economic and resource use criteria. Several pasture compositions were evaluated in this study consisting of a mixture of cool-season grass species (Orchardgrass, Perennial ryegrass, Kentucky bluegrass and, Tall Fescue) and legume species (white clover and red clover). Each pasture composition was evaluated under both current (21 climate models) and future (42 climate
models) climate scenarios. Considering the economic and resource use criteria, the best pasture composition was identified as a mixture of 50% perennial ryegrass and 50% red clover.

This work was supported in part by Environmental Science and Policy Program

Poster Number: BAE-15
Title: Biomass Conversion to Hydrocarbon Fuels by Pyrolysis and Electrocatalysis
Authors: Rachael Sak; Christopher Saffron; Matt Brusstar; Sharyn Lie; Bob Larson

Abstract: The objective of my research is to facilitate the expansion of biooil production by overcoming its corrosivity and instability. This would promote biomass pyrolysis in small-scale upgrading depots near the source of harvest by allowing it to be transported within current infrastructure to a centralized refinery for further upgrading. Previous approaches have partially separated out the water fraction from biooil prior to stabilization efforts — this research is exploring stabilization without this added step. As part of this research, a comprehensive life cycle analysis will be conducted that will include addressing the impacts of marginal land assumptions, indirect land use change, and global economic impacts. Indirect land use change is of particular concern because it has the potential to overwhelm the carbon sequestration benefit of biomass and to nullify any anticipated gain for many years.

This work was supported in part by Environmental Protection Agency

Poster Number: BAE-16
Title: Scalability of A Discrete Element Model for Salmonella Cross-Contamination in Granular Low Water Activity Foods
Authors: Quincy Suehr; Bradley Marks; Elliot Ryser; Sanghyup Jeong

Abstract: Modeling cross-contamination of bacteria in granular low-moisture foods is a particular challenge due to the discrete nature of these materials. Scaling-up models based on laboratory data to industrial-scale system is limited because of the lack of first-principle models. Ideal cross-contamination models should enhance scalability, so that it can be utilized for industrial systems without validation burden. The purpose of this study was to assess the scalability of a discrete element method (DEM) model of bacterial cross-contamination to industrial-scale systems. Almond kernels were inoculated with Salmonella Enteritidis PT30 and mixed with clean almonds in a rotating drum at a bench top scale of ~200 g (5 g of inoculated almonds). A DEM bacterial transfer model was developed from these results and validated against a pilot-scale model of ~1 kg. After validation, the model was used to simulate an industrial-scale scenario of ~200 kg of almonds mixed with 5 kg of contaminated almonds. The lab-scale experiments yielded 4.3±0.2 log(CFU/g) maximum transferrable bacterial load (MTBL) after 600 s at 8 rpm. Calibration models of the experiment were fit to the data (RMSE=0.005 log CFU/g) and validated with pilot-scale data sets (RMSE=0.057 log CFU/g). The results for the 200 kg mixer simulated similar trendline as actual experiments, showing MTBL of 4.1±0.1 log(CFU/g) after 600s at 8rpm, and demonstrated scalability of the DEM model. DEM modeling is an efficient and scalable method to model interactions of cross contamination in industrial settings.

This work was supported in part by USDA AFRI
**Chemical Engineering**

**Poster Number:** CHE-01  
**Title:** Synthesis of Biobased Polyols from Soymeal and Its Application in Polyurethane Rigid Foam  
**Authors:** Sayli Bote; Daniel Graiver; Ramani Narayan

**Abstract:** There is a considerable interest in the manufacture of biobased plastics using plant-biomass feedstock (e.g. Ford Motor Company’s biobased PUs). At present, biobased PUs are derived from plant oil (e.g. soybean oil) polyol. Ford uses plant oil biobased polyol at 7-15% in the manufacturing of bio-PUs for headrests and seats. There are many reports in the literature on the synthesis of polyols from biobased sources, mostly from plant oils. Since, multiple steps are involved in the manufacturing of polyols from plant oil, their cost is relatively high. Polyols derived from plant oils have been introduced into the urethane market but most of them have low hydroxyl value and secondary hydroxyl structure which is less reactive. In this work, we have used protein-biomass residue (soymeal) remaining after extraction of oil from soybean for manufacturing of biobased polyols. The soymeal was used directly without any pre-treatment for the synthesis of polyols using transamidation process. Soymeal was reacted with ethanolamine to give hydroxylamine (major) and diamine (minor) intermediates. The parameters like time, temperature, reactants ratio and kinetics of this reaction were studied. The amine intermediates were converted to polyols by reacting them with propylene carbonate. The obtained soymeal polyol was characterized for hydroxyl value, amine value, viscosity and percent insoluble. This soymeal polyol was used to study free rise profiles of polyurethane rigid foam. The above process can be used for any protein biomass residues (e.g. algae, DDGS). These polyamide polyols have primary as well as secondary hydroxyl group and are less susceptible to degradation by UV-light and hydrolysis than polyether or polyester polyols. Also, soymeal polyol has some primary and secondary amines which reduces amount of catalyst used for making polyurethanes. In future, we are going to study the kinetics of amines and propylene carbonate reaction, evaluate mechanical properties of rigid foam made from soymeal polyol.

**Poster Number:** CHE-02  
**Title:** Toughening of Carbon Fiber-Reinforced Epoxy Polymer Composites Utilizing Fiber Surface Treatment and Sizing for Aerospace and Automotive Applications  
**Authors:** Markus Downey; Lawrence Drzal

**Abstract:** While composite materials have long been used in the aviation industry, a much larger market is opening up in the automotive industry in an effort to meet government fuel economy standards by reducing vehicle weight. With many positive attributes such as high strength-to-weight ratio and corrosion resistance, carbon fiber epoxy composites are appealing for such light-weighting applications. Their brittle nature, i.e. lack of toughness is however still an issue. While toughening fiber-reinforced epoxy composites is fairly straightforward, simultaneously maintaining other mechanical properties represents a significant challenge. This research presents an approach of enhancing the toughness of a DGEBA/mPDA-based carbon fiber-reinforced epoxy composite, without significantly reducing the static-mechanical properties such as flexural properties and glass transition temperature. The research focuses on engineering the interphase of the composite to increase the fiber/matrix adhesion. The impact of combining an UV-ozone fiber surface treatment with an aromatic and aliphatic epoxy fiber sizing on composite toughness is investigated. The Mode I composite fracture toughness was enhanced by 23%
for the UV-ozone fiber surface treatment alone. With the addition of an aromatic and aliphatic fiber sizing, the composite fracture toughness was further increased to 50% and 84% respectively over the as-received, unsized fiber. The increased fiber/matrix adhesion also improved the transverse flexural strength. The higher toughness composite can either be used as a cost-reduction measure by reducing the amount of material needed or to engineer a larger safety margin for a given application. 

*This work was supported in part by General Electric Aviation*

**Poster Number:** CHE-03  
**Title:** Transport Limitations in Nanoscale Scaffolds for Multistep Catalytic Reactions  
**Authors:** Erica Earl; Scott Calabrese Barton

**Abstract:** Catalysts are used in a multitude of ways ranging from energy conversion to the production of materials. Highly efficient catalytic designs are found in nature, particularly in cells, which contain multi-step metabolic pathways where series of biochemical reactions catalyzed by enzymes take place. The efficiency of the system is maximized by substrate channeling, wherein the product of one enzyme is transported to a second enzyme in series to act as a reactant. Modes of substrate channeling include proximity between active sites, geometric confinement of the intermediate, electrostatic interactions and surface adsorption. We investigate the efficiency of these pathways through numerical modeling, to identify their limits and the extent to which they can work together. 

*This work was supported in part by Army Research Office via University of Utah: Multi-University Research Initiative (MURI)*

**Poster Number:** CHE-04  
**Title:** Using Protein Design to Evaluate the Relationship Between Protein Surface Potential and Lignin Adsorption for the Discovery of Cellulases with Reduced Lignin Binding  
**Authors:** Carolyn Haarmeyer; Matthew Smith; Shishir Chundawat; Deanne Sammond; Timothy Whitehead

**Abstract:** The increasing demand for renewable, non-petrochemical based sources of fuels and chemicals drives research towards energy production from lignocellulosic biomass. Although lignocellulosic biomass can be converted to value-added products, high production costs associated with the cellulase related deconstruction step impede the implementation of lignocellulosic biofuel production. Recent evidence clearly suggests that lignin, a biopolymer responsible for plant defense, hastens cellulase denaturation by adsorbing onto cellulases. In the present work, we have investigated protein-lignin adsorption using a monomeric enhanced Green Fluorescent Protein (meGFP) as a model protein system. We have designed and constructed meGFP variants with varied surface potentials such as net charge or surface hydrophobicity. These variants have comparable expression and thermostability to native meGFP. Quantification of adsorption between these variants and AFEX pretreated, dioxane extracted cornstover lignin has highlighted a possible relationship between meGFP net charge and meGFP lignin binding. Analysis of parallel datasets with other protein targets supports this relationship and suggests the importance of cellulase net charge in lignin adsorption. 

*This work is funded through grant # 1236120 from the National Science Foundation. Additionally, some of this work is supported by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists, Office of Sci*
Poster Number: CHE-05
Title: Investigating High Density Polyethylene – Graphene Nanoplatelet Composites for the Production of Fuel Lines and Fuel Tanks
Authors: Keith Honaker; Frederic Vautard; Lawrence Drzal

Abstract: Graphene nanoplatelets (GnP) of different sizes and surface areas were investigated for their ability to modify HDPE for potential fuel system applications focusing on the use of melt mixing in a twin-screw extruder. The mechanical properties (flexural modulus and strength at yield, Izod impact resistance), crystallinity of the polymer matrix, and permeation to oxygen and fuel were assessed as a function of the GnP concentration. The surface of the GnP particles acted as a nucleation site for the generation of HDPE crystallites, increasing the level of crystallinity of the polyethylene matrix. The flexural properties were improved, clearly influenced by the platelet size and quality of dispersion. A sharp, 46% decrease of the impact resistance was observed, even at very low GnP concentration (0.2 wt. %). With a 15 wt. % GnP-M-15 (platelets with a 15 micron diameter), a 73% reduction in oxygen permeation was observed and a 74% reduction in fuel vapor transmission. This correlation was similar throughout the GnP concentration range. The smaller diameter platelets had a lesser effect on the properties than GnP-M-15.

This work was supported in part by Hyundai-Kia America funded this project.

Poster Number: CHE-06
Title: Nanoscale Toughening of Carbon Fiber/Epoxy Composites Modified with a Self Assembling Block Copolymer
Authors: Nicholas T. Kamar; Lawrence T. Drzal

Abstract: Carbon fiber/epoxy composites (CFRPs) are used to reduce weight and maintain strength and stiffness for structural applications in aerospace and automotive industries. However, their cross-linked polymer matrices are brittle and have a low resistance to crack initiation and propagation. Therefore, this work investigated the processing and property characterization of hierarchical CFRPs modified with a thermoplastic elastomer. We explored the influence of both a reactive epoxy/amine fiber sizing and a block copolymer additive to the matrix. The triblock copolymer poly(styrene)-block-poly(butadiene)-block-poly(methylmethacrylate) (SBM) self assembles on the nanoscale within the epoxy matrix prior to layup and cure of the modified CFRPs. Mode-I fracture toughness testing revealed a 290% increase in GIC at 10 phr SBM. Scanning electron microscopy of double cantilever beam fracture surfaces identified the toughening mechanism as cavitation of sub 100 nm spherical micelles followed by void growth of epoxy and concomitant matrix shear yielding. Interestingly, the mechanical and thermomechanical properties of the composites were not found to decrease with increasing concentration of SBM for either longitudinal or transverse fiber directions.

This work was supported in part by GE Aviation

Poster Number: CHE-07
Title: Rapid Fine Conformational Epitope Mapping using Comprehensive Mutagenesis and Deep Sequencing
Authors: Caitlin Kowalsky; Timothy Whitehead

Abstract: Knowledge of the fine location of neutralizing and non-neutralizing epitopes on human pathogens affords a better understanding of the structural basis of antibody efficacy, which will expedite rational design of vaccines, prophylactics, and therapeutics. Conformational epitope mapping of a monoclonal antibody to its target is typically done after lead candidate generation. The reason for this is because current methods of epitope mapping are laborious and expensive. Full utilization of the wealth of information from single cell techniques and antibody repertoire sequencing awaits the development of a high-throughput, inexpensive method to map the conformational epitopes for antibody-antigen interactions. We have developed a novel method for rapid determination of fine conformational epitopes. This platform technology involves deep sequencing of yeast displayed antigen libraries and analytical equations to identify epitope positions. We show the methods effectiveness by determining critical (and previously unknown) neutralizing epitopes for pertussis toxin and a breast cancer target. We further show the implications of this method for structural-based vaccine design and antibody-antigen computational docking.

This work was supported in part by This work was funded by an NSF CAREER award (CBET-1254238) and a National Institutes of Health Award (5R21CA176854-02).

Poster Number: CHE-08
Title: Effects of Low Dimensionality on Properties of thermoelectrics
Authors: Shannon Kraemer; Winston Carr; Jared Williams; Donald Morelli; Viktor Poltavets

Abstract: A study on the effects of low dimensionality in composites and singular materials was carried out to investigate the effects on thermoelectric properties. It is proposed that with the correct set of guidelines bulk composite materials can achieve quantum confinement, inherently increasing the Seebeck coefficient through a band structure effect. For this study, the binary system, Pb1-xNaxTe-Cd1-xNaxTe, was chosen based on those guidelines. A solid state chemical approach was employed to produce bulk quantities of nanostructures that would mimic the key features of quantum well superlattices, thus resulting in quantum confined system. This study led to an investigation of the effects of different solid state synthetic methods, which includes comparing aqueous based techniques versus inert atmosphere techniques, on the thermoelectric properties of the materials.

Poster Number: CHE-09
Title: Efficient TiO2 Photocatalytic Films Made with Micro/Nano-Fibrillated Cellulose Templating
Authors: Yan Li; Lawrence T. Drzal

Abstract: A simple and cost-effective method of using micro/nano fibrillated cellulose as templates to create nano porosity in a thin film photocatalyst is being investigated. The templating was based on a modified liquid phase deposition (LPD) approach, combined with direct precursor coating of titania precursor followed by calcination. An optimized solvent composition of isopropanol/water ratio of 4 to 1 was found to yield coatings with uniform sphere-shaped TiO2 possessing a chain-like morphology oriented along the axis of the heat-removed cellulose fibers. The materials were characterized by means of scanning electronic microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), X-ray photoelectron spectroscopy (XPS), transmission electronic microscopy (TEM), raman spectroscopy, fourier transform infrared (FTIR) spectroscopy and X-ray diffraction (XRD). Additionally, thermal analysis
(TGA) was used to quantify the heating/calcination process during which the cellulose templates decomposed. Photocatalytic activity of the nano-chained titanium dioxide was investigated by monitoring the degradation of methyl orange (MO) with the use of quantitative diffuse reflectance uv-vis spectroscopy. The enhancement in photocatalytic performance was explained in terms of the surface area, pore size, and the special morphology. The three-dimensional web structure with pseudo one-dimensional sphere-chain could possibly retard the recombination of photo-generated electron-hole pairs and improve the charge transport. An increase of decomposition rate was found when the sample was compared with the traditional water-base precursor. Compared to other current TiO2 photocatalytic films, its time-efficiency was improved as well.

**Poster Number:** CHE-10  
**Title:** Thinner and Stronger Microporous Membranes for Batteries By Die Drawing  
**Authors:** Xinting Lin; K. Jayaraman

**Abstract:** Microporous polypropylene membranes are currently used as separators between electrodes in electric vehicle batteries. With the increasing demand for compact batteries, there is a need to make these membranes thinner (reduced by a factor of 2 or more) while retaining or increasing the stiffness and resistance to puncture of such membranes. Highly oriented porous sheets can be produced from solid phase die drawing of polymer composites below the melting temperature. Talc filled polypropylenes with two different grades of talc having different particle size distributions and different mean particle sizes at the same filler loading of 50 wt% or 23 vol% were drawn in the solid phase through a converging die at 128°C. The highest draw speed that could be achieved at 128°C for the composite with the lower mean particle size was twice the maximum speed that could be achieved with the other composite. The higher maximum draw speed for the composite with a greater fraction of smaller particles may be attributed to greater tensile strength during drawing from the reinforcement provided by the undebonded particles. These findings indicate a simple method to increase the tensile strength and stiffness of the polymer composites porous sheets while maintaining a high porosity with the help of an optimum fraction of smaller particles that will not be debonded during die-drawing. The authors are pleased to acknowledge assistance from Kevin Nichols of Eovations LLC with the experimental setup.

*This work was supported in part by BASF*

**Poster Number:** CHE-11  
**Title:** Molecule Dynamics Simulation on Substrate Transport on Alpha-Helix Peptide for Multistep Catalysis  
**Authors:** Yuanchao Liu; Scott Calabrese Barton

**Abstract:** Substrate channeling is a key step in multi-step catalysis, involving intermediate transportation between catalysts (e.g., enzyme, metal, TEMPO). [1] Polypeptides are the basic components of protein biomolecules and can also be the enzyme linker, contributing to substrate oxidation either through bulk or surface diffusion. [2]. Therefore, the study on intermediate/peptide interaction can give us further understanding on catalysis cascade. In this project, we are going to study the surface transportation of intermediate molecules on a-helix peptide [3], aiming to discover and design appropriate secondary structure favorable to substrate channeling or even tunneling effect. Based on this, the surface diffusivity, sorption energy and adsorption/desorption rate of intermediate molecules will be calculated.

This work was supported in part by ARO MURI for Multistep Catalysis.

Poster Number: CHE-12
Title: Design and Synthesis of Polydimethylsiloxane Polyester Polyol That Contains Biobased Content for Polyurethane Foam Applications
Authors: Hugh MacDowell; Ramani Narayan

Abstract: Polydimethylsiloxane exhibits compatibility issues with other polyols and additives used in polyurethane foam formulations, along with having anti-foaming properties, but can be used for mold release and flame retardancy properties. The polymerization of polydimethylsiloxane with dimer acid increases the compatibility with other polyols and decreases the anti-foaming effect. A polyol of hydroxyl value of 25 (mg KOH/g) was synthesized by condensation reaction of carbinol terminated polydimethylsiloxane and biobased dimer acid. Carbinol terminated polydimethylsiloxane used in the polyol reaction was synthesized by a reaction of propylene carbonate and aminopropyl terminated polydimethylsiloxane. The carbinol terminated polydimethylsiloxane product was purified and characterized by Fourier transform spectroscopy (FTIR) to confirm purity before further reaction with dimer acid. The condensation reaction of biobased dimer acid and carbinol terminated polydimethylsiloxane was conducted with the addition of titanium butoxide, under constant stir and vacuum to remove water. The resulting polyol product was characterized by acid value titration, hydroxyl value titration, thermogravimetric analysis, rheological property, and FTIR to determine structure. The resulting polyol can be used in further research in polyurethane foam formulations to increase the biobased content of the foam, act as a mold release, and decrease the flammability of the foam.

Poster Number: CHE-13
Title: Phosphorescent Inorganic Nanoclusters – A New Paradigm for Light Emitting Diode Emitters
Authors: Padmanaban S Kuttipillai; Yimu Zhao; Christopher J. Traverse; Richard J. Staples; Benjamin G. Levine; Richard R. Lunt

Abstract: The development of near infrared (NIR) organic light emitting diodes (OLEDs) is of significant interest for their application in telecommunications, sensors, night vision, and medicine. While visible OLEDs have found notable success and are already being commercialized in displays, efficient phosphors in the NIR have been limited. Moreover, the few NIR LED structures that have been demonstrated contain Pt based phosphors or lower efficiency fluorescent nanocrystals, typically containing toxic lead based compounds. Here, we report next-generation light emitting diodes (LEDs) with 2.5% quantum efficiency based on phosphorescent metal halide nanoclusters that are earth-abundant, inexpensive, and unique from fluorescent nanocrystals. LEDs have been fabricated with molybdenum-based nanocluster salts with various cation substitution to demonstrate tunable emission. Theoretical calculations were performed to determine the nature of the phosphorescent emitting state in these nanoclusters, which involves a strong Pseudo Jahn Teller (PJT) distortion. Based on luminescent transient dynamics and density functional theory (DFT) calculations we identify host quenching and exciton formation efficiency as key factors for improving electrically pumped devices. These materials have a strong potential to replace organic phosphorescent molecules in white and near-infrared light.
emitting diodes (LEDs) for low cost and high efficiency applications, providing an exciting new paradigm of inorganic phosphorescent emitters.

This work was supported by the U.S. Department of Energy, Office of Science, Basic Energy Sciences, under Award (No. DE-SC0010472) and Michigan State University

Poster Number: CHE-14  
Title: Thermally-Induced Stress Behavior of Single Crystal Sapphire-Single Crystal Yttria-Stabilized Zirconia Bilayers  
Authors: Eric M. Straley; Jason D. Nicholas

Abstract: Sapphire (Al2O3) and Yttria-Stabilized Zirconia (YSZ) multilayers have been used as oxidation prevention coatings, high-performance ionic conducting membranes, and high-temperature Micro-Electro-Mechanical System (MEMS) gas sensors. Due to the wide temperature ranges encountered in these applications, it is critical to understand the behavior of Al2O3-YSZ multilayers over a wide range of thermally induced-stresses. To that end, single crystal Al2O3 and YSZ wafers were bonded here for the first time, and their curvature behavior was analyzed as a function of temperature and layer thickness ratio. The bilayer curvature versus temperature data was then compared to predictions from linear elastic models in the literature relating curvature to the geometry, elastic constants, and thermally induced lattice mismatch strain of the bilayer. The results provide a guide for usable Al2O3-YSZ multilayer operating conditions and illustrate how changing the thicknesses of each layer affects bilayer curvature.

This work was supported in part by National Science Foundation (NSF) CAREER Award Number CBET-1254453

Poster Number: CHE-15  
Title: Novel Biobased Elastomers by Reactive Blending of Modified Natural Oil and Polysiloxanes  
Authors: Tambe Chetan; Daniel Graiver; Ramani Narayan

Abstract: A series of elastomers were prepared using silylated soybean oil and commercially available silicone based elastomers. Both the components are miscible with each other cure by same moisture cure mechanism via silanol condensation. These new elastomers with high biobased content, produce clear films and possess better mechanical and barrier properties along with longer shelf life compared to commercially available silylated polyurethane elastomers. Additionally, silylated soybean oil is a low viscosity product (30-50cPs) and acts as a reactive diluent for available high viscosity silicone elastomers. The viscosity can be adjusted by changing silylated oil composition as per the application demand. The crosslinking was qualitatively analyzed using ATR-FTIR and quantified using Gel-Swell analysis. The tensile strength of the silicone elastomer was improved by 30-40% while achieving the similar elongation. Our initial results showed that the new elastomers possess good water vapor and oxygen barrier.

Poster Number: CHE-16  
Title: Engineering Delivery Vehicles for siRNA Therapeutics  
Authors: Daniel Vocelle; Olivia M. Chesniak; Milton R. Smith III; Christina Chan; S. Patrick Walton
Abstract: 85% of known disease-associated proteins cannot be targeted by existing therapeutics, driving the need for new therapeutics and new therapeutic approaches. One potential approach, short interfering RNA (siRNA) therapeutics, is capable of highly specific targeting for a wide range of proteins through the use of RNA interference (RNAi). siRNA therapeutics are being developed for cancers, genetic disorders, and infectious diseases but are currently limited by delivery vehicles that are toxic, immunogenic, or ineffective. While many types of delivery vehicles have been developed, there is little consensus regarding the mechanisms or characteristics that determine which delivery vehicles are likely to be useful in vivo. Our goal is to define nanoparticle characteristics that are essential for siRNA delivery. Using silica nanoparticles (SNPs), we are investigating how the chemical and physical properties of the delivery vehicles influence functional properties such as siRNA function, siRNA binding affinity, membrane translocation, and intracellular trafficking. For our SNPs, vehicle size, structure, charge, and surface functionalization can be varied to determine optimal vehicle design criteria. Here we will present our results to date demonstrating that multiple vehicle characteristics influence the siRNA silencing that can be achieved, including amine content, stability of the SNPs at low pH, the quantity of siRNA bound per SNP, and the presence of carbohydrates (i.e., dextran).

This work was supported in part by National Institutes of Health (#GM079688, #RR024439, and #GM089866), MSU Foundation, National Science Foundation (CBET 0941055), MUCI, and the Center for Systems Biology

Poster Number: CHE-17
Title: Effects of Deck Composition in the Separation of Double Decker Polyhedral Oligomeric Silsesquioxanes Cis/Trans Isomers
Authors: David Vogelsang; Robert Maleczka. Jr; Andre Lee

Abstract: Double Decker Polyhedral Oligomeric Silsesquioxanes or DDSQ’s are building blocks that have been used with success in several applications. The synthesis of DDSQ’s results in unavoidable production of mixtures containing cis and trans isomers when two different moieties (R and X) are located in each deck. In this work DDSQ’s cages were synthesized making the R moiety methyl, isobutyl, or cyclohexyl and the X moiety p-phenylamine or m-phenylamine. The cis and trans isomers were isolated and a common absorption wavelength of 254nm was obtained for all the evaluated isomers by UV-vis spectroscopy. However, significant differences were obtained in the absorption peak height between para and meta moieties in the X position at the same concentration. The individual isomers as well as the cis/trans mixtures were analyzed by adsorption normal phase HPLC. From these experiments was found that for cis/trans mixtures the trans peak showed lower retention times than cis peak. Also, an inverse relation was observed between the retention time and the size of the R group.

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Poster Number: CHE-18
Title: Plasmid-Based Single-Pot Saturation Mutagenesis
Authors: Emily E. Wrenbeck; Justin R. Klesmith; James A. Stapleton; Adebola Adeniran; Keith E. J. Tyo; Timothy A. Whitehead
Abstract: Deep mutational scanning is a foundational tool for addressing functional consequences of large numbers of mutants, yet a more efficient and accessible method for construction of user-defined mutagenesis libraries is needed. Here we present Nicking Saturation Mutagenesis, a single-day, single-pot saturation mutagenesis method using routinely prepped plasmid dsDNA as input substrate. Reproducibility and convenience of the method are demonstrated through validation by an external research laboratory.

This work was supported by a graduate research fellowship from the MSU PBHS Biotechnology Training Program, grant number NIH-T32-GM110523 (to E.E.W.), Howard Hughes Medical Institute Gilliam fellowship (to A.A.), USDA NIFA Award No. 2016-67011-24701 (to J

Poster Number: CHE-19
Title: Influence of Electrolyte Conditions on the Electrochemical Behavior of Cu(Pd)-Al IMCs in Wire Bonding Packages
Authors: Yuelin Wu; K.N. Subramanian; Andre Lee

Abstract: Chloride concentration and mass fraction of Pd (x) was varied to comprehensively evaluate the strategy to inhibit the degradation of Cu1-xPdx-(Cu1-xPdx)9Al4 interface, whose cracking has been reported to cause the failure of Cu(Pd)-Al bonding. Corrosion potentials of Cu1-xPdx and (Cu1-xPdx)9Al4 (x=0, 0.02, 0.09 in mass fraction) were measured and (Cu1-xPdx)9Al4 was identified as the sacrificial anode at all x values under high chloride concentrations (>20ppm). However, under low chloride concentration (1ppm), with no Pd or small amount of Pd addition (x=0, 0.02), galvanic effect was negligible between Cu1-xPdx and (Cu1-xPdx)9Al4, while with higher amount of Pd addition (x=0.09), (Cu1-xPdx)9Al4 shifted to the cathode side and its dissolution rate was predicted to be effectively inhibited. The galvanic current density ig between Cu1-xPdx and (Cu1-xPdx)9Al4 were measured via zero resistance ammeter and it was found to decrease with the decreasing chloride concentration regardless of the x value or chloride concentration. Moreover, ig was found to shift direction when x=0.09 in 1ppm NaCl solution, just as predicted by the corrosion potential measurement. Polarization curves of Cu1-xPdx and (Cu1-xPdx)9Al4 were also obtained to fundamentally understand the effect of chloride concentration on the ig between Cu1-xPdx and (Cu1-xPdx)9Al4.

Poster Number: CHE-20
Title: Understanding Sugar Yield Loss and Enzyme Inhibition Due to Oligosaccharides Accumulation During High Solids-Loading Enzymatic Hydrolysis
Authors: Sai Si Xue; Nirmal Uppugundla; Michael Bowman; Shishir Chundawat; Brian Fox; David Cavalier; Mingjie Jin; Leonardo da Costa Sousa; Bruce Dale; Venkatesh Balan

Abstract: During enzymatic hydrolysis of biomass, polysaccharides are cleaved by glycosyl hydrolases to soluble oligosaccharides and then further hydrolyzed by β-glucosidase, β-xylanase and other enzymes to monomeric sugars. However, not all oligosaccharides can be hydrolyzed by commercial enzyme mixtures. Oligosaccharides may accumulate to levels of 18-25% of the total soluble sugars at high solid loading (>3-25% solids loading). Oligosaccharide accumulation reduces ethanol yields because industrial ethanol-producing strains can only consume monomeric sugars. Very little is understood about the nature of these oligomers and why they accumulate during hydrolysis. In this work, we report a large-scale, robust method to separate and produce recalcitrant oligosaccharides using affinity based charcoal fractionation and molecular weight-based separation using gel filtration chromatography from high

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solids-loading AFEX-corn stover (ACS) hydrolysate. The low DP (degree of polymerization) oligosaccharides can be digested using commercial enzyme mixtures (Ctec2, Htec2 and Multifect pectinase (MP)) after being separated from the hydrolysate, while the high DP oligosaccharides were found to be highly recalcitrant. Inhibition studies using pure substrates (Avicel and beech wood xylan) showed that low DP oligosaccharides are highly inhibitory to commercial enzymes, and the addition of monomeric sugars along with oligosaccharides further intensified the inhibition effects. Chemical structures of oligosaccharides with varying degrees of polymerization, composition of monomeric sugars, and the extent of branching patterns have also been identified by acid hydrolysis, methylate derivatization, LC-MS and NMR. Using these oligosaccharides as substrates, arrays of enzymes and microbes were screened to identify candidates with the ability to break down the un-hydrolyzed crosslinks in the plant cell wall and digest the oligosaccharides completely. This work helps us understand the mechanisms behind oligosaccharides accumulation and thus develop better strategies to increase sugar yields during biomass hydrolysis.

This work was supported in part by DOE GLBRC

Poster Number: CHE-21
Title: Graphene Nanoplatelet Films as an Electrostatic Actuator
Authors: Zeyang Yu; Lawrence Drzal

Abstract: Binder free, self-standing graphene nanoplatelets (GnP) R10 (with average diameter of nanoplatelets around 10μm) can be made into a free standing thin film ‘paper’ through vacuum filtration of GnP suspension in water. Electrodes were fabricated from GnP paper by compressing the filtered GnP film with 3.4psi and then coating the surface with epoxy using a doctor blade to control the thickness of polymer film at 0.45mm. Two types of GnP electrodes were fixed as the anode in a capacitive circuit of high power output. When high voltage is applied, electrons flow to charge the composite paper electrode. The electrodes were hinged at their ends in the vertical position and they would pivot towards a horizontal orientation against gravity when the potential was applied. Improvements in the actuating performance were made by modifying the composition of the electrode, either by increasing the surface area or the dielectric constant. Results have demonstrated that under a potential of 12.5KV, increasing the surface area by 3 times improved the rotation 155% while for incorporating dielectric particles into the composite paper electrode improved the rotation 130%.

Poster Number: CHE-22
Title: Synthesis, Characterization and Assessment of a Fibrous MnOx Catalytic Film formed on Fto By Dual-Session Cyclic Voltammetry
Authors: Hao Yuan; Richard Lunt; Gary Blanchard; Robert Ofoli

Abstract: We have developed a new electrodeposition method to synthesize a manganese-based (MnOx) catalytic film in situ on conductive surfaces in aqueous media. This approach uses an electrochemical deposition protocol involving two consecutive cyclic voltammetry (CV) sessions over different ranges of potential (0.0 to 0.6 V and 0.6 to 2.0 V), followed by calcination to increase catalyst crystallinity. The resulting film has a nanoscale fibrous morphology that is uniformly distributed over the conductive surface. The surface morphology and elemental composition were characterized by scanning electron microscopy (SEM), transmitting electron microscopy (TEM) and energy-dispersive x-ray spectroscopy (EDS). The catalytic functionality was assessed by cyclic voltammetry (CV), which showed
excellent effectiveness towards water oxidation. Its stability was assessed by consecutive CV and long term amperometry experiments, with the results showing stable catalytic performance over long periods of time. A nucleation-growth theory proposed to explain the mechanism(s) for formation of the fibrous surface morphology has been supported by several preliminary assessments. The effects of other synthesis parameters such as ionic strength, potential ranges, and number of scanning cycles were also evaluated. This protocol has the potential to open avenues for synthesis and optimization of other manganese-based water oxidation catalysts.


**CIVIL ENGINEERING**

**Poster Number:** CE-01  
**Title:** Influence of Temperature Induced Bond Degradation on Fire Resistance of RC Beams  
**Authors:** Ankit Agrawal; Venkatesh Kodur

**Abstract:** Reinforced concrete (RC) beams exposed to fire, lose capacity due to temperature induced deterioration in mechanical properties of both concrete and rebar. This degradation in strength properties and elastic modulus, accompanied with differential thermal expansion, causes loss of interfacial bond between rebar and concrete. The stress transfer between concrete and rebar, and hence the moment (or shear) capacity of a RC beam, is influenced by the extent of bond deterioration. In current practice, perfect bond is assumed between rebar and concrete while evaluating flexural capacity of RC beams under fire conditions. No reliable guidelines for incorporating bond degradation in fire resistance analysis of RC beams are available. Only a limited number of publications have appeared on this problem; and a fundamental understanding of the relationship between bond and temperature is still lacking, particularly for newer types of concrete. To address these knowledge gaps, both experimental and numerical investigations are being conducted at MSU. As part of material level tests, six different types of double tension pull-out DTP) specimens have been fabricated using different combinations of normal strength concrete, high strength concrete (HSC), fibers (polypolyprolene or steel fibers) and rebar types (smooth and ribbed bars). The DTP setup ensures presence of a longitudinal tensile stress in concrete surrounding the ribs. As part of numerical studies, a finite element based numerical model is developed that incorporates effect of temperature induced bond degradation is incorporated using zero thickness bond-link elements. Results show distinct influence of bond degradation on fire resistance of RC beams.

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**Poster Number:** CE-02  
**Title:** Utilizing Indigenous Materials for Building Construction  
**Authors:** Areej Almalkawi; Parviz Soroushian

**Abstract:** Modern buildings are generally constructed with materials such as Portland cement concrete, steel, timber, pre-fabricated gypsum panels, masonry units, asphalt, plastics, polymer composites, and insulating foams. Building systems incorporating these materials are designed to meet structural safety, fire resistance, energy-efficiency, quality of life, and durability requirements. Major economic and sustainability benefits can be realized in building construction through maximum use of locally available construction materials and resources. The building systems designed to make maximum use of indigenous materials should still provide adequate safety under relevant loads, quality of life, energy-efficiency, and durability. Seismic, blast, impact and wind resistance are among the considerations in development of these building systems. The main thrust of this project is to develop building systems which employ locally available resources to efficiently meet stringent structural (load-bearing and seismic energy absorption), moisture barrier, weathering resistance, thermal insulation, fire resistance, health and sustainability requirements. A sandwich composite is devised as the primary module for
development of the building system. This module comprises indigenous ferrocement skins and a lightweight cement-bonded natural fiber core. Indigenous cementitious binders play an enabling role in development of the sandwich composite. Strategies were devised for development of cementitious binders using indigenous raw materials which are abundantly available globally. These strategies emphasize simple processing of raw materials using locally available resources. The raw materials selected for development of indigenous cementitious binders include volcanic deposits, laterite clay, gypsum, limestone, soda ash, and natron. Various indigenous plant extracts are also considered as additives in cementitious binders to impart set retardation, activation and other effects.

Poster Number: CE-03  
**Title:** Performance of Reinforced Concrete Columns Under Hydrocarbon Fire Exposure  
**Authors:** Saleh Alogla; Venkatesh Kodur

**Abstract:** Concrete is the most widely used material in construction industry worldwide due to numerous advantages it offers over other materials including its superior fire performance. This high fire resistance of concrete is mostly attributed to its low thermal conductivity, higher heat capacity, and slower degradation in mechanical properties. However, concrete experiences degradation in the form of spalling, cracking or excess deformations all of which can eventually lead to failure of concrete structural members. Reinforced concrete columns, in particular, are crucial to structural integrity of structures and need to withstand fire exposure. Although performance of RC columns is well established under standard (building) fire conditions, the behavior of RC columns under hydrocarbon fires is not fully established. Under hydrocarbon fires, temperatures increase at a very rapid pace leading to high thermal gradients which in turn can induce high creep strain in RC columns. To study the performance of RC columns under hydrocarbon fires a series of numerical studies are performed on RC columns of different characteristics. Effect of high-temperature transient creep, under hydrocarbon fire exposure, is specifically accounted for in the fire resistance analysis to evaluate realistic response of RC columns. Results from the analysis indicate that RC columns experience rapid degradation in capacity under hydrocarbon fires, much higher than that under standard fires. This is mainly due to the higher temperature gradients and temperature induced creep strains. Results from the analysis also show that accounting for high-temperature transient creep greatly improves predicted deformations and failure time of RC columns. Neglecting high-temperature transient creep can lead to unrealistic behavior and un-conservative fire resistance predictions, particularly under hydrocarbon fire conditions.

Poster Number: CE-04  
**Title:** Analytical Solution to Earthquake-Induced Nonlinear Inelastic Second-Order Moments in Slender Reinforced Concrete Bridge Columns  
**Authors:** Ata Babazadeh; Rigoberto Burgueño

**Abstract:** A closed-form solution to the bending moment profile along reinforced concrete (RC) cantilever columns responding inelastically under end loads was derived by combing inelastic section response and nonlinear structural mechanics. The solution led to a mathematical expression for the extent of the plastic region (Lpr) on slender RC columns, which is significantly affected by nonlinear second-order moments, known as P-δ. The effects of nonlinear geometry caused by column bending deformation in conjunction with the dramatic decrease of flexural stiffness due to reinforcement yielding were considered in the solution’s derivation. Nonlinear geometry was ensured by the balance of external and internal forces on the deformed configuration of the column. Inelastic material properties
were represented by bilinear moment-curvature cross-section response with reduced post-yield flexural stiffness. The results from the nonlinear inelastic solution were verified against experimental data from three large-scale slender RC columns; and the accuracy of the proposed solution for predicting experimental Lpr values was compared against other linear and nonlinear models. It was found that geometrically nonlinear models generally offer a considerable advantage over a linear one for predicting the extent of Lpr. Yet, statistical analyses of the error measures showed that the inelastic solution provides a significant improvement in accuracy for predicting P-δ effects on Lpr. Therefore, use of the developed nonlinear inelastic solution is essential for accurate prediction of the second-order effects on the plastic region of slender RC columns subjected to axial and lateral loads.

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**Poster Number:** CE-05  
**Title:** Impact of Pavement Structural Response on Rolling Resistance and Vehicle Fuel Economy  
**Authors:** Danilo Balzarini; Imen Zaabar; Karim Chatti

**Abstract:** Reduction in vehicle fuel consumption is one of the main benefits considered in technical and economic evaluations of road improvements considering its significance. Analysis of the effects of pavement rolling resistance on vehicle fuel economy and emissions needs to consider the total system of the pavement, road geometry, vehicles, and climate. Surface roughness, texture, and structural response are the main pavement characteristics influencing rolling resistance. This project investigates the increase in vehicle energy consumption caused by pavement structural response. It was proven that this energy is equal to the dissipated energy in the pavement itself due to the deformation of pavement materials under passing vehicles, including delayed deformation of viscoelastic materials and other damping effects that consume energy in the pavement and subgrade. This mechanism has also been characterized in terms of the energy required for a rolling wheel to move uphill, facing the positive slope formed by the local deflection basin caused by the delayed deformation of the pavement. Pavement structural response to moving vehicles was calculated using models of both asphalt and concrete pavements, under different conditions of vehicle speed, and pavement temperature. Energy loss and excess fuel consumption were then compared for the two pavement types. Preliminary results show that commercial trucks driven over concrete pavements can save up to 1.5% in fuel consumption compared to when driven over asphalt pavements. Although such a percentage seems small, the energy and money savings become significant considering the massive vehicle fleet in the US.

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**Poster Number:** CE-06  
**Title:** Performance of Fiber Reinforced Polymer Strengthened Reinforced Concrete Slabs Subjected to Fire  
**Authors:** Pratik Bhatt; Venkatesh Kodur

**Abstract:** Fiber-reinforced polymers (FRP) are extensively used in the construction industry for repair and retrofitting of reinforced concrete (RC) structures. When used in buildings, appropriate fire safety requirements for structural members must be strictly fulfilled, as performance of structural members is affected significantly when exposed to fire conditions. Numerous experimental and numerical studies
are available in the literature investigating the behavior of FRP strengthened RC flexural members (beams and slabs) at ambient temperature. However, very limited information is available in the literature, in terms of both experimental and numerical studies, regarding the behavior of FRP strengthened flexural members at elevated temperature. In particular, there are no numerical studies predicting the behavior of FRP strengthened RC slabs at elevated temperature. The aim of this study is to develop a three-dimensional finite element model, using ABAQUS®, to analyze the performance of FRP strengthened RC slabs, subjected to fire. The model would be validated by comparing the predicted performance with the experimentally measured performance of FRP strengthened slabs subjected to fire, available in literature. The validated model can be applied to quantify the critical factors governing fire performance of FRP strengthened slabs, when subjected to fire.

Poster Number: CE-07
Title: Splitting Tensile Strength of Ultra-High Performance Concrete at Elevated Temperature
Authors: Xu Dong; Venkatesh Kodur

Abstract: Concrete is one of the most widely used construction materials for civil engineering infrastructure. In recent years, new types of concrete, such as ultra-high performance concrete(UHPC), are extensively developed to improve strength, durability, and sustainability. Currently, there is no research data to evaluate fire-resistance properties of UHPC. During fire conditions, spalling may occur in UHPC which can lead to loss of layers of concrete, and expose steel reinforcement. This direct exposure may result in reinforcing bars subjecting to fire directly, and this will lead to loss of stiffness and strength of structural elements. Splitting tensile strength is one of the most important property that resist spalling. Therefore, tests are carried out to study on the splitting tensile strength of UHPC from room temperature to 600°C. Data collected from tests is used to compare splitting tensile strength of UHPC with normal strength concrete(NSC) and high strength concrete(HSC) at various temperature.

Poster Number: CE-08
Title: Behavior of Composite Beam-to-Box Column Connection in Steel Buildings
Authors: Mohammadreza Eslami; Venkatesh Kodur; Hisashi Namba

Abstract: Connections in a structural system play a critical role in transferring loads from one member to the other. Behavior of steel framed buildings during earthquake is highly dependent on the performance of beam-to-column connections. The prequalified beam-to-column connections presented in US building code (AISC manual) are limited to connections comprising of I beam to wide flange columns; On the other hand, Japanese steel construction has moved towards a newer building system consisting of cold-formed box columns and wide flange steel beams. Currently, box columns are widely employed as a part of Seismic Moment Resisting Frame buildings (SMRF) in Japan. However, a box column has two webs at each side, but no web in the center where the beam web is connected. This is different from US practice, where wide flange H sections are used and there is a web at the center. This may cause an increase in the deformation of box column flange in bending moment and result in out-of-plane deformations. This research discusses out-of-plane deformations in a box column connected to a composite beam. The force flow pattern and ultimate flexural capacity are evaluated by considering main parameters affecting the deformations: width-to-thickness ratio of box column, height-to-thickness ratio of beam web, yield strength ratios, height-to-width ratio of connection, slab strength and geometry of weld access hole. Equations governing ultimate flexural capacity of web connections are derived. Finite element analysis is utilized to clarify the mechanism of mechanical stress transfer.
According to these findings, flexural capacity evaluating method is presented and the accuracy of equations is validated by comparing with published test data.

This work was supported in part by Japan Ministry of Education, Michigan State University

Poster Number: CE-09
Title: Developing Safety Performance Functions for Roundabouts Located in the State of Michigan
Authors: Ahmad M. Fawaz; Timothy Gates

Abstract: The percentage of crashes in the state of Michigan which occurred at conventional intersections controlled by traffic signals, stop, or yield signs, is estimated to be around 22.0% of the total crashes in 2011. Roundabouts have been proven to be an effective countermeasure to reduce the number of crashes and injury crashes in previous studies. This study aims to develop safety performance functions for single and multilane roundabouts located in the State of Michigan and then compare them against the NCHRP models. The results indicated that the NCHRP models under predict the total number of crashes for all type of roundabouts.

Poster Number: CE-10
Title: Grace-Based Evaluation of Terrestrial Water Storage Variations Simulated by a Global Land Surface Model with Human Impacts
Authors: Farshid Felfelani; Yadu Pokhrel

Abstract: Since the beginning of Gravity Recovery and Climate Experiment (GRACE) satellite mission in March 2002, the hydrological research community has extensively utilized the terrestrial water storage (TWS) variations derived from GRACE to evaluate the accuracy of hydrological models as well to constrain water storage simulations. In this study we use TWS anomalies derived from GRACE observations to assess the TWS variations simulated by a global land surface model called the HiGW-MAT [Pokhrel et al., 2015]. HiGW-MAT simulates the exchange of water vapor, energy, and momentum between the land surface and atmosphere on a physical basis and also, takes into account human land-water management such as flow regulation and groundwater pumping. River basins are selected such that all five main groups of Köppen climate classes are represented by characteristic and important rivers. Results show that in relatively uniform climatic regions and large river basins (e.g. Amazon, Niger, Ob, Danube, Mississippi and Xi) the model shows better agreement to GRACE time series compared to the small river basins and variable climatic zones (Churchill, Colorado and Murray). It is also found that for small river basins the water storage amplitude is less or equal to GRACE error and so, the GRACE-based evaluation may not be highly reliable. Furthermore, in most of the regions snow water is around zero and the subsurface water dominates the TWS variations except for high latitudes where snow water peaks precede the subsurface and river storage peaks. This sequence verifies the snow water as the dominant TWS component which infiltrates the river storage and groundwater with a time lag.

Poster Number: CE-11
Title: Nondestructive Condition Assessment of Concrete Structure Using NMR
Authors: Iman Harsini; Parviz Soroushian

Abstract: Various forms of concrete deterioration involve microcracking and distortion of the structure of cement hydrates. This project is developing a new non-destructive method for condition assessment
of concrete structures using nuclear magnetic resonance (NMR) principles. NMR and corroborative nondestructive tests are performed on concrete materials subjected to damaging effects of mechanical stress and frost action. The NMR data are found to provide new insight into the response of concrete to external and internal stresses. Changes in the level of constraint and mobility of water in concrete are monitored using nondestructive NMR techniques at different states of damage and deterioration. The NMR method was found to provide indications not only of the formation, propagation and widening of microcracks, but the effects of internal and external stresses on the gel and capillary pore systems of hydrated cement paste. The NMR signals enabled monitoring of the compaction and disordering of the calcium silicate hydrate structure and gel pores under external and internal pressure. Corroborative nondestructive tests involving measurements of the ultrasound pulse velocity and dynamic elastic modulus were used to supplement the nondestructive NMR test data. Optic microscopy was also employed as a destructive means of evaluating microcrack propagation in concrete experiencing damage and deterioration. The NMR data were found to provide more insight into the fundamental aspects of concrete damage mechanisms than other nondestructive test techniques.

This work was supported in part by US DOT

**Poster Number:** CE-12  
**Title:** Implementation of a Decision Framework for Corridor Planning within the Roadside Right-of-Way for Non-Traditional Developments  
**Authors:** Gentjan Heqimi; Timothy Gates; Adam McArthur

**Abstract:** A spatial decision framework for context-sensitive planning within the roadside Right-of-Way (ROW) was implemented for freeways in the State of Michigan. The framework represents a roadside suitability assessment model which may be used to support decision-making for ROW use and development, particularly those that are non-traditional. The model accommodates a broad range of developments, while considering a diverse range of roadside contextual features, including land cover, environmental and natural features among others. Contextual features were identified, weighted and prioritized based on coordination with state stakeholders. The primary function of the model is to identify areas along the highway corridor that are most (or least) suitable for development within the roadside ROW, as well as providing a relative indication of their overall suitability along a corridor. Various macro and micro level data were used to assess the potential of five non-traditional ROW developments, including solar panels, wind turbines, farming, vegetation management, and green infrastructure. The model was originally applied to a limited freeway network in Michigan. State implementation was based on available datasets and general land use planning importance. The resulting relative index scores for the statewide corridors were generally consistent with standard land-use planning considerations. The final product consists of a compilation of individual maps for each Michigan freeway segment utilizing a global relative scale. Reference data such as mile markers were further provided for geographical referencing purposes.

This work was supported in part by Michigan Department of Transportation (MDOT)

**Poster Number:** CE-13  
**Title:** Location Sensitive Snow Effects on Interstate Highway Crashes
**Authors:** Gentjan Heqimi; Timothy Gates

**Abstract:** Snowfall affects traffic safety by impacting vehicle performance, driver behavior, and the transportation infrastructure itself. Depending on intensity, snowfall can reduce visibility, pavement friction performance, and vehicle stability and maneuverability. Based on this premise the objective of this study was to investigate location sensitive snow effects on different types of crashes and crash outcomes at various snowfall intervals during winter weather. Using the geostatistical method of Ordinary Kriging, location specific historical snowfall values were estimated for each winter month between 2004 and 2014 along 286 miles of I-94 in southwestern Michigan. Collected data was then spatially joined with crash counts using the Michigan Geographic Framework Statewide All Roads shapefile as basis for the study. Two Negative Binomial Regression models were conducted on the dataset to assess snow effects. Explanatory variables in Model 1 included AADT, segment length, and snowfall. Explanatory variables in Model 2 included AADT, segment length, and four categorical snowfall intervals based on its quantile distribution. The results indicated that snow has a positive statistically significant effect on winter crashes for all of the types of crashes and crash outcomes analyzed. These effects are highest for those segments experiencing the largest amount of snowfall. Among the crash types, crashes involving a Truck and/or Bus experienced the highest percent increase in crash occurrence for each additional percent increase in snowfall. While for crash outcomes, Property Damage Only crashes were shown to be more susceptible to snowfall compared to Injury crashes.

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

**Poster Number:** CE-14  
**Title:** Bending Rigidity of Twisted Fibers  
**Authors:** Ali Imani Azad; Roozbeh Dargazany

**Abstract:** This research concentrates on developing an understanding from mechanical behavior and electrical response to mechanical exciters in twisted CNT fibers. The application of carbon nanotube (CNT) fibers have been highly increased due to their light weight, high strength, and high electrical conductivity. However, their complex hierarchical structure which consists of numerous CNTs in a cross section with different winding angles around the fiber’s axis causes considerable performance loss in translation of mechanical and electrical properties from CNT to fiber. Up today lack of understanding on the load transfer mechanism (LTM) in CNT fibers has barriered maximizing the performance of the CNT fibers. Among the several mechanical properties, bending properties is unknown and also very complicated in the twisted fibers. Several studies have been performed on this problem, but still there is big gap between results from analytical models and experimental results. As a part of LTM process understanding, in this research the bending of twisted fibers will be addressed. In the next step, a novel effective damage monitoring tool would be developed to relate and quantify the void formation and local failures inside the fibers with the electrical responses of the CNT fibers.

**Poster Number:** CE-15  
**Title:** Control of Post-Buckling Response of Non-Uniform Beams for Energy Harvesting Applications  
**Authors:** Pengcheng Jiao; Wassim Borchani; Nizar Lajnef 

**Abstract:** Buckling and post-buckling behaviors of elastic structural elements have been widely used to create mono-stable, bi-stable and multi-stable mechanisms that have shown a great efficiency in many applications such as sensing, actuation and energy harvesting. Under an increasing axial loading, the
strain energy stored in a buckled bilaterally constrained elastica is suddenly released, through a snap-through transition, as a kinetic energy. These transitions can be used to convert low-rate and low-frequency excitations into high-rate motions that are converted into electrical signals using piezoelectric transducers. However, for efficient sensing and energy harvesting, buckling transition events have to be controlled. It has been shown that the spacing between the transitions cannot be controlled just by tuning the geometry properties of a slender beam with a uniform cross-section. This paper investigates the effect of different non-uniform cross section scenarios on the post-buckling response of a bilaterally constrained beam. An energy based theoretical model that takes into account variable non-uniform cross-sections is herein presented. The variation of the beam’s cross section area can either be continuous or piecewise continuous. The total potential energy of the system is minimized under constraints that represent the physical confinement of the beam between the lateral boundaries. Results demonstrate that the spacing ratio between buckling-mode transitions can be efficiently controlled by the beam’s shape and geometry dimensions. Different beam designs are presented in this work depending on the desired spacing ratio.

**Poster Number:** CE-16  
**Title:** Hydrologic Modeling of Groundwater Recharge in the Ottawa County, Michigan  
**Authors:** Guoting Kang; Phanikumar Mantha

**Abstract:** Groundwater plays an important role in Ottawa County’s agriculture, industry, public supply and domestic water use. However, various studies have shown that water levels in the aquifers have been declining, especially in the central region of Ottawa County. We have also detected the dry-up of many streams in Ottawa County in our fieldwork during summer of 2015. To better understand the water cycle in order to achieve sustainability in groundwater use in Ottawa County, we need to understand the groundwater recharge process, which requires knowledge of the spatial and temporal variability in groundwater recharge. While direct measurements of groundwater recharge on a regional scale is nearly impossible, this study uses a process-based hydrologic model, which integrates detailed representations of land surface and subsurface processes, to simulate groundwater recharge at high temporal and high spatial resolutions. The model was built based on three major watersheds, the Rabbit River and Macatawa River watersheds, and part of the Grand River watershed, covering the entire Ottawa County and was calibrated using streamflow data from U.S. Geological Survey (USGS) gauging stations. In addition, synoptic and time-series streamflow data collected using Acoustic Doppler Current Profilers (ADCPs) through fieldwork in the summer of 2015, were used to validate and quantify the uncertainty of the model.

This work was supported in part by Ottawa County Water Resources Study - Phase II

**Poster Number:** CE-17  
**Title:** Mechanics-Based Service-Life Prediction of Elastomeric Nano-Composites  
**Authors:** Leila Kahili; Roozbeh Dargazany

**Abstract:** Elastomeric nanocomposites (ENC) are widely used in tires, bearings, protective armors, etc. because of their light weight, corrosion resistance, and durability. To avoid risk of life, large safety factors are utilized in the design process. Considering that ENCs comprise 6% of the national waste in the U.S., accurate prediction of failure for ENC components would have a tremendous economic and environmental impact. Recently, the predictive modeling of damage mechanisms has progressed;
nevertheless, these modeling efforts still remain fundamentally centered on a single-phenomenon, single-model approach where the models work individually. In the present work a platform will be designed that can host many models, integrate them into one framework that provides input for fatigue models of ENCs. The framework consists of a visco-elastic platform and several add-on modules. In order to construct a visco-elastic platform, the material matrix will be decomposed into a number of parallel networks, where each network describes a specific micro-mechanisms. For modeling the visco-elastic response of the matrix, a full-chain, temporary network model will be used in which each chain uses dynamic variables including location of each entanglement and the number of Kuhn steps in chain strands between entanglements.

**Poster Number:** CE-18  
**Title:** Combined Effect of SBS and Recycled Tire Rubber (RTR) Modification on Performance Grade and Fatigue Cracking Resistance  
**Authors:** Salih Kocak; M. Emin Kutay

**Abstract:** Polymer modification of asphalt binders has gained quite popularity in many transportation agencies, primarily due to the superior crack- and rut-resistant performance. However, added cost of polymer modification results in an appreciable increase in the initial cost of an asphalt pavement. There are more economical and sustainable alternatives to polymers, such as the so-called “De-Vulcanized Rubber (DVR)”. Primary advantage of DVR technology is that, it is made from scrap tires and when mixed with asphalt binder, the particles completely dissolve within the binder. Therefore, the final product is a complete fluid, not a suspension. The main objective of this study was to investigate the relative performances of the SBS polymer and DVR in an asphalt binder. The impact of the modifications on performance grade (PG) and fatigue cracking resistance was investigated. The results have shown that more sustainable modification of asphalt binders can be achieved by replacing the entire or some amount of SBS with DVR.

**Poster Number:** CE-19  
**Title:** A Rational Design Approach for Evaluating Fire Resistance of Concrete Filled Hollow Steel Columns  
**Authors:** V.K.R. Kodur; K. Ramya; K. Puneet

**Abstract:** Concrete filled steel tubular columns are widely used these days in the construction of framed structures. The two main reasons for this are, higher load bearing capacity and the fire resistance provided by those columns. The steel section protects the concrete from directly exposing to the fire and in turn the concrete filling delays the heating of steel as the heat from the steel is absorbed by the concrete. These columns do not need any fire protection externally (without compromising in fire safety). This makes the choice more economical and allows architects and engineers to design structures using exposed steel. Other benefits include the increased floor area, smaller sections would serve the required purpose. In this work, the main aspect is to develop a rational approach to calculate the capacities of concrete filled steel sections at elevated temperatures with AISC approach. We have AISC approach for calculating the capacities at room temperature. Following that, developed an approach to calculate the capacities at elevated temperatures. Using this approach, analyzed various hollow steel sections with three different concrete infill (plain, reinforced and steel fiber reinforced concrete). As we have an established method in EURO Code to calculate the capacities at elevated temperatures, the results from the developed approach are compared with the results from EURO code method. The
results from the developed approach seemed to be little conservative compared to that of EURO code method. And later, the developed approach is validated by comparison with experimental results.

Poster Number: CE-20  
Title: Thermo-Mechanical Modeling of Load Bearing Reinforced Concrete Walls Subjected to Fire Exposure  
Authors: Puneet Kumar; V.K.R. Kodur  

Abstract: Reinforced concrete (RC) load bearing walls are widely utilized in buildings due to the numerous advantages they offer in terms of high axial load carrying capacity, fire compartmentation, thermal and sound insulation, and high in-plane and out-of-plane stiffness. While structural performance of RC walls is investigated thoroughly, information related to fire performance of these walls is rather sparse in the literature. Fire resistance of these load bearing walls is mostly estimated through standard fire tests or prescriptive approaches, without any consideration to critical factors governing fire behavior. 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 walls for a wide range of variables such as: different fire scenarios, concrete types, 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. Results from these parametric studies are utilized to propose a rational design approach, for performance based fire design of RC walls.

Poster Number: CE-21  
Title: Investigation of Effect of Compaction Characteristics on Performance of Asphalt Mixtures  
Authors: Yogesh Kumbargeri; Michele Lanotte; M. Emin Kutay  

Abstract: Compaction is one of the major stages during flexible pavement construction that ensures strength and durability of asphalt pavements. Temperature and pressure are two vital factors that affect compaction. In cold climatic regions such as Michigan, there may be a large reduction in asphalt mix temperature during haulng of the mix from the asphalt plant to the paving site. Moreover, the different stages of compaction and the equipment used during the site operations have a significant effect on asphalt densification. The main goal of this study is to investigate the compaction temperature and pressure sensitivity of different asphalt mixtures during compaction and figure out their impact on the performance of the pavement structure. In order to examine the effect of the binder type, virgin and modified binders will be used in this study. The goal of this research study will be achieved by (i) compacting asphalt mixtures using the Superpave Gyratory Compactor (SGC) at different compaction temperatures and pressures, (ii) evaluating these asphalt mixtures with performance tests such as dynamic modulus, flow number and disk shaped compact tension test, (iii) ranking the different mixtures, temperatures and pressure with respect to performance and (iv) developing correlation models between compaction and performance characteristics of asphalt mixtures. It is envisioned that this study will provide important information for Quality Assurance/Quality Control procedures used during the asphalt road construction.

Poster Number: CE-22  
Title: Feasibility of Quasi-Static Characterization Method for Dynamic Behavior of Liquid Nanofoam
Authors: Mingzhe Li; Weiyi Lu

Abstract: The mechanical behavior of liquid nanofoam (LN), a liquid suspension of nanoporous particles, at various strain rates has been experimentally investigated. First of all, the unique liquid infiltration behavior of a silica gel based LN is fully characterized by an Instron 5982 universal tester under quasi-static loading condition. Large amount of energy is dissipated into heat due to the effective excess solid-liquid interfacial tension. The energy absorption efficiency of the LN is determined by the liquid infiltration pressure and the total deformability. After that, the same LN is impacted by a lab-customized drop tower apparatus at intermediate strain rates (around 100 s⁻¹). The measured strain-stress curves are highly hysteretic. In comparison with the quasi-static sorption isotherm curve, the liquid infiltration pressure as well as the total deformability of the LN are not affected by the increased strain rate. In other words, the dynamic behavior of LN can be characterized by quasi-static compressive tests. More importantly, under blunt impact and even real blast scenarios, the energy absorption capacity of LN can be activated at desired pressure range due to the strain rate independent liquid infiltration behavior. The ultra-fast energy dissipation rate must be attributed to the extremely large specific surface area of the nanoporous media and the significantly enhanced liquid flow speed in nanopores.

Poster Number: CE-23
Title: Elastic Postbuckling Response of Bilaterally Constrained Non-Prismatic Columns
Authors: Suihan Liu; Rigoberto Burgueño

Abstract: Axially loaded bilaterally constrained columns can attain multiple snap-through buckling events in their elastic postbuckling response for use as energy concentrators that transform external quasi-static displacement input to high-rate motions to excite vibration-based piezoelectric transducers. Regulation of the postbuckling behavior can lead to increased performance of the energy harvesting device. This study presents how stiffness variations along the column element lead to enhanced control of the noted elastic postbuckling response. Results from experiments and numerical simulations show that non-uniform stiffness designs are able to tailor the location and sequence of buckling events by creating a concentrated buckling region on the column. Compared to a uniform design, non-prismatic columns can attain a higher number of mode transitions under the same global strain level and also create local stress waves that propagate along the element due to the stiffness variations, which leads an enhanced kinetic energy generation during the postbuckling response. The presented results confirm that non-prismatic columns are a viable way to control the elastic post-buckling response of these device elements, thus providing more options to the use of 1D structural prototypes for exploiting their elastic instabilities as energy triggering mechanism for energy harvesters with improved efficiency and performance.

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Poster Number: CE-24
Title: Value-Added Use of Carbon Dioxide for Production of a New Class of Sustainable Hydraulic Cements
Authors: Faris Matalkah; Parviz Soroushian

Abstract: Production of Portland cement accounts for about 7% of carbon dioxide emissions and 4% of energy use worldwide. The Portland cement chemistry also lacks the versatility required for value-added
use of broad categories of solid industrial wastes the chemistry of which is evolving in light of new of emission control requirements. This project employs an alternative inorganic binder chemistry for production of concrete. This binder chemistry, which relies upon hydrates and carbonates to render binding effects, offers the potential to significantly lower the carbon footprint and energy content of concrete. It is also highly robust, and can made value-added use of diverse industrial wastes which are not compatible with the chemistry of ordinary Portland cement. The project emphasizes value-added use of carbon dioxide for production of hydraulic cements of refined chemistry which compromise more than 80% waste and by-product raw materials. The resulting hydraulic cements incorporate carbonate anions in metastable forms, which transform into fine crystalline carbonates in the course of cement hydration. The integrated action of carbonates and hydrates is essential for meeting the standard performance requirements of hydraulic cements used in concrete production. This research project promises to yield a commercially viable approach to large-volume and value-added use of carbon dioxide. The hydraulic cements developed in the project offer significant performance, cost and sustainability advantages over ordinary Portland cement. A preliminary analysis concluded that the life-cycle cost, energy content and carbon footprint of the new hydraulic cements are, respectively, about 50%, 75% and 90% lower than those of Portland cement.

This work was supported in part by US Department of Energy, US Department of Agriculture, US Environmental Protection Agency

Poster Number: CE-25  
Title: Comparative Behavior of Fire-Exposed Composite Girders Subjected to Flexural and Shear Loading  
Authors: Mohannad Naser; Venkatesh Kodur

Abstract: This paper presents results from experimental studies on the comparative behavior of fire exposed composite steel girders subjected to flexural and shear loading. Three composite girders, comprising of steel girders and concrete slab, were tested under simultaneous structural loading and fire exposure. The main test variables are type and magnitude of loading, as well as level of composite action. The composite girder, mainly subjected to flexural loading, failed through flexural yielding of steel girder without any signs of shear failure. On the other hand, girders with shear loading failed in shear through shear web buckling early into fire exposure. A comparative performance evaluation of response parameters clearly shows that shear limit state should be considered when evaluating behavior of fire exposed composite girders.

This work was supported in part by National Science Foundation

Poster Number: CE-26  
Title: Analysis of Water Quality, Water Scarcity and Leading Factors to Using Contaminated Water Sources in Rural Communities  
Authors: Tula Ngasala; Susan Masten; Phanikumar Mantha

Abstract: Water scarcity and poor water quality are major challenges facing many rural areas where agriculture and livestock keeping are their main activities. Surface and groundwater sources are highly polluted due to poor water resource management and lack of modern agricultural practices. Families’ well-being are being affected due to poor access to water sources, seasonal availability and their economic status. The water quality of surface, shallow wells and deep wells in Naitolia Village, Arusha,
Tanzania was determined to identify the extent of contamination. Water Quality Index (WQI) for pH, nitrate, nitrite, ammonia and turbidity was used to show the overall water quality for each water source. Households were surveyed to identify factors that contribute to poor access and reliability to water sources. Results showed the maximum contaminant levels from all water sources exceeded W.H.O standards. Surface water, shallow wells and deep wells had the WQI of 1973, 833 and 58 respectively (<50-excellent, >300-very poor). Survey responses showed that more than 80% of this community use water sources that are highly contaminated, less than 19% of the population have access to deep wells. Although deep wells are the least contaminated, after considering other factors such as distance to water sources, economic status, seasonal availability and water quality, it was found that, in terms of access and quantity, boreholes were the least reliable, shallow wells were the most reliable followed by surface water. Improving the existing water resources is one of the sustainable solutions to improve health and well-being of families of Naitolia

**Poster Number:** CE-27  
**Title:** Development of an Acceptance Test for Chip Seal Project  
**Authors:** Ugurcan Ozdemir; M. Emin Kutay

**Abstract:** Chip seal is one of the most popular preventive maintenance techniques performed by many DOTs, county road departments and cities. The procedure involves binder application (emulsion asphalts, or sometimes cutback asphalts) on the surface of a deteriorated pavement, followed by spreading aggregates, compaction, curing and discarding loose aggregates by sweeping via rotary power brooms, respectively. One of the most important parameters affecting performance of chip seal is percent aggregate embedment depth into the binder. Depending on the percent embedment depth of chip seal samples, asphalt chip seals are susceptible to distresses such as aggregate chip loss and bleeding. Asphalt chip seals having the embedment depth less than 50% are usually more susceptible to aggregate loss due to insufficient bonding between binder and aggregate; whereas, asphalt chip seals having the aggregate embedment higher than 70% may lead to bleeding problems on the surface of the pavement. The main goal of this study was to develop a standard test procedure to directly calculate aggregate embedment depth in asphalt chip seal treatment via digital image analysis. Two image based algorithms were developed to calculate embedment depth, and another algorithm was developed to compute aggregate surface coverage area with binder. The statistical analysis results indicated that there is a good correlation between embedment depth obtained from image-based algorithm and sand patch test results. It was observed that binder application rate range specified in MDOT’s specification ensured to keep percent embedment range between about 50% and 70% which is desired range for not having distresses.

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

**Poster Number:** CE-28  
**Title:** Freezing and Thawing of Frost-Susceptible Soils (Development of a Reliable Predictive Model)  
**Authors:** Pegah Rajaei; Gilbert Baladi

**Abstract:** Frost depth is an essential factor in design of various transportation infrastructures. In frost susceptible soils, as soils freezes, water migrates through the soil voids below the freezing line towards the freezing front and causes excessive heave. The excessive heave can cause instability issues in the
structure, therefore predicting the frost depth and resulting frost heave accurately can play a major role in the design. On the other hand, as the spring begins the pavement starts to thaw from the top down and to a lesser extend from the bottom up. During this period, the pavement is in a critical condition where the upper and lower layers are thawed but the layer in between is frozen, acts as an impermeable layer and makes the water trapped in the system and the soil layer saturated. The stiffness and load bearing capacity of the saturated layer decrease considerably and cause premature deformations. This phenomenon occurs particularly in low volume roads. Spring load restrictions (SLR) are usually placed as preservation strategies. The objectives of this study were to develop accurate and reliable models for predicting frost and thaw depths and frost heave, to estimate the resulting heave pressure and to develop a model for estimating the SLR implementation period.

This work was supported in part by Michigan Department of Transportation

**Poster Number:** CE-29  
**Title:** Pavement Surface Characterization for Optimization of Trade-Off Between Grip and Rolling Resistance  
**Authors:** Shabnam Rajaei; Rozbeh Dargazany; Karim Chatti

**Abstract:** Understanding the interaction between pavement and tire surfaces is of great importance since it can improve the perception of friction, rolling resistance, wear, interior and exterior noise, splash and spray and thermal conductance between these surfaces. Friction plays an important role in vehicle safety while rolling resistance can affect fuel consumption of the vehicle. Several factors influence these two phenomena, which in this study the effect of tire properties and pavement surface characteristics are taken into account. An optimal method will be demonstrated to characterize the surface properties that yield the least rolling resistance without sacrificing grip in the process. Experimental studies will be done for obtaining comprehensive measurements of different sets of surface texture (from micro-texture to unevenness), their rolling resistance and friction.

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

**Poster Number:** CE-30  
**Title:** A Pattern Recognition Approach Based on Image Data Analysis for Structural Damage Detection with Discrete Binary Data  
**Authors:** Hadi Salehi; Saptarshi Das; Shantanu Chakrabartty; Subir Biswas; Rigoberto Burgueño

**Abstract:** A continuing challenge in structural health monitoring (SHM) is power availability for sensors to collect and communicate data. While self-powered sensors are addressing some concerns, the harvested power with current technology is still limited, and improving the network efficiency requires reducing the power budget. A way to minimize the communication power demand is to transmit the minimum amount of information, namely one bit. The binary signal can be generated at a sensor node according to a local rule based on physical measurements, but interpretation at the global level requires dealing with discrete binary (1 or 0) data, which implies system information with reduced resolution. This study presents an approach for the interpretation of such kind of binary data for use in structural assessment and damage identification. The approach was established upon the simulation of the discrete binary data generated from self-powered wireless sensors. Finite element simulation was used to generate the virtual data. A data interpretation system using pattern recognition (PR) along with a
conditional probability chain that takes into account the effect of time delay on the data was developed for damage detection. The performance and efficiency of the proposed approach was evaluated and tested for the case of a simply supported aluminum plate under distributed harmonic loading. Results demonstrate good performance of the proposed method and the applicability of PR methods as a promising damage identification algorithm for binary data sets in novel self-powered wireless sensor networks.

This work was supported in part by National Science Foundation

Poster Number: CE-31
Title: Characterizing Properties of Ultra High Performance Concrete (UHPC) at Elevated Temperatures
Authors: Mahmood Ahmad Sarwar; Venkatesh Kodur

Abstract: Concrete is one of the most widely used material in construction applications. Newer types of concrete are being developed to improve the performance and durability properties and explore environmentally friendly considerations. The most recent version of concrete is ultra high performance concrete (UHPC). Due to the high tensile strength that can be attained with UHPC, it is increasingly used in infrastructure applications. For use in building applications these concretes have to satisfy fire resistance requirements for which high temperature mechanical properties of UHPC is critical. However, data pertaining to UHPC’s properties at elevated temperatures is quite limited. Therefore compressive strength of UHPC at elevated temperatures are studied as part of a new research project at Michigan State University. A total of twenty-seven compressive strength tests of varying types of concrete (of which nine are UHPC), will be conducted at temperatures varying from twenty to eight-hundred degrees Celsius. Thus far, six UHPC tests have been conducted (temperatures ranging from twenty to four-hundred degrees Celsius) and their corresponding data has been compared to past research pertaining to normal strength concrete (NSC). Results from these tests will be used to propose a relation for compressive strength of UHPC as a function of temperature.

Poster Number: CE-32
Title: Development of a Continental-Scale Land Hydrology Model with Human Impacts for North America
Authors: Sanghoon Shin; Yadu Pokhrel

Abstract: Water resources sustainability has been threatened by increasing water demands and changing supplies due to climate change. In order to accurately predict water resources availability, it is important to assess the anthropogenic effects due to land-water management, which are the major drivers of water cycle change in many regions. In this study, an integrated continental-scale land hydrology model named Leaf-Hydro-Flood (LHF) model (Pokhrel et al., 2013) is used to simulate the natural and human-induced changes of water flows and storages over North America. We use two versions of LHF model: one with and the other without human water use. The model is tested for river flows over a range of basin scales across the United States, and the human impact on water resources is assessed by comparing the model results with a synthesis of ground- and satellite-based observations. We also present the available detailed hydrological data in the United States, and our approach to integrate them into the model and to improve modeling schemes.
**Poster Number:** CE-33  
**Title:** Multi-Gene Genetic Programming Approach for the Prediction of Crumb Rubber Modified (CRM) Binder Viscosity  
**Authors:** Sepehr Soleimani; Michele A. Lanotte; M. Emin Kutay

**Abstract:** Adding crumb rubber to asphalt binder results in an instantaneous and delayed variation of the modified binder viscosity during the production process. Although several studies have been carried out in this area, behavioral characterization of CRM binder viscosity is a challenging task because this phenomenon is influenced by several parameters and needs cumbersome lab efforts. In this study, a multi-gene genetic programming (MGGP) approach is proposed for the prediction of the CRM binder viscosity. The main goal is to formulate the viscosity of the CRM binder in terms of the gradation and surface area of rubber particles, rubber content, density, as well as mixing time and temperature. Analyses were first carried out on crumb rubber products derived from ambient and cryogenic size-reduction processes, then viscosity tests were performed at a given shear rate and temperature, on CRM binders produced in laboratory in a wide range of mixing time and temperature. The results indicate that the MGGP models have a superb accuracy and efficiency especially when compared against linear regression models. The contribution of each parameter is evaluated through a sensitivity analysis. Moreover, a parametric study is performed to investigate the effect of each parameter on the response. The model and the parametric study proved to be in agreement with the interaction phenomena which occur within the production process of asphalt rubber binders.

**Poster Number:** CE-34  
**Title:** Flexural Behavior of Ultra High Performance Fiber Reinforced Concrete Beams  
**Authors:** Roya Solhmirzaei; Venkatesh Kodur

**Abstract:** Ultra-high performance fiber reinforced concrete (UHPFRC), is an emerging class of cementitious materials offering very high compressive and tensile strength, improved durability and ductility properties. Being a relatively new construction material, there is limited data on response of structural members fabricated using UHPFRC. To generate such data, six reinforced UHPFRC beams were fabricated for testing under flexural loading. Two beams were tested under four point bending test. Flexural behavior of beams, including crack propagation, load deflection response, failure patterns, and flexural capacity were traced. Finally, a simplified approach based on sectional analysis and strain compatibility principles was applied to derive moment-curvature response of UHPFRC beams. This approach takes into consideration the high tensile strength and tension softening effect in evaluating moment-curvature response of UHPFRC beams. Material models suggested in literature, based on experimental tests, were used in analytical predictions. This approach is validated against test data published in literature and subsequently utilized to predict the ultimate capacity of reinforced UHPFRC beams fabricated as part of this study. The experimental and analytical studies carried out in this study will help to establish fundamental principles governing flexural and shear response of UHPFRC beams.

**Poster Number:** CE-35  
**Title:** Prediction of Pedestrian Crashes at Midblock Crossing Areas Using Site and Behavioral Characteristics  
**Authors:** Steven Stapleton; Timothy Gates
Abstract: Safety performance functions (SPFs) provide a promising approach for estimating the number of pedestrian crashes at midblock crossing facilities. Research is limited in terms of disaggregate-level studies considering the effects of motor vehicle/bicycle/pedestrian volumes, roadway geometry, and other factors on pedestrian crashes, due in large part to the relative infrequency at which such crashes occur. This study addresses this shortfall by observing motorist and pedestrian behavior at crosswalks. Data were collected at more than 30 midblock crossing locations within Detroit, East Lansing and Kalamazoo. The sites were selected to provide a broad range of road user volumes and geometric characteristics as well as a variety of crossing facilities, including crossings with no additional treatment, rectangular rapid flashing beacons, pedestrian hybrid beacons, and in-street pedestrian crossing signs in order to identify the effects of the various behavioral, exposure, and geometric characteristics on traffic crashes. Data collected for each site include behavior of drivers upon encountering a crossing pedestrian, evasive actions taken by the road users or pedestrians during such encounters, motor vehicle volumes, pedestrian crossing volumes, existing traffic control devices, and cross-sectional characteristics of the roadway. Traffic crash data are also being compiled for each location. The data are currently being prepared for integration with the SPF development to examine how the effects of these variables affect safety performance along urban roadways.

This work was supported in part by FHWA

Poster Number: CE-36
Title: Thermal, Electrical and Structural Behavior of ‘Reversible Bonded’ Composite Joints
Authors: Suhail Hyder Vattathurvalappil; Mahmoodul Haq; Ermiąs G. Koricho; Lawrence T. Drzal

Abstract: Adhesively bonded joints offer the best route for light-weighting by eliminating holes, fasteners and associated stress concentrations. However, conventional thermostet-bonded joints are ‘single-cure,’ and cannot be dis-assembled or repaired. Thermoplastic adhesives modified by conductive nanoparticles allow coupling with electromagnetic radiations via non-contact methods, and increase the adhesive temperature to the required processing temperatures to assemble and disassemble the resulting joints. In this work, thermoplastic adhesives (polycarbonate) reinforced with graphene nanoplatelets (GnP) and ferromagnetic nanoparticles (FMnP) were developed to study the reversible bonding behavior of glass-fiber reinforced composite substrates under microwave electromagnetic radiation. Varying concentrations of GnP and FMnP were embedded in thermoplastic adhesives to investigate the thermal, electrical, and mechanical behavior of the adhesives and the resulting adhesively bonded joints. Numerical homogenization was also performed using mean-field approach to predict the GnP/FMnP modified adhesive mechanical properties. Results indicate that depending on the amount of GnP/FMnP contents, the thermal, electrical, and mechanical properties of the adhesives were significantly varied. Results also showed that the numerical prediction of effective modulus in the linear elastic regime agreed well with experimental findings. Overall, active adhesives such as those attempted in this work have a great potential in a wide range of applications wherein in-situ repair, re-assembly and recyclability are essential. Experimentally validated numerical simulations are also essential to aid the development of highly tailorable ‘reversible adhesives’ and to fully exploit the benefits they offer.

This work was supported in part by Department of Energy

Poster Number: CE-37
Title: Impacts of Maintenance treatments on the Life Cycle Pavement Condition and Distress of the LTPP SPS-3 Test Sections
Authors: Gopikrishna Musunuru; Gilbert Baladi

Abstract: One of the objectives of the Long-Term Pavement Performance (LTPP) Specific Pavement Studies (SPS)-3 experiment is to examine the effectiveness of maintenance treatments on the performance of flexible pavements compared to the performance of untreated control sections. The applied maintenance treatments include slurry seal, chip seal, crack seal, and thin overlay. In a research study sponsored by the LTPP program of the Federal Highway Administration (FHWA), the impacts of these maintenance treatments on the functional and structural performance of the flexible pavement test sections of the SPS-3 experiment were analyzed. The analyses of the functional performance was based on ride quality using the International Roughness Index (IRI) and safety (rut depth). While analyses of the structural performance was based on the pavement alligator, transverse, and longitudinal cracking and on rut depths. For each SPS-3 test section, the functional performance is represented by the Remaining Functional Period (RFP) and the structural performance by the Remaining Structural Period (RSP). Both metrics, the RFP and the RSP, were developed in this study to rate the performance of flexible, rigid, and composite pavement sections. This paper presents and discusses the results of the analyses of the performance of the SPS-3 test sections. It is shown that, as expected, after treatment pavement performance is a function of the before treatment condition or distress. The thin overlay treatment was most effective and improved the pavement performance relative to IRI and rut depth but did not improve the pavement performance relative to alligator, longitudinal, and transverse cracking.

This work was supported in part by Federal Highway Administration
**COMPUTER SCIENCE**

**Poster Number:** CSE-01  
**Title:** A High Performance Block Eigensolver for Nuclear Configuration Interaction Calculations  
**Authors:** Md Afibuzzaman; Hasan Metin Aktulga

**Abstract:** High accuracy prediction on the properties of light atomic nuclei using Configuration Interaction(CI) requires computing some extremal eigenpairs of the many-body Hamilton matrix, $H$. $H$ is a sparse matrix, and although a Lanczos based eigensolver is commonly used for symmetric sparse eigenvalue problems, one can use the Locally Optimal Block Preconditioned Conjugate Gradient (LOBPCG) as it requires the multiplication of Sparse Matrix with Multiple vectors (SpMM). In SpMM, one can make use of the increased data locality and obtain much higher performance. A significant time is spent on multiplication of the $H$ sparse matrix with multiple vectors and existing implementations of these multiplications do not perform as expected. Here we analyze 4 different ways to implement SpMM and the transpose operation, SpMM_T. We base our implementation on the Compressed Sparse Blocks (CSB) format and target multicore architectures. The four implementations we consider here are: the traditional CSR (Compressed Sparse Row), Row partitioning algorithm, CSB using OpenMP and CSB using Cilk runtime environment. We also develop and analyze a performance model that allows us to estimate the performance comparisons of our implementations. Extensive performance analysis show that the new CSB/OpenMP implementation achieves 3-4x speedup for SpMM and SpMM_T operations over good implementations based on CSR. Using a block eigensolver with optimized SpMM operations, we can attain 1.5-2x speed up in the overall execution time of the Lanczos based eigensolver used in MFDn.

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**Poster Number:** CSE-02  
**Title:** Intelligent and Automatic Quantification of in vivo Cells in MRI  
**Authors:** Muhammad Afridi; Steven Hoffman; Arun Ross; Xiaoming Liu; Erik Shapiro

**Abstract:** Cell-based therapy (CBT) is emerging as a promising solution for a large number of serious health issues including organ transplant, cancer and brain injuries with limited success in humans. The key hurdle is our inability to determine the number and location of cells transplanted in live organs (in vivo) which severely affects our understanding about in vivo cell behavior. Therefore, experts conduct an MRI of the affected organ and then manually locate the transplanted cells to understand their behavior. However, manual enumeration in 3D MRI is a tedious task that is prone to subjectivity and inaccuracy. Hence, performing an essential large scale MRI analysis to understand in vivo cell behavior is clearly infeasible which directly hinders the success of CBT in humans. This study presents the first comprehensive research on how a computer based accurate, automatic and intelligent cell quantification approach can be developed for MRI scans. The proposed approach utilizes a deep learning based convolutional neural network (CNN) framework for accurately learning cell features in MRI and further exploits the principles of transfer learning via CNNs to learn accurately with only small amount of available medical data. Additionally, this study also shows how CNNs can incorporate learning from human labeling behavior to learn more accurate cell detection models. Comprehensive experimental evaluation using more than 100,000 testing samples show the proposed approach performs with an accuracy of up to 99.8% in vitro and 97.3% in vivo which was significantly superior to the traditional computer-vision and other CNN based approaches.
This work was supported in part by We are thankful to the support provided by NIH grants DP2 OD004362 (EMS), R21 CA185163 (EMS), R01 DK107697 (EMS), R21 AG041266 (EMS).

**Poster Number:** CSE-03  
**Title:** A Machine-to-Machine Outsourcing Approach to Monitoring Quality of Experience for Operational Cellular Networks  
**Authors:** Faraz Ahmed; Jeffrey Erman; Zihui Ge; Alex X. Liu; Jia Wang; He Yan

**Abstract:** Cellular data networks are being increasingly used to connect to the Internet, to provide seamless Internet access with high quality of experience, it is crucial for cellular network operators to monitor network health and assess service quality perceived by its customers. Machine-to-Machine (M2M) devices communicate using the same cellular network as human operated devices such as mobile phones. This provides an unprecedented opportunity for cellular network operators to use M2M devices as free sensors on the field to measure what end-users experience. In this paper, we propose to out source network service quality monitoring to M2M devices. This approach provides a brand-new view that is much closer to the end-users' experience. We present our design and prototype of a monitoring system called M2MScan for a large-scale operational cellular network. We first identify a candidate set of M2M devices with highly predictable mobility and communication patterns using data collected from a large-scale cellular provider in North America. We then use these M2M devices to detect cell tower outage and estimate customer impact of cell tower outages. We evaluate M2MScan by using cell tower outages in a 2-months time window and our operational experience reveals that: (i) customer’s experience can be measured at a fine-granularity by monitoring M2M device communication; (ii) customer experience during network outages varies both in space and time; and (iii) customer experience estimates can be used by cellular network provider to improve network coverage and network resiliency. to the best of our knowledge, this is the first work that employs M2M devices to monitor operational cellular networks at a large scale.

**Poster Number:** CSE-04  
**Title:** Epileptic Seizure Inference  
**Authors:** Atra Akandeh; Fathi Salem

**Abstract:** Epilepsy is one of the most debilitating neurological disorders affecting about 70 million people in the world (according to the International League Against Epilepsy). Epilepsy entails a temporal change in the brain’s electrical activity that expresses itself in motor, psychic, and sensory manifestations associated with spasms. Diagnosis of epilepsy is usually performed by analyzing electroencephalogram (EEG) signals, as well as the patient’s neurological behavior. However, this approach requires time-consuming recordings and their analysis by an expert. Automated analysis of EEG recordings to assist in the diagnosis and inference of epilepsy has continued to this day. The most common methods for seizure detection are based on principal and independent component analysis, clustering techniques, and data mining classification techniques, and recently feedforward neural networks. In this project, we propose an automatic analysis system based on deep neural networks in order to infer and classify the brain firing signals into one of four possible epileptic states: inter-ictal, pre-ictal, ictal and post-ical. This approach will integrate two main components: feature extraction and inference/classification. The methodology will also incorporate non-convex optimization methods using homotopic diffusion equations to improve the deep network performance.
**Poster Number:** CSE-05  
**Title:** Keystrokes Recognition Using Wi-Fi Signals  
**Authors:** Kamran Ali; Alex X. Liu; Wei Wang; Muhammad Shahzad

**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 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% for reasonable typing speeds.

**Poster Number:** CSE-06  
**Title:** WiGesture: Facial Gesture Recognition Using WiFi Signals  
**Authors:** Salman Ali; Kamran Ali; Alex X. Liu; Wei Wang

**Abstract:** Recently WiFi signals have been used for detecting human activities based on disturbances created in Received Signal Strength and Channel Side Information (CSI). Variations in CSI values for Multiple Input Multiple Output (MIMO) streams of WiFi devices with multiple antennas can be leveraged to detect and recognize various human or non-human activities within the vicinity. In this paper, we propose WiGesture, a CSI based facial gesture recognition system that quantifies small variations in CSI caused by gestures related to pronunciation of common interjections. Detection of such interjections associated with a particular emotion or sentiment are particularly difficult to detect since the variations are mostly embedded as noise in the CSI variations. To achieve this, WiGesture needs to detect and analyze fine-grained signal reflections from multi-paths generated from facial movements. We not only propose a novel approach to differentiate gestures, we also present our work in a real case application of smartphone usage scenario. The implementation of WiGesture is done in real time on a commodity WiFi device with detection accuracy in the range of 80% using only 6 training samples.

**Poster Number:** CSE-08  
**Title:** Automated Detection and Tracking of a Trailers Coupler  
**Authors:** Yousef Atoum; Joseph Roth; Xiaoming Liu

**Abstract:** Our work aims at developing an effective and efficient computer vision (CV) system to continuously detect and track a trailers tongue in real time, for the purpose of simplifying the action of coupling the tongue of the trailer to a truck. Even for experienced truck drivers, attaching the trailer to the truck might be a challenging task. More recently, some newly manufactured cars contain a rear-view
built-in camera that would help in this process. We propose to use the camera sensor in developing an automatic CV system to detect and track the trailers coupler. We explore a large variety of possible detectors and trackers including Correlation Filter (CF) and Convolutional Neural Networks (CNN). to evaluate our system, we collect data from several trailer dealer sites. The dataset contains 406 videos varying in trailer types (models, colors, and shapes), weather conditions (Sunny and cloudy), and different environments (streets, gravel, snow and dirt). The videos also have several challenges such as pose, scale and illumination variations. Extensive experimental results demonstrate the accuracy, robustness, and efficiency of our automated system.

*This work was supported in part by General Motors (GM)*

**Poster Number:** CSE-07  
**Title:** Livestock Detection and Tracking in the Thermal Spectrum  
**Authors:** Aaron Gonzales; Arun Ross

**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 as a surveillance instrument to monitor a livestock pen. In particular, we will develop automated computer vision and pattern recognition methods to detect and track livestock as well as intruders - both animal and human - attempting to compromise the security of the livestock pen. 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 classifier that detects individual objects (animals/human) in an enclosure and labels them using a multi-class classifier. Next, we will develop a method to track individual objects in order to determine their intent (e.g., do they pose a threat to the other animals). Finally, we will acquire data using a thermal camera and evaluate the performance of the proposed methods. The proposed methods are expected to be resilient to a number of confounding factors such as occlusion, inclement weather, low-intensity lighting, etc.

**Poster Number:** CSE-09  
**Title:** Automated Online Exam Proctoring  
**Authors:** Yousef Atoum; Liping Chen; Alex Liu; Stephen Hsu; Xiaoming Liu

**Abstract:** Massive open online courses (MOOCs) and other forms of remote education continue to increase in popularity and reach. The ability to efficiently proctor remote online examinations is an important limiting factor to the scalability of this next stage in education. Presently, human proctoring is the most common approach of evaluation, by either requiring the test taker to visit an examination center, or by monitoring them visually and acoustically during exams via a webcam. However, such methods are labor-intensive and costly. In this work, we present a multimedia analytics system that performs automatic online exam proctoring. The system hardware includes one webcam, one wearcam, and a microphone, for the purpose of monitoring the visual and acoustic environment of the testing location. The system includes six basic components that continuously estimate the key behavior cues: user verification, text detection, voice detection, active window detection, gaze estimation and phone detection. By combining the continuous estimation components, and applying a temporal sliding window, we design higher-level features to classify whether the test taker is cheating at any moment during the exam. to evaluate our proposed system, we collect multimedia (audio and visual) data from
24 subjects performing various types of cheating while taking online exams. Extensive experimental results demonstrate the accuracy, robustness, and efficiency of our online exam proctoring system.

This work was supported in part by Michigan State University Targeted Support Grants for Technology Development (TSGTD) program.

Poster Number: CSE-10
Title: From Which Camera Did This Iris Image Come From?
Authors: Sudipta Banerjee; Arun Ross

Abstract: Iris recognition systems use images of the iris (which is the textured annular portion of the human eye) for human recognition. The proposed work attempts to automatically determine the identity of the sensor, i.e., the device, based on the raw image alone. Device identification is useful in applications where digital tampering is prevalent. Further, it can be used to invoke a specific set of image processing routines based on knowledge of the sensor that was used to acquire the image. Current research exploits the notion of Photo Response Non-Uniformity (PRNU) noise - a distinctive sensor pattern embedded in the image - for device identification. However, the use of PRNU noise pattern has certain limitations. For example, the noise pattern can be contaminated by the scene details, thereby, impacting the device identification accuracy. In our work, we use the recently proposed Enhanced Sensor Pattern Noise (ESPN) to enhance the sensor pattern noise and subdue the scene content in the context of iris images acquired in the near-infrared spectrum. Experiments involving images from multiple iris sensors confirm the benefits of the proposed approach.

Poster Number: CSE-11
Title: Stochastic Convex Sparse Principle Component Analysis
Authors: Inci M. Baytas; Kaixiang Lin; Fei Wang; Jiayu Zhou; Anil K. Jain

Abstract: Principal Component Analysis (PCA) is a dimensionality reduction and data analysis tool commonly used in many areas. The main idea of PCA is to represent high dimensional data with a few representative components that capture most of the variance present in the data. However, there is an obvious disadvantage of traditional PCA when it is applied to analyze data where interpretability is important. In applications, where the features have some physical meaning, we lose the ability to interpret the principal components extracted by conventional PCA because each principal component is a linear combination of all the original features. For this reason, sparse PCA has been proposed to improve the interpretability of traditional PCA, by introducing sparsity to the loading vectors of principle components. In this paper, we propose a convex sparse principle component analysis (Cvx-SPCA), which leverages a proximal variance reduced stochastic scheme to achieve a geometric convergence rate. We further show that the convergence analysis can be significantly simplified by using a weak condition, allowing a broader class of objectives to be applied. The efficiency and effectiveness of the proposed method is demonstrated on a large scale electronic medical record cohort.

Poster Number: CSE-12
Title: Face Image Quality for Automatic Face Recognition
Authors: Lacey Best-Rowden; Anil K. Jain
Abstract:
Poster Number: CSE-13  
Title: Exploring Sex Prediction from a Near Infrared Iris Image  
Authors: Denton Bobeldyk; Arun Ross  

Abstract: Recent research has explored the possibility of automatically deducing the sex of an individual based on near infrared (NIR) images of the iris. This has benefits in the context of an iris biometric system, where an individual is recognized based on an NIR image of the iris. Most operational iris biometric systems typically acquire an image of the extended ocular region (rather than just the iris only) for processing. In this work, we investigate the sex-predictive accuracy associated with three different regions: (a) the entire ocular region; (b) the iris-excluded ocular region; and (c) the iris-only region. We employ the BSIF texture operator (Binarized Statistical Image Feature) to extract features from these regions, and use a Support Vector Machine (SVM) to classify the extracted feature set as Male or Female. Experiments on a dataset containing 3314 images suggests that the iris region only provides modest sex-specific cues compared to the surrounding ocular region. This research underscores the importance of using the periocular region in iris recognition systems.

Poster Number: CSE-14  
Title: FingerprintMash: Latent Fingerprint Value Determination by Expert Crowdsourcing  
Authors: Tarang Chugh; Kai Cao; Anil K. Jain  

Abstract: Automatic fingerprint identification systems (AFIS), first introduced in the early 1980s, are now used by virtually every law enforcement and forensic agency to identify victims and suspects. However, identifying a person, whether by latent experts or AFIS, based on latent (partial) fingerprints left at crime scenes continues to pose a challenge. This challenge is primarily due to the generally low quality or value of latent prints. Latent fingerprint value can be defined in terms of quality and quantity of information content (e.g., ridge clarity and no. of minutiae). In forensics, latents are typically categorized by experts based on their value: (i) value for identification (VID), (ii) value for exclusion only (VEO), and (iii) no value (NV). But, this manual process of value determination is subjective. In order to understand this subjectivity and to develop a baseline for evaluating automatic methods of value determination, our research has made the following contributions: (i) Designed a crowdsourcing tool, called FingerprintMash, which allows latent experts to assign an absolute and a relative value to a latent and a pair of latents, respectively, (ii) asked a pool of 33 fingerprint experts to assign values to a set of 100 latent pairs chosen randomly from our database of 516 latents, (iii) used matrix completion to infer latent rankings based on absolute and relative values, and (iv) utilized Multidimensional Scaling (MDS) to visualize the 516 x 516 similarity matrix of the 516 latents to determine the underlying factors that latent experts use to assign a value. Our analysis shows that (i) there is large variability in the values assigned by the expert crowd, (ii) crowdsourced value (median) performs better than value by a single examiner, in terms of predicting the AFIS performance, and (iii) Multidimensional Scaling enables us to understand the basis of latent experts’ value determination.

Poster Number: CSE-15  
Title: Exploring Spatial Skills of Introductory Programming Students  
Authors: Sarah Coburn; Mark Urban-Lurain
Abstract: Introductory programming courses are often perceived as difficult, frequently discouraging potentially talented students from continuing in the major. One potential reason for this difficulty is extraneous cognitive load: information that competes for mental resources with the essential concepts in introductory programming courses. We examine spatial visualization skills: the ability to perceive and mentally manipulate spatial objects. We propose that spatial visualization skills positively impact the ability to process visual information in working memory, therefore minimizing extraneous load and allowing mental resources to be dedicated to learning essential computer programming concepts. We present initial findings of student spatial skills before and after a semester in an introductory programming course, and the relationship with course performance. We discuss ongoing research on training student spatial skills, as well as future research for improving introductory programming curriculum by presenting concepts spatially, utilizing multiple channels of working memory.

Poster Number: CSE-16
Title: The Forge: Building Efficient Packet Classifiers
Authors: James Daly; Eric Torng

Abstract: Packet classification is a major component of network devices, such as firewalls and forwarding tables. Because these devices have real-time constraints, it is important that they are able to classify packets efficiently. If they do not, the entire network may become congested. For newer software-defined networks, fast updates are also important. We present a new classifier that provides both fast classification times and fast updates.

Poster Number: CSE-17
Title: A Bayesian Belief Fusion Framework for Integrating Match Scores with Auxiliary Information in Fingerprint Verification Systems
Authors: Yaohui Ding; Ajita Rattani; Arun Ross

Abstract: Recent research has addressed the robustness of fingerprint verification systems against spoof attacks by combining match scores with both liveness measures as well as image quality in a learning-based fusion framework. Designing such a fusion framework is challenging because quality and liveness measures can impact the match score and, therefore, the influence of these variables on the match score has to be modelled. We advance the state-of-the-art on this topic by proposing two Bayesian Belief Network (BBN) models that can utilize these measures effectively and appropriately model the relationship between quality, liveness measure and match scores. We show that the proposed BBN models result in consistently better matching performance than existing fusion frameworks.

Poster Number: CSE-18
Title: The Effects of Evolution and Spatial Structure on Diversity in Biological Reserves
Authors: Emily Dolson; Michael Wiser; Charles Ofria

Abstract: Conservation ecologists have long argued over the best way of placing reserves across an environment to maximize population diversity. Many have studied the effect of protecting many small regions of an ecosystem vs. a single large region, with varied results. However, this research tends to ignore evolutionary dynamics under the rationale that the spatiotemporal scale required is prohibitive. We used the Avida digital evolution research platform to overcome this barrier and study the response
of phenotypic diversity to eight different reserve placement configurations. The capacity for mutation, and therefore evolution, substantially altered the dynamics of diversity in the population. When mutations were allowed, reserve configurations involving a greater number of consequently smaller reserves were substantially more effective at maintaining existing diversity and generating new diversity. However, when mutations were disallowed, reserve configuration had little effect on diversity generation and maintenance. While further research is necessary before translating these results into policy decisions, this study demonstrates the importance of considering evolution when making such decisions and suggests that a larger number of smaller reserves may have evolutionary benefits.

*This work was supported in part by - BEACON Center - NSF Doctoral Fellowship*

**Poster Number:** CSE-19  
**Title:** Causality of Verbs for Grounded Language Understanding  
**Authors:** Qiaozi Gao; Malcolm Doering; Shaohua Yang; Joyce Chai

**Abstract:** Linguistics studies have shown that concrete action verbs often denote some Change of State (CoS) as the result of an action. However, the causality of verbs and its potential connection with the physical world has not been systematically explored. to address this limitation, this work presents our study on verb causality modeling. We first conducted a crowd-sourcing study to identify potential categories of causality for a selected set of verbs. Associated with these categories, we then defined a set of rule-based detectors using visual perception information. Our empirical results have demonstrated that these simple detectors can be directly applied for grounding language to perception (i.e., grounding semantic roles of verbs to perceived objects) and achieve competitive performance. When the training data is available, the association between the detectors and the verbs can be further learned, which is shown to achieve significant performance gain compared to a state-of-the-art approach in grounding.

*This work was supported in part by NSF and DARPA.*

**Poster Number:** CSE-20  
**Title:** Mapping the Genomic Architecture of Adaptive Traits with Interspecific Introgressive Origin  
**Authors:** Hussein Hejase; Kevin Liu

**Abstract:** Introgression involves the transfer of genetic information from one species/population to another as a result of hybridization and repeated backcrossing. Introgression has played a key role in the evolution of novel traits in many different organisms, including adaptation to high-altitude environments in humans, evolution of mimetic butterfly wing patterns, and pesticide resistance in house mice. The goal of this work is to identify the genomic architecture of introgressed traits. We use association mapping, which pinpoints statistical associations between genotypic and trait characters, to uncover the underlying genetic factors contributing to variation in a trait of interest. One of the issues that need to be addressed when conducting an association mapping study is sample relatedness, which induces spurious associations between genotypic and trait characters when the evolutionary relatedness among samples is not accounted for or wrong. To address this issue, we introduce Coal-Map 2, a new method that combines a linear mixed model to evaluate the relationship between genotypic and trait characters with an evolutionary model to capture complex sample relatedness. We explore the performance of Coal-Map 2 using an extensive performance study. We find that Coal-Map 2 significantly
outperforms state-of-the-art methods (including EIGENSTRAT and our previously introduced method Coal-Map) both in terms of true positive rate and false positive rate. At a typical false positive rate of 5%, Coal-Map 2's true positive rate was better than EIGENSTRAT and Coal-Map by 20% and 10%, respectively.

This work was supported in part by This work was partially supported by Grant CCF-1565719 from the National Science Foundation and by startup funds from Michigan State University (to K.L.).

Poster Number: CSE-21
Title: Towards a Truthful Online Spectrum Auction with Dynamic Demand and Supply
Authors: Chowdhury Hyder; Thomas Jeitschko; Li Xiao

Abstract: In spectrum trading, secondary users bid for the spectrum units being made available by the primary users. Auction theory has been widely applied to improve spectrum allocation in such spectrum trading scenarios. However in contrast to reality, most of the research work assume either static user population or static spectrum supply or both. In this work, we investigate a realistic dynamic auction environment where secondary users with diverse delay bounds arrive dynamically and spectrum becomes available at random. We propose a priority ranking based online auction mechanism that prevents bidders from gaining advantage by misreporting information. We prove that the proposed auction mechanism is truthful and individual rational. We illustrate the properties of the mechanism in terms of spectrum utilization rate, bidder satisfaction rate, and average bidder utility through extensive simulations.

This work was supported in part by NSF

Poster Number: CSE-22
Title: Large-Pose Face Alignment via CNN-Based Dense 3D Model Fitting
Authors: Amin Jourabloo; Xiaoming Liu

Abstract: Face alignment aims to estimate the locations of a set of landmarks for a given image. This problem has received much attention as evidenced by the recent advancement in both the methodology and performance. However, most of the existing works neither explicitly handle face images with arbitrary poses, nor perform large-scale experiments on non-frontal and profile face images. In order to address these limitations, we proposed a novel face alignment algorithm that estimates both 2D and 3D landmarks and their 2D visibilities for a face image with an arbitrary pose. By integrating a 3D point distribution model, a cascaded coupled-regressor approach is designed to estimate both the camera projection matrix and the 3D landmarks. Furthermore, the 3D model also allows us to automatically estimate the 2D landmark visibilities via surface normal. We use a substantially larger collection of all-pose face images to evaluate our algorithm and demonstrate superior performances than the state-of-the-art methods.

Poster Number: CSE-23
Title: The Evolutionary Origins of Phenotypic Plasticity
Authors: Alexander Lalejini; Charles Ofria
Abstract: Many effective and innovative survival mechanisms used by natural organisms rely on the capacity for phenotypic plasticity; that is, the ability of a genotype to alter how it is expressed based on the current environmental conditions. Understanding the evolution of phenotypic plasticity is an important step towards understanding the origins of many types of biological complexity, as well as to meeting challenges in evolutionary computation where dynamic solutions are required. In this work, we leverage the Avida Digital Evolution Platform to experimentally explore the selective pressures and evolutionary pathways that lead to phenotypic plasticity. We present evolved lineages wherein unconditional traits tend to evolve first; next, imprecise forms of phenotypic plasticity often appear before optimal forms finally evolve. We visualize the phenotypic states traversed by evolved lineages across environments with differing rates of mutations and environmental change. We see that under all conditions, populations can fail to evolve phenotypic plasticity, instead relying on mutation-based solutions.

This work was supported in part by This work was supported in part the US National Science Foundation under cooperative agreement No. DBI-0939454 and by Michigan State University through a fellowship for Lalejini.

Poster Number: CSE-24
Title: Multi-Task Feature Interaction Learning
Authors: Kaixiang Lin; Jianpeng Xu; Shuiwang Ji; Jiayu Zhou

Abstract: Linear models are widely used in various data mining and machine learning algorithms. One major limitation of such models is the lack of capability to capture predictive information from interactions between features. While introducing high-order feature interaction terms can overcome this limitation, this approach dramatically increases the model complexity and imposes significant challenges in the learning against overfitting. When there are multiple related learning tasks, feature interactions from these tasks are usually related and modeling such relatedness is the key to improve their generalization. In this paper, we propose a novel Multi-Task feature Interaction Learning (MTIL) framework to exploit the task relatedness from high-order feature interactions. Specifically, we collectively represent the feature interactions from multiple tasks as a tensor, and prior knowledge of task relatedness can be incorporated into different structured regularizations on this tensor. We formulate two concrete approaches under this framework, namely the shared interaction approach and the embedded interaction approach. The former assumes tasks share the same set of interactions, and the latter assumes feature interactions from multiple tasks share a common subspace. We have provided efficient algorithms for solving the two formulations. Extensive empirical studies on both synthetic and real datasets have demonstrated the effectiveness of the proposed framework.

This work was supported in part by Office of Naval Research and National Science Foundation.

Poster Number: CSE-25
Title: Inter-Femtocell Interference Identification and Resource Management
Authors: Chin-Jung Liu; Pei Huang; Li Xiao

Abstract: OFDMA femtocell is a promising technology to improve indoor wireless cellular network coverage in a cost-effective way. Large-scale deployment of femtocells in urban area is expected in the near future. However, inter-femtocell interference significantly limits the achievable throughput of a
femtocell network. A typical approach to mitigate inter-cell interference is known as resource isolation, which aims at assigning non-overlapping resources to interfering femtocells. A major challenge for interference mitigation in femtocell networks is that the femtocells are often installed by end-consumers without any pre-planning. Very limited information about the femtocells is available, making it hard to decipher the inter-femtocell interference. Previous studies either take time to resolve collisions online or adopt a conservative approach to identify interferers. Although the latter approach avoids wasting time on resolving collisions, it may result in resource underutilization. In this paper, we propose an efficient method to identify inter-femtocell interference by analyzing the received patterns observed by mobile stations. We conducted experiments on GNU Radio/USRP to demonstrate that the proposed interference identification method can successfully identify real interferers while excluding non-interfering femto-cells from suspicious interfering femtocells. With the proposed interference identification, the resource allocation to the femtocells can achieve better fairness and higher throughput.

**Poster Number:** CSE-26  
**Title:** Model Repair  
**Authors:** Mohammad Roohitavaf; Sandeep Kulkarni

**Abstract:** Model repair tries to find an optimal balance between model checking -- which focuses on verifying the given model and model synthesis -- which focuses on designing a model that is correct by construction. In particular, model repair begins with an existing model that satisfies a subset of desired properties. Then it revises that model so that it preserves those properties while also satisfying some new properties such as fault-tolerance, stabilization, safety and liveness.

**Poster Number:** CSE-27  
**Title:** Network Aware Task Scheduling in Data Centers  
**Authors:** Ali Munir; Alex Liu

**Abstract:** Datacenters are being used as a critical infrastructure for high-revenue online services such as web search, social networking, and recommendation systems. For provisioning such large-scale online applications, datacenters face extreme challenges in providing desired user experience. These datacenter applications have very demanding latency requirements and even a small fraction of a second can make a quantifiable difference in user experience thus impacting the revenue. For example, Google observed a 20% traffic reduction from an extra 500ms, and Amazon found that every additional 100ms of latency costs them a 1% loss in business revenue. to improve the performance of these applications, existing datacenter schedulers optimize either the placement of tasks or the scheduling of network flows. The task scheduler strives to place tasks close to their input data to minimize network traffic, while assuming fair sharing of the network. The network scheduler strives to finish flows as quickly as possible based on their sources and destinations determined by the task scheduler. Inconsistent assumptions of the two schedulers can compromise the overall application performance. In this work, we propose NEAT, a task scheduling framework that leverages information from the underlying network scheduler to make task placement decisions. The core of NEAT is a task completion time predictor that estimates the completion time of a task under a given network condition and a given network scheduling policy. NEAT improves application performance by up to 4x for suboptimal network scheduling policies and up to 30% for optimal network scheduling policies.
**Poster Number:** CSE-28  
**Title:** Toward Efficient Methods for Charge Equilibration in Polarizable, Reactive Molecular Dynamics Applications  
**Authors:** Kurt A. O'Hearn; H. Metin Aktulga  
**Abstract:** Polarizable, reactive methods, which incorporate range-limited quantum mechanics-like (QM) interactions based on bond-order potentials, have been shown to be an effective combination of the advantageous characteristics of QM and classical methods. The objective of this work is to enhance the efficiency of reactive force field molecular dynamics applications. Specifically, efforts are focused on optimization of the most costly phase of the PuReMD simulation, charge equilibration (QEq). Krylov subspace iterative approaches are employed for solving the large sparse symmetric linear systems defining the underlying QEq problem. The results of work on accelerating the convergence rate of these iterative techniques via incomplete LU (ILU) preconditioning techniques are presented. Ongoing investigations on parallelization of computation and application of preconditioning factors and the overarching solver are also discussed.

**Poster Number:** CSE-29  
**Title:** Clustering Millions of Faces By Identity  
**Authors:** Charles Otto; Dayong Wang; Anil Jain  
**Abstract:** In this work, we attempt to address the following problem: Given a large number of unlabeled face images, cluster them into the individual identities present in this data. We consider this a relevant problem in different application scenarios ranging from social media to law enforcement. In large-scale scenarios the number of faces in the collection can be of the order of hundreds of million, while the number of clusters can range from a few thousand to millions—leading to difficulties in terms of both run-time complexity and evaluating clustering and per-cluster quality. A modified Rank-Order clustering algorithm is developed based on an approximate k-nearest-neighbor algorithm to achieve the desired scalability. In this work, we attempt to address the following problem: Given a large number of unlabeled face images, cluster them into the individual identities present in this data. We consider this a relevant problem in different application scenarios ranging from social media to law enforcement. In large-scale scenarios the number of faces in the collection can be of the order of hundreds of million, while the number of clusters can range from a few thousand to millions—leading to difficulties in terms of both run-time complexity and evaluating clustering and per-cluster quality. A modified Rank-Order clustering algorithm is developed based on an approximate k-nearest-neighbor algorithm to achieve the desired scalability. We cluster up to 123 million face images into over 10 million clusters, and analyze the results in terms of both external cluster quality measures (known face labels) and internal cluster quality measures (unknown face labels) and run-time. In terms of external cluster quality, our algorithm achieves an F-measure of 0.87 (range is [0,1]) on a small face dataset (LFW, consisting of 13K faces), and 0.27 on the largest dataset considered (123M faces). Additionally, we present preliminary work on video frame clustering (achieving 0.71 F-measure when clustering all frames in the YouTube Faces dataset). An internal per-cluster quality measure is developed which can be used to rank individual clusters and to automatically identify a subset of good quality clusters for manual investigation. We cluster up to 123 million face images into over 10 million clusters, and analyze the results in terms of both external cluster quality measures (known face labels) and internal cluster quality measures (unknown face labels) and run-time. In terms of external cluster quality, our algorithm achieves an F-measure of 0.87 (range is [0,1]) on a small face dataset (LFW, consisting of 13K faces), and 0.27 on the largest dataset considered (123M faces). Additionally, we present preliminary work on video frame clustering (achieving 0.71 F-measure when clustering all frames in the YouTube Faces dataset). An internal per-cluster quality
measure is developed which can be used to rank individual clusters and to automatically identify a subset of good quality clusters for manual investigation.

**Poster Number:** CSE-30  
**Title:** Secure Face Unlock: Robust Spoof Face Detection on Smartphones?  
**Authors:** Keyurkumar Patel; Hu Han; Anil K. Jain

**Abstract:** With the wide deployment of face recognition systems in applications from de-duplication to mobile device unlocking, security against face spoofing attacks requires increased attention; such attacks can be launched via printed photos, video replays and 3D masks of a face. We address the problem of facial spoof detection against print (photo) and replay (photo or video) attacks based on the analysis of image aliasing (e.g., surface reflection, moire pattern, color distortion, and shape deformation) in spoof face images. Our application of interest is smartphone unlock, given that growing number of phones have face unlock and mobile payment capabilities. We develop an efficient face spoof detection system on an Android smartphone. The system was trained using an in-house database of real and spoof faces of 1,000 persons that included both print and replay attacks. Experimental results on public- domain face spoof databases, and the MSU USSA database show that the proposed approach is effective in face spoof detection for both cross-database and intra-database testing scenarios. User studies of our Android face spoof detection system involving 20 participants show that the proposed approach works very well in real application scenarios.

**Poster Number:** CSE-31  
**Title:** iFrame: Dynamic Indoor Map Construction through Automatic Mobile Sensing  
**Authors:** Chen Qiu; Matt Mutka

**Abstract:** Many pervasive applications depend upon maps for navigation and support of location based services. Maps are commonly available for outdoor pervasive applications from a variety of sources. An individual can determine their location outdoors on these maps via GPS. Indoor mobile applications may also need to know the layout of buildings, however indoor maps of buildings are less prevalent. Moreover, indoor maps may need to be dynamic and updated regularly because of the layout changes by people. We present iFrame, a dynamic approach that leverages existing mobile sensing capabilities for constructing indoor maps. We explore how iFrame users may collaborate and contribute to constructing 2-dimensional indoor maps by merely carrying mobile devices. The iFrame approach consists of four steps: 1) Abstract the unknown indoor map as a matrix; 2) Leverage collaborating mobile devices that incorporate three mobile sensing technologies - accelerometers to support dead reckoning, Bluetooth RSSI detection, and WiFi RSSI detection; 3) Combine the three methods by Curve Fit Fusion, and 4) Extend iFrame from one room to a whole building by shadow rates and anchor points analysis. We conducted a deployment study that shows iFrame is a light-weight and unattended approach that provides a skeleton map of a real building effectively and automatically. The layouts of 12 rooms are reconstructed within 5-10 minutes. Changes of layout in indoor maps can be detected and the resolution of the reconstructed indoor floor plans can be improved when there is an increase in the number of cooperating users.

_This work was supported in part by This work is supported in part by NSF Grant No. CNS-1320561._
**Poster Number:** CSE-32  
**Title:** Network Completion with Provable Guarantees by Leveraging Side information  
**Authors:** Abdol-Hossein Esfahanian; Dennis Ross; FarzanMasrour; HayderRadha; Iman Barjasteh; Rana Forsati  
**Abstract:** Link prediction is an important aspect of social network analysis and an area of key research within that is the network completion problem, where it is assumed that only a small sample of a is observed and we would like to infer the unobserved part of the network. In a typical network completion problem the standard methods, such as matrix completion, are inapplicable due the non-uniform sampling of observed links. This paper investigates the network completion problem and demonstrates that by effectively leveraging the side information about the nodes (such as the pairwise similarity), it is possible to predict the unobserved part of the network with high accuracy. to this end, we propose an efficient algorithm that decouples the completion from transduction stage to effectively exploit the similarity information. This crucial difference greatly boosts the performance where appropriate similarity information is used. The recovery error of the proposed algorithm is analyzed theoretically based on the richness of the similarity information and the size of the observed sub-network. to the best of our knowledge, this is the first algorithm that addresses the network completion with similarity of nodes with provable guarantees. Through extensive experiments on four real world datasets, we demonstrate that (i) leveraging side information in matrix completion by decoupling the completion from transduction significantly improves the link prediction performance, (ii) proposed two-stage method can deal with the cold-start problem that arises when a new entity enters the network, and (iii) our approach is scalable to large-scale networks.

**Poster Number:** CSE-33  
**Title:** Adaptive 3D Face Reconstruction From Unconstrained Photo Collections  
**Authors:** Joseph Roth; Yiyin Tong; Xiaoming Liu  
**Abstract:** This work presents a method for adaptive 3D face reconstruction from an unconstrained photo collection. Given a collection of “in-the-wild” face images captured under a variety of pose, expression, and illumination conditions, the algorithm produces a 3D face surface model of an individual along with albedo information. Motivated by the success of recent face reconstruction techniques on large photo collections, we extend prior work to adapt to low quality photo collections with fewer images. We achieve this by fitting a 3D Morphable Model to form a personalized template and developing a novel photometric stereo formulation, under a coarse to fine scheme. Superior experimental results are reported on synthetic and real-world data.

**Poster Number:** CSE-34  
**Title:** An Efficient Integrated Approach to Precision Irrigation System Design for Optimal Usage Using EMO and Subsurface Water Retention Technology (SWRT)  
**Authors:** Proteek Roy; Kalyanmoy Deb  
**Abstract:** For growing population in today's world, water is vital for food and biomass production and it is necessary to make effective use of water. Subsurface Water Retention Technology (SWRT) has been invented for minimizing irrigation water supply and maximizing retention of water in the root zone. Irrigation scheduling and shape and placement of SWRT membranes depend on one another to achieve optimal yield. Here we have integrated water flow and nutrient transport modeling software-HYDRUS2D with an Evolutionary Multi-objective Optimization (EMO) algorithm, namely NSGA-II, to find
optimal membrane geometry and placement in soil along with maximum retention of surface water. Two objectives that we optimize are 1) maximization of root water uptake efficiency (RUE) indicating the amount of water available within the soil root zone and 2) maximization of water use efficiency (WUE) indicating the available water inside the membranes. We have split irrigation system in weekly scheduling manner and rainfall information is incorporated throughout crop growing season. We have implemented an efficient approach of EMO algorithm by parallel implementation of function evaluation and recently developed efficient non-dominated sorting algorithm. Time complexity of this efficient algorithm is lower than the state-of-the-art algorithm in the worst case when statistical independence is assumed among objectives. Although this fast algorithm has little effect on the running time compared to time taken by HYDRUS software, our theoretical investigation provides future consequences on the algorithm. Our overall results suggest that we can choose optimal scheduling strategy with corresponding SWRT technology to minimize water supply and maximize surface water retention.

This work was supported in part by BEACON Center for the Study of Evolution in Action

**Poster Number:** CSE-35  
**Title:** Task Learning through Visual Demonstration and Situated Dialogue  
**Authors:** Changson Liu; Sari Saba Sadiya; Shaohua Yang; Joyce Y. Chai

**Abstract:** To enable effective collaborations between humans and cognitive robots, it is important for robots to continuously acquire task knowledge from human partners. To address this issue, we are currently developing a framework that supports task learning through visual demonstration and natural language dialogue. One core component of this framework is the integration of language and vision that is driven by dialogue for task knowledge learning. This paper describes our on-going effort, particularly, grounded task learning through joint processing of video and dialogue using And-Or-Graphs (AOG).

This work was supported in part by DARPA SIMPLEX program N66001-15-C-4035

**Poster Number:** CSE-36  
**Title:** Incremental Acquisition of Verb Hypothesis Space towards Physical World Interaction  
**Authors:** Lanbo She; Joyce Y. Chai

**Abstract:** As a new generation of cognitive robots start to enter our lives, it is important to enable robots to follow human commands and to learn new actions from human language instructions. While grounding language to perception has received much attention in recent years, few work has addressed grounding language to action. To address this limitation, this paper presents an approach that explicitly represents verb semantics through hypothesis spaces of fluents and automatically acquires these hypothesis spaces by interacting with humans. The learned hypothesis spaces can be used to automatically plan for lower-level primitive actions towards physical world interaction. Our empirical results have shown that the representation of hypothesis space of fluents, combined with the learned hypothesis selection algorithm, outperforms a previous leading approach. In addition, our approach supports incremental learning which can serve as a basis for future life-long learning from humans.

This work was supported in part by This work was supported by IIS-1208390 from the National Science Foundation and N00014-11-1-0410 from the Office of Naval Research.
Poster Number: CSE-37
Title: Machine Learned Learning Machine
Authors: Leigh Sheneman; Arend Hintze
Abstract: In nature, organisms demonstrate the ability to both evolve and learn. At the evolutionary level, selective pressures can influence how the organisms brain is organized and how it’s components work, which shapes how the organism learns during it’s lifetime. While there are many different types of learning, here we define learning as the ability to integrate the consequences of past behaviors into future decision making. When placed in an ambiguous environment, organisms must learn what task will lead to a performance improvement. Evolutionary experiments in natural organisms would require long periods of time, making it virtually impossible to study the evolution of learning. On top of that, the neural mechanisms involved in learning must first be identified, and even then accessing the inner-workings of the brain is difficult to say the least. Recent research has been moving towards developing computational models that shed light on the natural systems in question. However, to date there has not been a system that demonstrates the ability to evolve an organisms capability to learn in it’s lifetime. To remedy that shortcoming, we invented a new type of gate for Markov Brain Networks (a form of evolvable neural network) that allows agents to incorporate feedback into action choices. We used an environment to test the agents' ability to learn over evolutionary time. Furthermore, we show that the agents also are able to incorporate their experiences into their decision making process. Thus, we have created a model that is able to change its underlying structure as well as react to its environment – a system that learns.

Poster Number: CSE-38
Title: Predicting Missing Demographic Information in Biometric Records Using Label Propagation Schemes
Authors: Thomas Swearingen; Arun Ross
Abstract: Biometric systems use biological attributes such as face, fingerprint, or iris to automatically recognize an individual. In many law enforcement applications, the biometric record of a person in the database is often supplemented with demographic data such as age, race, gender, etc. In such applications, some of the records may have missing or incorrect demographic data. In this work, we develop a Label Propagation method to impute demographic data to partially incomplete biometric records. The proposed method utilizes a graph-like structure to capture similarities between biometric records based on the face image, name, gender and race of individuals. This structure is then used by the Label Propagation method to predict missing data. Experiments confirm the efficacy of the scheme in predicting missing values in biometric records.

Poster Number: CSE-39
Title: Opposition Based Optimization for Multi-Objective Problems
Authors: AKM Khaled Talukder; Shahryar Rahnamayan; Kalyanmoy Deb
Abstract: For more than two decades, stand-alone evolutionary multi-objective optimization (EMO) methods have been adequately demonstrated to find a set of trade-off solutions near Pareto-front for various multi-objective optimization problems. Despite a long-standing existence of classical generative single-objective based methods, a very few EMO studies have combined the two approaches for a better gain. In this paper, we investigate the effect of seeding the initial population of an EMO algorithm with
extreme solutions obtained using a single-objective method. Our proposed approach is further aided with an opposition based offspring creation mechanism which strategically places new solutions on the current Pareto frontier by a simple, yet a novel arbitration policy that utilizes the relative distances from the extreme solutions in the current population members. We conduct an extensive simulation of our proposed approach on a wide variety of two and three-objective benchmark test problems. Results are shown to be remarkably better than the original EMO approach in terms of hyper-volume metric. The results are interesting and should motivate EMO researchers to integrate single-objective focused optimization and an opposition-based concept with diversity-preserving EMO procedures for an overall better performance.

**Poster Number:** CSE-40  
**Title:** Learning with Missing Modalities via Cascaded Residual Autoencoder  
**Authors:** Luan Tran; Xiaoming Liu; Jiayu Zhou; Rong Jin  

**Abstract:** Aordable sensors lead to an increasing interest in acquiring and modeling data with multiple modalities. In the domain of object recognition, learning from multiple modalities has shown to significantly improve the recognition performance. However, in practice it is very common that the sensing equipment experiences unforeseeable sensor malfunction or conguration issues, leading to corrupted data points with one or more missing modalities for learning. Most existing multi-modal learning algorithms could not handle missing modalities, and would discard either all modalities with missing values or all corrupted data. To leverage the valuable information in these corrupted data, we propose to impute the missing data given the observed information, by leveraging the relatedness among different modalities. While imputation has been well studied for missing at random (MAR), imputing the block-wise missing data of modalities is rarely studied. The problem is challenging because methods developed for MAR are not capable of recovering enough details for corrupted modalities, leading to a suboptimal recognition performance. In this paper, we propose a novel Cascaded Residual Autoencoder (CRA) to impute missing modalities. By stacking residual autoencoders, CRA grows iteratively to model the residual between the current prediction and original data. Extensive experiments demonstrate the superior performance of the CRA on both the data imputation task and the object recognition task on the imputed data.

*This work was supported in part by NGA*

**Poster Number:** CSE-41  
**Title:** Privacy Preserving Data Publishing for Medical Data  
**Authors:** Ding Wang; Pang-Ning Tan  

**Abstract:** Privacy preserving data publishing (PPDP) has attracted considerable attention in recent years due to the pressing need for publishing data without comprising users' confidential information. In this project, we examined the limitations of existing data perturbation methods for anonymizing patients' medical data. A major challenge in PPDP is to strike a balance between data privacy and data utility, the latter of which refers to the value of data after anonymization. We measure the utility of the anonymized data in terms of how well it can be used to train accurate models for classifying medical data. We argue that existing PPDP methods may significantly degrade the performance of classifiers since the perturbations were made in an unsupervised fashion, i.e., with no regards to the true class distribution of the data. To overcome this problem, we present a novel approach called surrogate
learning that employs an out-of-domain feature transformation approach to transform the data into a new representation, while preserving its data utility and providing theoretically proven privacy guarantees.

**Poster Number:** CSE-42  
**Title:** Discriminative Fusion of Multiple Brain Networks for Early Mild Cognitive Impairment Detection  
**Authors:** Qi Wang; Jiayu Zhou

**Abstract:** In neuroimaging research, brain networks derived from different tractography methods may lead to different results and perform differently when used in classification tasks. As there is no ground truth to determine which brain network models are most accurate or most sensitive to group differences, we developed a new sparse learning method that combines information from multiple network models.

**Poster Number:** CSE-43  
**Title:** A Performance Study of the Impact of Recombination and Other Evolutionary Processes on State-of-the-Art Phylogenetic Inference Methods  
**Authors:** Zhiwei Wang; Kevin Liu

**Abstract:** The phylogeny, or evolutionary history, of a set of genomes is shaped by recombination acting alongside other evolutionary processes such as point mutations and genetic drift. Phylogenies are typically inferred from biomolecular sequence data using computational approaches. The most widely-used state-of-the-art methods assume that genomic loci are independently and identically distributed -- an assumption made for pure mathematical convenience -- which effectively assumes: (1) infinite recombination between loci and (2) zero recombination within each individual locus. Past studies have shown that the first assumption (i.e., no intra-locus recombination) has a relatively small impact on the accuracy of phylogeny inference when compared to other factors (e.g., evolutionary divergence). However, *both* the first and second assumptions are commonly violated in many empirical phylogenetic studies. A major open question remains: what is the impact of violations of the second assumption (infinite inter-locus recombination) upon state-of-the-art phylogenetic inference methods? To investigate this question, we conducted an extensive performance study using simulated and empirical datasets. Preliminary results confirm that the accuracy of state-of-the-art methods is degraded by violations of the assumption of infinite inter-locus recombination. We note that the state of the art tends to treat recombination as a nuisance; in contrast, we demonstrate that the genomic patterns created by recombination represent a useful signal for inference purposes, much like the patterns left by point mutations.

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**Poster Number:** CSE-44  
**Title:** Multi-Task Learning with Tensor Decomposition and its Application on Geospatio-Temporal Data  
**Authors:** Jianpeng Xu; Jiayu Zhou; Pang-Ning Tan; Lifeng Luo
Abstract: Geospatio-temporal data mining is essential to important applications in domains such as ecology, medicine and agriculture sciences. Predictions for a response variable are usually required for multiple locations, which raises the interest of learning the models for multiple locations simultaneously. Meanwhile, some of the climate phenomena are also interesting to be explored, such as climate teleconnection and El Niño. Taking these climate phenomena into the predictive framework could potentially help to improve the performance. In this paper, we propose a multi-task learning framework that builds the predictive models for multiple locations simultaneously. We incorporate tensor decomposition techniques in the framework to explore the relationship between tasks implicitly. The factors learned from tensor decomposition can be regarded as task group, timeseries group and feature group, which might represent interesting climate concepts, such as regions with teleconnections, possible climate indices, and hidden feature space. Experiments are performed on a real world climate data composed by the monthly data from over 1000 weather stations globally in more than 30 years.

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Poster Number: CSE-45
Title: Grounded Semantic Role Labeling
Authors: Shaohua Yang; Qiaozhi Gao; Changsong Liu; Caiming Xiong; Joyce Chai

Abstract: Semantic Role Labeling (SRL) captures semantic roles (or participants) such as agent, patient, and theme associated with verbs from the text. While it provides important intermediate semantic representation for many traditional NLP tasks (such as information extraction and question answering), it is not aimed for capturing grounded semantics so that an artificial agent can reason, learn, and perform the actions with respect to the physical environment. To address this problem, this work extends traditional SRL to grounded SRL where arguments of verbs are grounded to participants of actions in the physical world. By integrating language and vision processing through joint inference, our approach not only grounds explicit roles, but also grounds implicit roles that are not mentioned in language descriptions.

This work was supported in part by DARPA SIMPLEX program N66001-15-C-4035

Poster Number: CSE-46
Title: Multi-Task Convolutional Neural Network for Face Recognition in Constrained Environment
Authors: Xi Yin; Xiaoming Liu

Abstract: Face recognition is a challenging problem due to its variations in pose, expression, illumination, etc. It has long been considered as a single-task learning problem of extracting robust facial features. In this paper, we study face recognition on Multi-PIE using a multi-task convolutional neural network (MT-CNN). First, we consider face recognition as a multi-task problem where extracting identity feature is the main task and estimating pose, expression, and illumination are side tasks. We show that performing side tasks helps face recognition. Second, we propose a task-directed MT-CNN framework by grouping different poses to learn pose-specific identity features, simultaneously across all poses. During the
testing stage, the estimated pose is used as a signal to automatically direct feature extraction. Extensive experiments on the entire dataset of Multi-PIE demonstrate the effectiveness of the proposed approach. To the best of our knowledge, this is the first paper that uses all data in Multi-PIE for face recognition.

**Poster Number:** CSE-47  
**Title:** Analysis of Bounds on Hybrid Vector Clocks  
**Authors:** Sorrachai Yingchareonthawornchai; Sandeep Kulkarni; Murat Demirbas; Eric Torng

**Abstract:** Hybrid vector clocks (HVC) implement vector clocks (VC) in a space-efficient manner by exploiting the availability of loosely-synchronized physical clocks at each node. In this paper, we develop a model for determining the bounds on the size of HVC. Our model uses four parameters: δ: uncertainty window, Δ: minimum message delay, α: communication frequency and n: number of nodes in the system. We derive the size of HVC in terms of a differential equation, and show that the size predicted by our model is almost identical to the results obtained by simulation. We also identify closed form solutions that provide tight lower and upper bounds for useful special cases. Our model and simulations show the HVC size is a sigmoid function with respect to increasing; it has a slow start but it grows exponentially after a phase transition. We present equations to identify the phase transition point and show that for many practical applications and deployment environments, the size of HVC remains only as a couple entries and substantially less than n. We also find that, in a model with random unicast message transmissions, increasing n actually helps for reducing HVC size.

*This work was supported in part by NSF CNS 1329807, NSF CNS 1318678, NSF XPS 1533870, and XPS 1533802.*

**Poster Number:** CSE-48  
**Title:** Hashing for Incomplete Data Source with Application of Predicting Lake Water Chemistry Data  
**Authors:** Shuai Yuan; Pang-Ning Tan

**Abstract:** It is known that the real world datasets often contain a large number of features. The high dimensionality of the data makes pair-wise computation extremely expensive. To conquer this problem, hashing based method has been introduced. Hashing is an approach to transfer data to a low dimensional representation that can preserve a certain property in the original high dimensional space. It is very popular in similarity search due to its memory and computational efficiency. Besides the high dimensionality, real world data is always noisy and contains different amount of missing values. In this poster we propose a framework that can hash the data with lots of missing values from a high dimensional space into a low dimensional representation in the meantime preserve certain characteristics.

*This work was supported in part by NSF*

**Poster Number:** CSE-49  
**Title:** Cross-spectral Periocular Biometrics  
**Authors:** Steven Hoffman; Muhammad Jamal Afridi; Arun Ross
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 design a registration and feature extraction scheme 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). We present experimental results to evaluate the efficacy of the proposed approach.
Abstract: In Brain Machine Interfaces, the recording of brain activity can be performed by connecting intercortical electrodes with wires to external computers, but to avoid risk of infection and mobility limitations, it is highly desirable to have wireless power and data telemetry. Moreover, with the desire of wireless technologies, improvements in the areas of power-area efficiency of spike sorting algorithms implemented in neural signal processors (NSPs) and tracking of drifts in chronic neural signals are of special interest. This research thrust aims to improve three areas: (1) wireless power and data telemetry, (2) power-area efficiency of spike sorting algorithms, and (3) methods for tracking drifts in neural signal recorded overtime. Firstly, a new approach that consists of using concentric helical coils is presented. This approach benefits from a relatively high coupling coefficient which is resistant to coils displacements while it makes a comfortable situation for the subject. Wireless power transmission as well as data telemetry using OOK modulation is accomplished in this project. Secondly, streaming digital hardware architectures have been developed with the goal of implementing spike sorting algorithms on chip, enabling significant power and area savings without loss of sorting performance compared to existing NSPs. Statistical analysis on neural signals was performed to optimize design parameters and minimize hardware cost. Lastly, in the design of algorithms to track the drifts of neural spikes, clustering methods for spike sorting algorithms are under study to determine specific parameters that could make them track migration and appearance of new neurons in the recording.

This work was supported in part by NIOSH, MSU_SPG

Abstract: A major challenge in collaborative filtering based recommender systems is how to provide recommendations when rating data is sparse or entirely missing for a subset of users or items, commonly known as the cold-start problem. In recent years, there has been considerable interest in developing new solutions that address the cold-start problem. These solutions are mainly based on the idea of exploiting other sources of information to compensate for the lack of rating data. In this paper, we propose a novel algorithmic framework based on matrix factorization that simultaneously exploits the similarity information among users and items to alleviate the cold-start problem. In contrast to existing methods, the proposed algorithm decouples the following two aspects of the cold-start problem: (a) the completion of a rating sub-matrix, which is generated by excluding cold-start users and items from the original rating matrix; and (b) the transduction of knowledge from existing ratings to cold-start items/users using side information. This crucial difference significantly boosts the performance when approximate side information is incorporated. We provide theoretical guarantees on the estimation error of the proposed two-stage algorithm based on the richness of similarity information in capturing the rating data. To the best of our knowledge, this is the first algorithm that addresses the cold-start problem with provable guarantees. We also conduct thorough experiments on synthetic and real
datasets that demonstrate the effectiveness of the proposed algorithm and highlights the usefulness of auxiliary information in dealing with both cold-start users and items.

**Poster Number:** ECE-03  
**Title:** Dynamic Modeling of Robotic Fish Caudal Fin with Electrorheological Fluid-Enabled Tunable Stiffness  
**Authors:** Sanaz Bazaz Behbahani; Xiaobo Tan

**Abstract:** In this study, we investigate a robotic fish actuated by a flexible caudal fin, which is filled with electrorheological (ER) fluid and thus enables tunable stiffness. This feature can be used in optimizing the robotic fish speed or maneuverability in different operating regimes. Lighthill’s large amplitude elongated-body theory is used to calculate the hydrodynamic force on the caudal fin, and Hamilton’s principle is used to derive the dynamic equations of motion of the caudal fin. The dynamic equations are then discritized using the finite element method, to obtain an approximate numerical solution. In particular, simulation is conducted to understand the influence of the applied electric field on the stiffness and thrust performance of the caudal fin. Experiments are conducted on a prototyped ER fluid filled flexible beam to validate the proposed dynamic model. First, the effective Young’s modulus of the beam is calculated in air, by measuring the vibration of the beam and extracting natural frequency and damping ratio. The natural frequency of the beam is measured in water as well. Finally, the flexible beam is oscillated in water using a servo.

This work was supported in part by National Science Foundation (Grant DBI 0939454, IIS 1319602, IIP 1343413, CCF 1331852, and ECCS 1446793).

**Poster Number:** ECE-04  
**Title:** Creating and Curating Reproducible Research Artifacts in the Internet-of-Things Era  
**Authors:** Sam Boling; Andrew J. Mason

**Abstract:** Abstract: Reproducible research has been recognized as a growing concern in most areas of science. To achieve widespread adoption of repeatable, transparent research practices, some commentators have identified a need for better software for authoring reproducible publications. Complicating this goal, scientific investigations increasingly involve interdisciplinary teams, sophisticated workflows for acquiring and analyzing data, and huge datasets that rely on considerable metadata to interpret. Computational scientists have begun to adopt tools for managing the complex histories of their data and procedures, but software which simultaneously allows researchers to specify experiments, remotely control equipment, and capture and organize data remains immature. This project demonstrates a software architecture for programmable remote control of custom and commercial lab equipment, automatic annotation and queryable storage of data sets, and provenance-aware specification and refinement of experiment and analysis procedures. The design consists of a suite of small, single-purpose software services which may be connected and controlled from a web browser, notably including a graphical programming tool, an abstraction layer for interfacing with commercial hardware and custom embedded systems, and a hybrid document/table database for persistent storage of annotated experimental data. The software implementation embraces modern web technologies and best practices to produce a modular, user-extensible framework that is well-suited for helping to integrate computer-controlled research labs with the emerging Internet of Things.  
This work was supported in part by NIH grant R01ES022302
**Poster Number:** ECE-05  
**Title:** Injection Molding Terahertz Passive Components  
**Authors:** Jennifer Byford; Zachary Purtill; Premjeet Chahal

**Abstract:** A new fabrication process for passive terahertz components is introduced. To improve upon prior work in dielectric block machining, micromachining, and injection molding to create terahertz passive components we introduce the use of 3D printed injection molds as a low cost alternative for fabrication. This new process increases the amount of available materials to use in devices, is easy, and cost effective. Molds are 3D printed on commercially available printers using polylactic acid (PLA), a biodegradable aliphatic polyester and VeroWhite. An injection molding machine is used to melt low density polyethylene (LDPE) or high density polyethylene (HDPE) pellets and fill the molds. Sample passive THz components are designed in ANSYS HFSS and fabricated using the new process including a probe, ridge waveguide, and photonic crystal filter. Samples are then measured using a frequency domain terahertz system and compared to their expected performance from simulation. Future work to improve the process is also considered.

*This work was supported in part by GAANN Grant*

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**Poster Number:** ECE-06  
**Title:** Nonlinear Model Predictive Control of a Tail-Actuated Robotic Fish  
**Authors:** Maria Castañó; Xiaobo Tan

**Abstract:** Oceanic sustainability has been a growing global concern due to the increase of potential threats to the integrity of aquatic ecosystems. As a result, there has been an increase of interest on the use of autonomous aquatic robots to monitor such environments. In recent years, underwater robots that propel and maneuver themselves as real fish, often called robotic fish, have emerged as mobile sensing platforms for the monitoring of freshwater and marine environments. These robots achieve locomotion via actively controlled fins, and actuation is often achieved via oscillatory inputs. Given the unpredictability of the environments these robots charter, path planning and accurate trajectory control is of importance for mission success and to achieve high energy efficiency. In this work, we propose a nonlinear model predictive control (NMPC) for tracking of an optimal planned path. In this design, we use the the bias, and amplitude of the tail-beat as the input to be determined by the NMPC. The effectiveness of the proposed approach is demonstrated via simulation.

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

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**Poster Number:** ECE-07  
**Title:** Study of the Effect of Temperature and Pocket Holder Depth on Single Crystal Diamond Growth via Microwave Plasma Assisted CVD  
**Authors:** Amanda Charris; Shreya Nad; Jes Asmussen

**Abstract:** Single crystal diamond (SCD) substrates were successfully synthesized via microwave plasma assisted chemical vapor deposition (MPACVD) in a 2.45 GHz microwave plasma CVD reactor at an
experimental pressure of 240 torr (320mbar), H2 flow rate 400 sccm, and 5% CH4/H2 methane concentration. The SCD seed was placed in pocket substrate holder as discussed in [1]. Input power variations from 1.8 kW to 3.3 kW were performed in order to keep the temperature constant between 1000°C and 1020°C. Growth times of 10 hours, 24 hours, 48 hours, and 72 hours was conducted. The growth rate varied between 26 and 30 μm/h depending on the input discharge power density. Thick (1.1 mm – 1.7mm) diamond crystals were deposited on 3.5mm x 3.5mm x 1.4mm HPHT type lb, (100)-oriented single crystal diamond seed substrates. The surface morphologies exhibited smooth and flat top surface without the formation of a polycrystalline diamond rim. By modifying the pocket holder depths, substrate temperatures, and power densities, different crystal shapes were synthesized. Consequently, under these different growth conditions different faces on CVD crystals were observed and were investigated using scanning electron microscopy (SEM) and single crystal x-ray diffraction. The effect of the temperature, pocket holder depth, and power level variations on the crystal growth rate, dimensions and quality are discussed. [1] S. Nad, Y. Gu, and J. Asmussen, Diam. Relat. Mater., vol. 60, pp. 26–34, 2015.

**Poster Number:** ECE-08  
**Title:** Natural Language Based Robotic Programming  
**Authors:** Yu Cheng; Jiatong Bao; Yunyi Jia; Zhihui Deng; Haichu Chen; Lixin Dong; Ning Xi

**Abstract:** There are multiple ways to program a new skill for a robotic system. Natural language (NL) programming is a very promising method due to its versatility, ease of use for humans, and the lack of need for extensive training. Since NL instructions given by human users can not be understood by the robots directly, the linguistic input has to be transformed into a formal representation which tries to capture the intent of the users and removes the ambiguity of NL. Current formal representations implicitly require instructors to give step by step NL action plans, then map the instructions into formal representation. This requires the instructor to be familiar with both the task and the robot such that the instructor is able to decompose the task into action plans with respect to the robot being used, which is not suitable for industrial applications, such as assembly tasks. Also, it is inconvenient and increases the burden for untrained users. To overcome this issue, we propose to use Dependency Relation Matrix (DRM) to model the assembly jobs tasked with the NL instructions as a group of spatial relations. The proposed approach is more reasonable, convenient, and suitable for untrained users to describe the task and program the skill for the robot. Additionally, DRM can be used to decompose the given task as a sequence of subtasks and symbolically parameterize each subtask. In this paper, we describe the DRM framework, describe how to decompose and parameterize the tasks, and illustrate the utility of this approach with experiment results.

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

**Poster Number:** ECE-10  
**Title:** Distributed Time Difference of Arrival Localization of a Moving Target  
**Authors:** Osama Ennasr; Xiaobo Tan

**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 solve the problem by distributing the estimation among all agents in the network, avoiding problems posed by the centralized approach, such as single-node failure. Each agent in the network runs its own extended Kalman filter (EKF) in order to estimate the target’s position, while a neighbor-based averaging procedure ensures that all agents agree on the same estimation. This approach does not require each node to fully observe the process, i.e. some nodes in the network may have an insufficient number of neighbors to accurately estimate the target's position. A bound on the maximum estimation error is established analytically, with numerical examples illustrating the performance of the proposed algorithm.

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

Poster Number: ECE-11
Title: Waveguide Verification Standards for the Characterization of Magnetic Materials
Authors: Jonathan Frasch; Edward Rothwell

Abstract: Measuring unknown materials requires care in the calibration and setup of the measurement system. Without a proper procedure, the level of error in the measured and derived property values becomes uncertain. Many magnetic materials are manufactured and can have a variable composition. A surrogate material with predictable and consistent measurement values can provide a measure of the quality of the calibration and give useful information about the error of the system. We have developed a class of surrogate samples with consistent properties, which are made from fully insertable metallic segments. The size and position of these segments are determined through the use of evolutionary algorithms, which search the possible designs for those that best match a given profile for electrical permittivity and magnetic permeability when using the Nicolson-Ross-Weir methodology for extraction. Analysis of these designs is carried out using a mode-matching method for sequential changes of dimension of the waveguide. Results for an X-Band surrogate have already been obtained and further work is in progress for additional frequency bands.

This work was supported in part by Livingston Tool & Mfg. Co.

Poster Number: ECE-12
Title: Mobile Node Location Tracking Using LED Optical-Based Simultaneous Localization and Communication
Authors: Jason N. Greenberg; Xiaobo Tan

Abstract: Localization and communication are both essential functionalities of any practical sensor network. Being able to achieve both functionalities through a single technique, i.e. Simultaneous Localization And Communication (SLAC), would greatly reduce the complexities of system implementation. In this poster presentation implementation details of a location tracking algorithm using an LED-based optical communication system for location identification and a Kalman Filter for position estimation is discussed. The intended application of this method is for use in small low-powered underwater robotic sensor network applications where the current acoustic based-technologies are not feasible since they are often too bulky and require too much energy to be practical on these robots. Furthermore acoustic technologies are limited to low data rates and typically suffer from propagation
delays which make them unsuitable to a data hungry network which is densely connected. This poster presents simulation and experimental results of this tracking technique applied to a terrestrial network of mobile and stationary robots as proof of concept. Future work will explore the effectiveness of this technique in an aquatic setting.

This work was supported in part by NSF

Poster Number: ECE-13
Title: A Generative Kriging Surrogate Model for Constrained and Unconstrained Multiobjective Optimization
Authors: Rayan Hussein; Kalyanmoy Deb

Abstract: Surrogate models are effective in reducing the computational time required for solving optimization problems. However, there have been a lukewarm interest in nding multiple trade-o solutions for multi-objective optimization problems using surrogate models. The literature on surrogate modeling for constrained optimization problems is also rare. The difficulty lies in the requirement of building and solving multiple surrogate models, one for each Pareto-optimal solution. In this paper, we rst provide a brief introduction of the past studies and suggest a computationally fast, Kriging-based, and generative procedure for nding multiple near Pareto-optimal solutions in a systematic manner. The expected improvement metric is maximized using a real-parameter genetic algorithm for nding new solutions for high-delity evaluations. The approach is computationally fast due to the interlinking of building multiple surrogate models and in its systematic sequencing methodology for assisting one model with another. In standard two and three-objective test problems with and without constraints, our proposed methodology takes only a few hundreds of high-delity solution evaluations to nd a widely distributed near Pareto-optimal solutions compared to the standard EMO methods requiring tens of thousands of high-delity solution evaluations. The framework is generic and can be extended to utilize other surrogate modeling methods easily.

Poster Number: ECE-14
Title: Critical Evaluation of Shunt and Series Compensation Schemes for Hybrid Matrix Converter
Authors: Ameer Janabi; Bingsen Wang

Abstract: This poster is focused on conditioning the voltage and current waveform quality of a hybrid matrix converter that consists of a conventional nine-switch matrix converter and a back-to-back voltage source converter. Upon critical evaluation of the existing methods for shunt and series compensation, the fundamental limitations for achieving superior results have been identified. A new strategy based on power averaging for obtaining the reference compensating current and voltage has been proposed. The effectiveness of the proposed method has been evidenced by the simulation results for both the shunt and series compensation with concurrent presence of the harmonic components in voltages and currents.

Poster Number: ECE-15
Title: Lightweight Linear Electric Machine Design for Free Piston Engine
Authors: William Jensen; Shanelle Foster
Abstract: Electric vehicles are restricted in their driving range by the limited energy storage capacity of current battery technology. Extending the driving range can be achieved by utilizing an internal combustion engine (ICE) to charge the battery that powers the drivetrain. To improve on this system, a free piston engine (FPE) equipped with a linear generator can replace the ICE. A FPE allows for flexible fuel options and the elimination of the crankshaft, which can lead to cleaner electric energy generation. Lightweighting the linear generator enables the FPE to operate at a higher speed and can possibly lead to improved vehicle efficiency. This project presents a linear machine design that allows for the freedom to use any material to support the moving secondary. Aluminum is chosen to replace the back iron in the moving secondary of the linear generator because it is lighter, cheaper, and easier to couple to the combustion piston. A Halbach array of permanent magnets is incorporated in the design of the proposed machine to maintain the main flux path in the secondary. Finite Element (FE) simulation results demonstrate that by replacing the back iron in the secondary with aluminum, the rated speed of the machine increases without significant degradation in performance. Simulation results are also compared with a commercially available linear machine to verify the advantage of designing a lightweight machine with a Halbach array. Analytical and FE thermal analysis of the proposed machine are used to evaluate steady-state operating temperatures at rated current.

Poster Number: ECE-16
Title: Monolithic Multichannel GaN LED Arrays
Authors: Wasif Khan; Wen Li

Abstract: Establishment of a reliable bi-directional communication channel between the nervous system of a freely behaving vertebrate and the external environment is important for the treatment of neurological diseases and events like spinal cord injury, stroke and traumatic major amputations. Optogenetics, which uses light stimulation to control the excitation and inhibition of action potentials in genetically modified neurons. However, conventional methods like tethered optical fiber impedes the subject from moving freely and poor spatial resolution of other methods limits their functionality. A light-stimulating interface with sufficient light intensity that also allows free behavior of the experiment subject is imperative. In response to meet these challenges, monolithic multichannel micro LED arrays have been fabricated using less expensive reactive ion etching. These LED arrays could be surgically implanted on the cortex of an animal subject to stimulate light in vivo without hindering the animal’s free behavior. Annealing was performed to improve the performance of the LED’s. These arrays demonstrated sufficient light intensity that is required for genetically modified neuron activation. The fabricated LED’s showed lower heat dissipation, which reduces the risk of impairing the neurons. The results of the RIE etching process, electrical and optical performance of the fabricated LED arrays were also characterized.

Poster Number: ECE-17
Title: Investigation, Optimization and Demagnetization Effect of the Use of New Ferrite Magnets for Design of Spoke Type and PMASynRM Motors
Authors: Cristian A. Lopez; Elias G. Strangas

Abstract: Reducing the amount of rare earth materials used in interior permanent magnet (IPM) machines makes for a lower cost and rare earth material non-dependency. Using new to the market ferrite magnets could make this possible. A study of the effect of the use of new ferrites in certain performance measures could be done to compare to the performance of currently used ferrite magnets
and also determine the effect of temperature in demagnetization. Two types of motor designs, the spoke type ferrite and the permanent magnet synchronous reluctance motor (PMASynRM) were studied and optimized to make a fair comparison. A clear increase of 13% - 22% in torque performance was found when using the new ferrites with the optimization still to be done.

**Poster Number:** ECE-18  
**Title:** Large-Signal RF Model Extraction of GaN HEMT Power Amplifiers  
**Authors:** Nicholas C. Miller; John D. Albrecht

**Abstract:** Power amplifier circuit design relies heavily on device parameterization to capture non-linear behavior. Extracting high-fidelity models often involves extensive electrical characterization that must be repeated after any change in the underlying device design, materials, or fabrication. If the high-speed device is operating at a fundamental frequency of 35 GHz, it becomes exceedingly difficult to measure device responses at the harmonics. Due to the non-linear nature of the devices, large-signal single-tone stimuli will generate non-negligible signals at harmonics of the fundamental frequency. These large voltage inputs also yield hot electron effects, implying that proper treatment of electronic band structure becomes paramount. Furthermore, external matching circuits, e.g., high-Q bandpass filters, must be included to properly emulate transistors in power amplifier systems. A predictive simulation is an attractive alternative to fabrication and measurements for high-frequency, large-signal characterizations of electronic devices that would otherwise be prohibitively expensive. Moreover, compact models, which accurately predict the underlying device performance, could be imported into circuit design software, e.g. Keysight’s Advanced Design System (ADS,) and used for circuit design with state-of-the-art transistors.

*This work was supported in part by The SMART Scholarship Program*

**Poster Number:** ECE-19  
**Title:** Embedded Passive RF Tags Towards Intrinsically Locatable Buried Plastic Materials  
**Authors:** Mohd Ifwat Mohd Ghazali; Sanran Karuppuswami; Premjeet Chahal

**Abstract:** This paper demonstrates the use of passive harmonic tags as markers for buried plastic pipes. The tag design is based on a double slot antenna that can be buried in the plastic pipes during manufacturing. Design and measurement results are presented for two tag designs: one with a metal backing and one without. The tags are embedded in a plastic casing representing the walls of the plastic pipes. The tag operates at a fundamental frequency (fo) of 2.5 GHz with a return signal (2fo) of 5 GHz. Use of harmonic tags eliminates the clutter from the surface of the ground and thus enhances signal to noise (S/N) ratio of the return signal without the use of filters. The antenna is linearly polarized and polarization can be used as a marker for the direction of the buried pipes. The tag design is compact and can also readily be interrogated using simple hand-held radar units.

*This work was supported in part by Department of Transportation, Midland Research Institute for Value Chain Creation*
**Title:** Enhancing the Safe and Efficient High Pressure Microwave Plasma Assisted CVD Operating Regime for SCD Synthesis Using Continuous Wave and Pulsed Microwave Excitation  
**Authors:** Matthias Muehle; Jes Asmussen; Michael F. Becker; Thomas Schuelke

**Abstract:** Achieving single crystalline diamond (SCD) wafer sizes above 1” requires serious growth effort. Diamond is not increasing its lateral dimensions during the growth process. Thus there are 3 main concepts to increase SCD dimensions: (1) mosaic growth, (2) flipped side approach, and (3) flipped seed approach. The first two concepts have been realized. The built-up of internal stress between the individual clones or on the flipped side makes these approaches impractical. The two major concerns with the superior flipped side approach are a significantly higher amount of SCD post processing and far more total growth needed. While we made good progress in mastering the first issue, the problem of significantly increasing the growth rate still has to be addressed. The development of new growth reactors allowed enhancing the safe and efficient growth window resulting in deposition rates up to 75 um/hour. This reactor was limited in maximum pressure (300 torr) due the stability of the plasma. We equipped a reactor with a power supply, switchable between continuous and pulsed excitation. We propose a series of different reactor performance curve experiments while expanding the pressure range to 400 torr using a continuous wave discharge. The substrate temperature as function of the input power will be recorded. Photography and optical emission spectroscopy we will be recorded for plasma characterization. Variations of different parameters of a pulsed microwave discharge, such as pulsing frequency, duty cycle and the role of Pavg vs. Ppeak by varying Pmin and Pmax, are performed.

**Poster Number:** ECE-21  
**Title:** Portable Electrochemical Malaria Detection System for Affordable In-Field Measurement  
**Authors:** Sina Parsnejad; Tung-yi Lin; Linlin Tu; Andrew Mason

**Abstract:** Malaria is one of the most important infectious diseases in the 21st century with an estimated 216 million infections and 655 thousand deaths reported in 2010. Despite efforts, this disease is the number one cause of morbidity and mortality in children under 5. Diagnosis of Malaria is difficult and currently the only viable method is to detect Malaria parasites is visual analysis using as microscopes and image processors. However, these methods are expensive, stationary and require trained professionals to implement and, hence, fail to perform well in poor rural areas and remote locations. In order to address these issues, we are developing a portable electrochemical detection system. The system is composed of an inexpensive, discardable, electrochemical biosensor and an attachable electrochemical instrumentation module that is connected to and powered by a smartphone. The smartphone processes and stores data and provides a user interface to display test results and control the detection system. The electrochemical instrumentation module utilizes state-of-the-art analog chips and a low power digital microcontroller to realize a miniaturized and low power sensor data acquisition sytem that can adapte intelligently and autonomously to various measurement conditions. together, the microfluidic biosensor and miniaturized electrochemical instrumentation module enable aportable and affordable system that does not require trained users and can operate in rural areas.

*This work was supported in part by NIH*

**Poster Number:** ECE-22  
**Title:** Soft Pneumatic Bending Actuator with integrated CNT-Based Strain Sensors  
**Authors:** Thassyo Pinto; Le Cai; Chuan Wang; Xiaobo Tan
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 actuators are the major elements of soft robots, and their elastomeric substrate enables generation of sophisticated motion with simple controls. Although several fabrication methods, material selection, and structure design have been investigated for the construction of soft bending actuators, 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 work, we present the design, fabrication, and testing of a new type of CNT-based sensor array for measuring strain along the bottom layer of a soft pneumatic bending actuator. Simulation and experimentation were performed in order to analyze the soft actuator deformation during bending. The results demonstrate the promise of the proposed soft actuators 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 CAPES Foundation (BEX-13404-13-0); National Science Foundation (DBI-0939454)

Poster Number: ECE-23
Title: Computational Investigation Using Subregion Finite Element Method for Solving the Inverse Problem in Eddy Current NDE
Authors: Mohammad R. Rawashdeh; Lalita Udpa; S. Ratnajeevan H. Hoole

Abstract: Eddy Current Testing (ECT) plays a key role in detecting cracks and corrosion in conductors and ferromagnetic materials. A computational model for ECT is valuable for optimizing the parameters of the test procedure and maximize the detection probability of defects. Finite Element Method (FEM) is widely used in industry for developing simulation models. This paper presents an efficient mathematical technique in which the subregion method can be used in conjunction with finite element method to simulate an Eddy Current Test and generate defect signals. The proposed study is particularly useful in the solution of inverse problems where the objective is to detect and reconstruct multiple defects, given eddy current test data. The underlying idea in this method is to separate the defect region from the rest of the geometry so that only this subregion is considered in the iterative process. Several examples of defects are presented along with tangible results and improved processing time demonstrate the power of subregion finite element method as an effective method in solving inverse problems in Nondestructive Evaluation (NDE).

Poster Number: ECE-24
Title: Cupula-Inspired IPMC Sensor: Fabrication, Simulation and Sensor Characterization
Authors: Montassar Aidi Sharif; Hong Lei; Xiaobo Tan

Abstract: Ionic polymer metal composites (IPMCs) have inherent sensing and actuation capabilities. IPMCs are functional materials that produce a current or a voltage under an applied mechanical load and produce a mechanical displacement under an applied voltage. IPMCs have applications in multiple fields such as biomedical engineering and underwater robotics. This work presents the mechanoelectrical model of an IPMC when it is used as a flow sensor in mimicking the fish lateral line system. We consider both an IPMC alone and an IPMC encapsulated with a cupula-like structure.
COMSOL 5.1 has been used to implement a 2D finite element model to simulate the IPMC and the cupula-based IPMC in underwater environments. Experiments involving IPMC sensors under both AC and DC flow conditions are conducted to validate the FE model.

**Poster Number:** ECE-25  
**Title:** Experimental Implementation of Extended Kalman Filter-Based Optical Beam Tracking with a Single Receiver  
**Authors:** Pratap Bhanu Solanki; Xiaobo Tan

**Abstract:** For an efficient free-space optical communication, the receiver should have a close-to-line-of-sight (LOS) link with the transmitter. Maintaining an alignment for LOS is a difficult task due to the constant movement of the underlying mobile platform or unwanted disturbances. The previously proposed Extended Kalman Filter-based algorithm uses light intensity measurements from single receiver photo-diode and a scanning technique to estimate the relative orientation between the receiver and the transmitter, which is used to adjust the receiver’s orientation accordingly. This work focuses on the experimental implementation of the algorithms, and evaluates the estimation and control performance through an extensive set of simulation and experiments. The proposed algorithms are found to be effective in general, and their limitations are further explored in this work.  
*This work was supported in part by National Science Foundation (IIS 1319602, ECCS 1446793)*

**Poster Number:** ECE-26  
**Title:** Modeling and Assessment of PV Solar Plants for Composite System Reliability Considering Radiation Variability and Component Availability  
**Authors:** Samer Sulaeman; Joydeep Mitra

**Abstract:** This paper presents a method to model the output power of large PV systems in composite system reliability assessment. Grid level PV systems are usually constructed from a large number of power electronic components and PV panels. Modeling of these systems in power system reliability is a complex task due to the dependency of the output power on the intermittent source (solar) and the availability of a large number of system components. An analytical method to construct a capacity outage probability and frequency table (COPAFT) that captures both the intermittency of the input source and component failures is proposed to model PV systems. The intermittency of the input source and components availabilities are modeled separately and then convolved to construct a single COPAFT. The resulting COPAFT forms a multi-state reliability model of the entire solar facility. The proposed method reduces the complexity of modeling and evaluating large PV systems in composite system reliability assessment. The method is demonstrated on IEEE RTS. Considering the PV farm location with a view to enhance system reliability, a sensitivity study was conducted to measure the effect of the location of the PV farm on overall system reliability. The results confirm that connecting PV farms to the buses that are at a high risk enhances the overall system reliability.

**Poster Number:** ECE-27  
**Title:** Locally Linear Manifold Model for Gap-Filling Algorithms of Hyperspectral Imagery  
**Authors:** Suha Suliman; Hayder Radha

**Abstract:** Landsat 7 Enhanced Thematic Mapper Plus (ETM+) Scan Line Corrector (SLC) device, which corrects for the satellite motion, has failed since May 2003 resulting in a loss of about 22% of the data.
Thus, each scan overlaps in the middle of each scene instead of performing a regular parallel scans. Many data recovery approaches were implemented to fill in the gaps and most of them have limitation in terms of low accuracy at certain areas and high computing time. To improve the reconstruction of Landsat 7 SLC-off images, Locally Linear Manifold (LLM) model is proposed for filling gaps in hyperspectral imagery. In this approach, each spectral band is modeled as a non-linear locally affine manifold that can be learned from the matching bands at different time instances. Moreover, each band is divided into small overlapping spatial patches. In particular, each patch is considered to be a linear combination (approximately on an affine space) of a set of corresponding patches from the same location that are adjacent in time or from the same season of the year. Fill patches are selected from Landsat 5 Thematic Mapper (TM) products of the year 1984 through 2011 which have similar spatial and radiometric resolution as Landsat 7 products. Using this approach, the gap-filling process involves feasible point on the learned manifold to approximate the missing pixels. The proposed LLM framework is compared to some existing single-source (Average and Inverse Distance Weight (IDW)) and multi-source (Local Linear Histogram Matching (LLHM) and Adaptive Window Linear Histogram Matching (AWLHM)) gap-filling methodologies. We analyze the effectiveness of the proposed LLM approach through simulation examples with known ground-truth. It is shown that the LLM-model driven approach outperforms all existing recovery methods considered in this study. The superiority of LLM is illustrated by providing better reconstructed images with higher accuracy even over heterogeneous landscape. Moreover, it is relatively simple to realize algorithmically and it needs much less computing time when compared to the state-of-the-art AWLHM approach.

Poster Number: ECE-28  
Title: VO2-Based MEMS Mirror  
Authors: David Torres; Tongyu Wang; Sarah Dooley; Xiaobo Tan; Huikai Xie; Nelson Sepúlveda

Abstract: We present the fabrication of the first microelectromechanical systems (MEMS) mirror devices with integrated vanadium dioxide (VO2), where the actuation mechanism is mainly due to the solid-solid phase transition of VO2. The device consists of four actuators that control the movement of a platform with a reflective layer, where movement of individual actuators would tilt the platform (tilt movement) and synchronous movement of the actuators would increase/decrease the elevation of the platform (piston movement). The present VO2-based MEMS mirror device is operated electro-thermally through integrated resistive heaters, and its behavior is characterized across the phase transition of VO2, which occurs at a temperature of approximately 68 degree Celsius and spans about 10 degree Celsius. The maximum vertical displacement (piston actuation) of the mirror platform is 75 μm, and it occurs for an input voltage of 1.1 V. This translates to an average power consumption of 6.5 mW per mirror actuator, and a total power consumption of 26.1 mW for the entire device.

This work was supported in part by This work was supported in part by the National Science Foundation under Grant ECCS 1306311 and Grant CMMI 1301243. Device development was made possible by a cooperative research and development agreement (CRADA No. 15-075-RY-01) between AFRLs Sensors Dir

Poster Number: ECE-29  
Title: Transformation of Functional Connectivity Brain Networks to Signals  
Authors: Marisel Villafañe-Delgado; Selin Aviyente

Abstract: Functional connectivity networks in the brain exhibit complex network characteristics, such as small-worldness and scale-free. The transformation of networks to time series brings an alternative for
the characterization of network’s structure. Previously proposed methods are limited to binary graphs and hence cannot be applied to functional connectivity networks. In this work, it is proposed to employ the resistance distance matrix of weighted graphs as the distance matrix for transforming networks to signals based on classical multidimensional scaling. By using properties of the resistance distance, we present a framework for obtaining information about the network’s structure based on the signals and then reconstructing the original network from those signals. Finally, the proposed method is applied to functional connectivity networks based on electroencephalographic data.

This work was supported in part by NSF GRFP

Poster Number: ECE-30
Title: Causality Analysis of fMRI Data Based on the Directed Information Theory Framework
Authors: Zhe Wang; Ahmed Alahmadi; David C. Zhu; Tongtong Li

Abstract: Here, we conduct fMRI based causality analysis in brain connectivity by exploiting the directed information (DI) theory framework. More specifically, we provide the detailed procedure on how to calculate the DI for two finite time series. The two major steps involved here are optimal bin size selection for data digitization, and probability estimation. Also, we demonstrate the applicability of DI based causality analysis using experimental fMRI data, and compare the results with that of the Granger Causality (GC) analysis. Our analysis indicates that GC analysis is effective in detecting linear or nearly linear causal relationship, but may have difficulty in capturing nonlinear causal relationships. On the other hand, DI based causality analysis is more effective in capturing both linear and non-linear causal relationships.

Poster Number: ECE-31
Title: Lab-on-CMOS Platforms for Highly Integrated Microfluidic Biosensor Arrays
Authors: Heyu Yin; Lin Li; Andrew J. Mason

Abstract: Monolithic microsystems based on complementary metal-oxide-semiconductor (CMOS) microelectronics offer great promises to analyze biological and chemical processes via high throughput platforms that physically interface miniaturized sensors with fluid samples. The “lab-on-CMOS” concept pioneered at MSU seeks to develop an integrated microsystem platform that incorporates a biointerface array, CMOS instrumentation circuits and microfluidic sample handling devices into a compact, cost-effective, continuous-use, analytical system suitable for biological research and biomedical applications. The lab-on-CMOS platform we are currently developing utilizes a CMOS electrochemical instrumentation chip with an array of sensor electrodes directly on the CMOS chip to eliminate wiring constraints and minimize measurement noise. An epoxy carrier is employed to extend the surface area of the sensor-electronics chip for subsequent integration with multi-channel microfluidics. A screen-printed planar metallization technique for lab-on-CMOS that overcomes challenges associated with traditional thin film metallization has been developed. Utilizing the epoxy chip-in-carrier packaging approach with screen-printed metallization, electrical interconnects are shown to reliably resolve up to 10μm step height differences between the CMOS chip and the surrounding carrier. The metallization process was also shown to be compatible with subsequent microfluidic integration to complete a lab-on-CMOS device platform that is well suited for high throughput biosensor measurement.

This work was supported in part by NSF_ECCS-1307939
Poster Number: ECE-32  
Title: Wearable Electrochemical Gas Sensor Array for Personal Air Pollution Exposure Assessment  
Authors: Heyu Yin; Sina Parsnejad; Hao Wan; Sam Boling Ehsan Ashoorie; Andrew J. Mason

Abstract: Exposure to air pollution consistently ranks among the leading causes of illness and mortality globally, and the growing potential impact of airborne pollutants and explosive gases on human health and occupational safety has escalated the demand for sensors to monitor hazardous gases. Unfortunately, current preventative measures and treatments for air toxins are ineffective due in large part of our inability to properly characterize and quantify acute exposure to air pollutants. to overcome these challenges, a wearable autonomous multi-gas sensor system capable of real-time environmental monitoring could provide immediate feedback to warn the wearer of imminent environmental threats as well as a record of individual exposure that would aid the development of new treatment approaches. We present a miniaturized wearable system for the pollutant gas monitoring that seeks to achieve this goal by synergistically integrating sensors, electronics, and data analysis algorithms into an autonomous wearable system. Electrochemical sensors featuring room temperature ionic liquid electrolytes are utilized for low-power operation, high sensitivity and selectivity, and long life with low maintenance. Micro-fabricated electrode structures enable miniaturization and rapid response. A custom multi-mode electrochemical instrumentation circuit combines all needed signal condition while minimizing system cost, size and power consumption. Embedded sensor array signal processing algorithms enable gas classification and concentration estimation of a real-world mixture of gas analytes within wearable system for acute exposure assessment.

This work was supported in part by NIH_R01ES022302

Poster Number: ECE-33  
Title: Fully-Printed Stretchable Conductor and Strain Gauge  
Authors: Suoming Zhang; Le Cai; Wei Li; Jinshui Miao; tongyu Wang; Nelson Sepúlveda; Junghoon Yeom; Chuan Wang

Abstract: This paper exploits the strategy to make the device fabricated by the non-stretchable material Silver Nanoparticles (AgNPs) stretchable by investigating the geometry design using a fully printed process as the application of stretchable conductor and strain gauge. We had printed the AgNPs pattern onto the elastomer substrate and showed the stretchability of the device could be tuned by changing the radius of the serpentine structure. The device with smaller radius was more sensitive to the strain, resulting a high gauge factor of 1000000, demonstrated as a strain gauge to detect the finger motion of human beings, while the device with larger radius was more stretchable (more than 25%), used as a stretchable conductor for driving the LED. The printed strategy and demonstrated application would have broad prospects in stretchable electronics.
Environmental Engineering

Poster Number: ENE-01
Title: Evaluating the Threat of Upwelling Brines in Lower Michigan - A Data-Intensive Groundwater Sustainability Study
Authors: Zachary Curtis; Huasheng Liao; Prasanna Sampath; Shu-Guang Li

Abstract: Several studies suggest that upwelling brines are the source of elevated salinity in some near-surface groundwater environments of the Michigan Basin, including east-central Lower Michigan, southwestern Ontario, and beneath Lake Michigan and Saginaw Bay. Recently, elevated groundwater salinity has been observed in west-central Lower Michigan (Michigan Lowlands). We hypothesize that the elevated salinity of the shallow groundwater in the Michigan lowlands is related to the complex upwelling of brine seen elsewhere in the Basin, and that human activity and/or climate change has enhanced the upwelling in recent years. Multi-scale, data-driven simulations of water quality ([Cl-]) and groundwater hydrology revealed a hierarchical pattern of low [Cl-] in recharge areas and elevated [Cl-] in discharge areas of Lower Michigan – compelling evidence for the widespread upwelling of brines. Geospatial analysis of collected field samples and historical water quality data in the Michigan Lowlands supports the upwelling hypothesis, and temporal analysis of Cl- concentrations shows a general increase with time. A water use model developed for the past 50 years correlates areas with increased pumping with current-day Cl- contamination in the Michigan Lowlands. A fully three-dimensional transient groundwater model is being calibrated to archived static water levels (SWLs) collected over the past 50 years to evaluate long-term groundwater sustainability in this region. Preliminary results show that areas with significant simulated drawdown (1966-2015) correspond to Cl- “hot-spots”. Future work includes finishing the model calibration, developing “hot-spot” sub-models, and forecasting groundwater conditions for the next 5, 10, 20 and 50 years.

This work was supported in part by Michigan Department of Agriculture and Rural Development County of Ottawa (Michigan)

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

Abstract: Deposition kinetics of bacteriophage MS2 over the negatively-charged gold sensor and positively-charged polyelectrolyte-coated sensors were studied by using quartz crystal microbalance with dissipation (QCM-D). The PEMs were assembled in different ionic strengths by alternately depositing the negatively-charged poly(styrene-4-sulfonate) (PSS) and positively-charged poly(dimethyl diallyl ammonium chloride) (PDADMAC). Two assembled PEMs had zeta potentials of 7.35 and 27.5 mV, respectively. MS2 deposition kinetics onto the negative surface was more favorable at a high ionic strength of 100 mM, while in tests with the positively-charged surface lower ionic strength promoted deposition. The trends are consistent with the hypothesis that electrostatic repulsion controls MS2-surface interaction. Predictions by the Dejaguiu-Laudau-Verwey-Overbeek (DLVO) theory corroborated the hypothesis. The evolution of QCM-D frequency indicated that deposition-induced charge compensation or reversal may be controlling the overall amount of deposited virus. Overall, the
attachment efficiency (αA) of MS2 on the same PEM was calculated to be 10-30 times higher in 100 mM NaCl than in 10 mM NaCl.

**Poster Number:** ENE-03  
**Title:** Source-Separated Urine Processing Using Clays: Nitrogen Recovery and Pathogen Removal  
**Authors:** Sanpreet Gill; Ruiwei Sui; Lucas Notarantonio; Rebecca Lahr

**Abstract:** Urine contains 80% of the N and 50% of the P in municipal wastewater, but accounts for only 1% of the total wastewater volume. Therefore, it is beneficial to separate urine from wastewater to generate low-value fertilizer products, similar to our methods for recycling plastics. The urine of healthy adults can contain low levels of Pseudomonas, Clostridium, and Staphylococcus which can grow in urine diversion systems and persist through the initial steps of urine processing. Therefore, we are examining the capabilities of clays, such as bentonite and chabazite to both recover nutrients and reduce the risks of pathogens in source-separated urine derived fertilizer products. The use of low cost technologies can aid in closed loop sanitation system and improving lives of people around the globe. Moreover, producing low value fertilizer products may reduce our dependence on high-end synthetic fertilizers. This research involves design and construction of a pilot scale reactor to examine and optimize N recovery and the removal of pathogens from source-separated urine using the untested bentonite and chabazite. A well-established PCR-chip method is being used to rapidly monitor pathogens. The influence of the sampling level, grain size, and working regime (column bed with varying height of sorption media) on the fate of microorganisms and the recovery of nitrogen is being studied. Anticipated outcomes include pilot scale reactor, understanding of the fate of pathogens at each phase of the reactor.

**Poster Number:** ENE-04  
**Title:** The Application of Loop Mediated Isothermal Amplification (LAMP) for Rapid Detection of vcrA, bvcA and tceA in Groundwater Samples  
**Authors:** Yogendra Kanitkar; Robert Stedtfeld; Syed Hashsham; Paul Hatzinger; Alison Cupples

**Abstract:** Typically, real time PCR (qPCR) is to monitor the activity of Dehalococcoides spp. in groundwater. Although qPCR methods have been successful for monitoring reductive dechlorination, alternate molecular methods that are faster and cheaper, may make quantification easier. We developed LAMP assays for the rapid and specific quantification of the reductive dehalogenase genes vcrA, tceA, and bvcA in bioaugmented groundwater samples. The quantification of DNA templates with LAMP was compared to qPCR and the use of direct amplification for quantification was investigated. The method was applied to two commercially available cultures (SDC-9 and KB-1). Groundwater samples obtained from bioaugmented sites Concord, CA (3), Tulsa, OK (15), and Kelly Air force Base, TX (7) were used to prepare triplicates of three amplification template types (DNA templates, direct cells, and centrifuged cells) for each sample. to evaluate the effectiveness of direct amplification templates for absolute quantification, quantification of direct cell and centrifuged templates were compared with DNA templates. Quantification with LAMP using DNA templates was comparable to qPCR (R2~0.99). Quantification using direct cells underestimated the target gene copies in groundwater samples compared to DNA templates. However, quantification was effective above >106 gene copies/L which is lower than107 gene copies/L, the accepted threshold for natural attenuation. Current efforts involve establishing a quantitative relationship between gene numbers obtained with extracted DNA and those
obtained with direct cells. If such a relationship can be established, then future monitoring efforts could occur without the use of DNA extraction.

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

Poster Number: ENE-05
Title: Microwave Assisted Synthesis: Chloroaluminium Phtalocyanine for Transparent Organic Photovoltaics
Authors: Eunsang Lee; Cameron J. Andrews; Annick Antil

Abstract: Metal phthalocyanine (M-Pcs) are macrocyclic compounds that are widely used as blue-green dye because of their adjustable absorption property and chemical stability. M-Pcs can be also used as electron donor material in organic photovoltaic (OPV) since they are organic semiconductor. Among the various M-Pcs absorbing light around 700nm, chloroaluminium phthalocyanine (ClAlPc) in thin layers absorbs only in the near-infrared region. Solar cells can therefore be transparent, which allows their use in new applications such as windows. Since ClAlPc is not commonly used by the dye industry, its synthesis conditions have not been well studied. Two precursors have been mainly used to synthesis M-Pcs: phthalonitrile (PN) and phthalic anhydride (PA). Although it is known that PN produces higher purity M-Pcs, PA is preferred by the dye industry because of its lower cost. However, the PA process increases impurity in M-Pcs, which reduces the efficiency of OPV. The goal of this work is to establish optimal synthesis conditions of ClAlPc for two precursors in term of material purity for OPV application. So far, ClAlPc synthesis has been performed under heating mantle at approximately 240 °C for 6 hours with refluxing aromatic hydrocarbon solvent having high boiling point. This work presents microwave synthesis that allows reaction time reduced to 1 hour for both precursors under same conditions, reducing reaction time remarkably. Another advantage of microwave synthesis is feasibility of various reaction condition. Therefore, we will control pressure, power (energy intensity), and temperature to optimize ClAlPc synthesis, and analyze ClAlPc purity by mass spectrometry and UV-visible spectrometry.

This work was supported in part by A Green Chemistry Approach to Organic and Transparent Photovoltaic Material Synthesis and Device Fabrication (NSF-1511098)

Poster Number: ENE-06
Title: Metagenomic Analysis of Antibiotic Resistant Genes in a Conventional and Membrane Bioreactor Wastewater Treatment Plant
Authors: Camille McCall; Mariya Munir; Terence Marsh; Irene Xagoraraki

Abstract: Wastewater treatment plants (WWTPs) are known environments for the presence and transfer of antibiotic resistant genes (ARGs), an evolving environmental pollutant. This study aimed to explore the prevalence of ARGs and antibiotic resistant bacteria (ARB) in two different (conventional and membrane bioreactor (MBR)) municipal WWTPs in Michigan (USA). A bioinformatics approach was implemented in order to detect ARGs in three metagenomes: activated sludge (AS), before disinfection (BD), and effluent, or after disinfection (AD) in each WWTP. Sequence alignment tools were used to align genetic material to two nucleotide ARG reference databases. Metagenomic alignment detected sulfonamide, tetracycline, macrolides, elfamycin, aminoglycoside, and β-lactamase to be prevalent (≥ 80% nucleotide homology) ARGs in both WWTPs. Effluent samples yielded the highest presence of ARGs in each plant compared to AS and BD samples. Quantitative analysis found that 57.89 and 41.67% of
unique prevalent ARGs appeared after disinfection for the conventional and MBR WWTPs, respectively. Chlorine disinfection revealed a greater presence of ARGs in effluent samples relative to UV disinfection.

**Poster Number:** ENE-07  
**Title:** Diversity of DNA Viruses in Membrane Bioreactor Effluents in France and the United States: Comparisons with the Effluent of a Conventional Utility and Natural Waters  
**Authors:** Evan O'Brien; Mariam Munir; Terence Marsh; Volodymyr Tarabara; Geoffroy Lesage; Marc Heran; Irene Xagoraraki

**Abstract:** Metagenomics analysis has been applied to investigate viral diversity in wastewater, but previous studies have focused primarily on raw untreated wastewater and activated sludge, with little research directed towards studying viral diversity in treated wastewater effluent. Still less research has been performed to study the impact of the wastewater treatment process performed and the disinfection method utilized. This study aims to assess viral diversity in the effluents of three wastewater treatment plants in the United States and France, two membrane bioreactors and one conventional activated sludge plant, with three different types of disinfection. Analyses show that the primary treatment process utilized has little impact on effluent viral diversity; more significant is the type of disinfection applied. Comparisons show that wastewater effluents have significantly different viral diversity with relation to receiving surface water bodies, indicating that disinfection should be a considered factor when assessing the impact of wastewater effluent on environmental microbial diversity.

**Poster Number:** ENE-08  
**Title:** Microbial Water Quality Characterization at Sloan Creek in Red Cedar River Watershed  
**Authors:** Amira Oun; Ruth Kline-Robach; Irene Xagoraraki

**Abstract:** Sources of fecal water pollution were assessed in the Sloan creek (sub-watershed of Red Cedar river watershed), which was newly listed as impaired according to MDEQ 2014 integrated report. The current work aims to determine whether microbial water quality standards (WQS) are being met and to identify the probable source of contamination in the watershed by using: Culture fecal indicator (E.coli), total and host-specific (human and bovine) Bacteroidales genetic markers, and microbial diversity identification using Illumina sequencing and metagenomics analysis. These methods used in conjunction with environmental information such as land use, precipitation, and water flow rate in the creek. Water samples were collected from three sites in the watershed once a week and following each rain event during Spring and summer of 2015. Culture fecal indicator E. coli were routinely detected in the three sampled sites. 75% of samples (n= 192) exceed the recreational water quality guidelines by several orders of magnitude. High concentrations of total Bacteroides spp, and Human and bovine associated Bacteroides were detected in the three sites indicating influence of multiple sources of contaminations. Results suggest that the probable sources of contamination are leakage from septic tanks and runoff from a concentrated animal feeding operation located nearby Sloan Creek.

**Poster Number:** ENE-09  
**Title:** Circulation and Thermal Structure in Michigan’s Inland Lakes: A Comparative Analysis Across Lakes  
**Authors:** Ammar Safaei; Tuan D. Nguyen; Elena Litchman; Mantha S. Phanikumar

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Abstract: We investigate physical processes in Michigan's inland lakes during the summer months using field observations and numerical modeling. A three-dimensional, unstructured grid hydrodynamic model was applied to Lake Huron (59,600 km²) and Gull Lake (8 km² surface area), a relatively small lake located in southwestern Michigan in the Kalamazoo County. We use Acoustic Doppler Current Profiler observations of currents and waves as well as temperature data form thermistor chains to test the numerical models. Field observations and model results are analyzed using spectral and wavelet analyses to gain insights into the physical processes in the lakes.

This work was supported in part by National Science Foundation.

Poster Number: ENE-10
Title: Carbamazepine Biodegradation, Putative Carbamazepine Biodegrading Phylotypes and Xenobiotic Degrading Genes in Agricultural Soils
Authors: Jean-Rene Thelusmon; Timothy J. Strathmann; Alison M. Cupples

Abstract: The antiepileptic drug carbamazepine (CBZ) has been introduced into agricultural soils via irrigation with treated wastewater and biosolids application. Such contamination is problematic given CBZ recalcitrance and its unknown risks to the ecosystems or human health. This study examined CBZ biodegradation in two agricultural soils (4 and 6) and its effects on the soil microbial communities. The experimental design involved three CBZ concentrations, aerobic and anaerobic conditions and two sampling events. CBZ concentrations were determined using a modified QuEChERS approach, solid phase extraction and LC MS/MS. The effect of CBZ on the soil microbial community was investigated using high throughput sequencing and a computational approach predicting functional composition of the metagenomes (PICRUSt). The most significant CBZ biodegradation occurred in soil 4 under aerobic conditions. Contrastingly, CBZ biodegradation was limited under anaerobic conditions in soil 4 and under both conditions in soil 6. For soil 4, several phylotypes were enriched following CBZ degradation compared to the controls. These phylotypes are considered putative CBZ degraders as they appear to be benefitting from CBZ biodegradation. In contrast, numerous phylotypes decreased in abundance following CBZ exposure. PICRUSt revealed a greater abundance of xenobiotic degrading genes in soil 4 compared to soil 6.

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

Poster Number: ENE-11
Title: Behavior of Oil Droplets at the Membrane Surface During Microfiltration
Authors: Emily N. Tummons; Volodymyr V. Tarabara; Jia Wei Chew; Anthony G. Fane

Abstract: A fundamental study of microfiltration membrane fouling by emulsified oil was conducted using a combination of real-time visualization, force balance on a droplet, and permeate flux analysis. The model 0.1% v/v hexadecane-in-water emulsions contained sodium dodecyl sulfate (0.1 mM, 0.4 mM, or 0.8 mM) to regulate interfacial tension. Direct Observation Through the Membrane tests with Anopore (0.2 μm pore diameter) and track-etch (5 μm pore diameter) membranes revealed three characteristic stages of membrane fouling: 1) droplet attachment and clustering, 2) droplet deformation, and 3) droplet coalescence. In qualitative agreement with visualization results, the force balance predicted that droplets less than or equal to 40 μm would remain pinned at 5 μm pores while larger droplets would be swept off the surface by the crossflow drag. In a separate set of constant
pressure crossflow filtration tests with track-etch membranes, the average oil rejection was ≥ 98% while the permeate flux decreased to a pseudo-steady-state ~10% of the initial value. The results indicate that membrane fouling by emulsified oil is controlled by droplet coalescence and crossflow shear: the transport of oil to the membrane surface by the permeate flow is balanced by the shear-induced removal of the droplets that coalesce to exceed a critical size.

This work was supported in part by This material is based upon work supported by the National Science Foundation Graduate Research Fellowship for Emily N. Tummons under Grant no. DGE-0802267 and the National Science Foundation Partnerships for International Research and Education program u

**Poster Number:** ENE-12  
**Title:** Utilizing Fermentation Byproducts to Enhance Hydrogen Production Using Spinel Photocatalysts  
**Authors:** Xiaoyu Wang; Susan Masten; Simon Davies

**Abstract:** It is important to find clean, renewable energy sources which are more abundant, have a lower-cost, and produce less pollution than fossil fuels. One route to this goal is to use sunlight and a semiconductor photocatalyst to produce hydrogen. In this process sunlight excites electrons from the valence band of the photocatalyst into its conduction band where the electron may reduce water or H+ to hydrogen. Unfortunately the efficiency of this process is very low due to rapid electron-hole recombination. One way to enhance the efficiency of this process is to use a hole scavenger to reduce the extent of electron-hole recombination. In this work the effect of various scavengers found in wastewaters, such as alcohols and organic acids, on photohydrogen production is being investigated. The ultimate aim of the study is to produce hydrogen while also reducing the amount of these waste products in the water.

**Poster Number:** ENE-13  
**Title:** Pieces of the Puzzle: How Physical and Meteorological Factors Combine to Impact Bacterial Concentrations at Chicago Beaches  
**Authors:** Chelsea Weiskerger; Meredith Nevers; Richard Whitman; Phanikumar Mantha

**Abstract:** Bacterial content observed at beaches along Lake Michigan’s southwestern shore varies on temporal and spatial scales. Previous research indicates that these variations are due in part to meteorological conditions, but in order to effectively assess beach conditions and how they relate to bacterial contamination, these beaches must be considered as systems; affected by weather, waves, usage, geology, morphology. In this study, geomorphic conditions at twenty Chicago beaches are compared to meteorological factors, in terms of ability to predict bacterial contamination. Regression tree and path analyses are conducted on a combination of meteorological and geomorphic factors. This leads to a hierarchy of factors which significantly account for variation in daily E. coli observations and beach-by-beach probability of advisory or closure due to bacterial contamination. Path analyses show that for daily E. coli counts, physical and meteorological factors explain 30.7% of the variation in data, with 17 out of 21 variables playing a statistically significant role in explaining the data. However, these variables account for 77.0% of the variation in the probability of advisory or closure data, with 17 out of the 21 variables showing statistical significance. These analyses can help elucidate the relative importance of a variety of factors, and shed light on the difference between analyzing raw E. coli and aggregating data by beach. Knowing the relative importance of meteorological and physical factors in
bacterial contamination at Chicago beaches will allow managers and researchers to improve upon predictive models for beach contamination, based on empirical data.

This work was supported in part by United States Geological Survey, Contract G13PX01435

**Poster Number:** ENE-14  
**Title:** The Effect of Environmental Exposure on Interactions Between the Gut Microbiome and the Host Immune Response  
**Authors:** Maggie R. Williams; Robert D. Stedtfeld; Tiffany Stedtfeld; Robert Crawford; Prianca Bhaduri; Tomomi Kuwahara; Brad Upham; James M. Tiedje; Norbert Kaminski; Syed A. Hashsham

**Abstract:** The relationship between the gut microbiome and the host is a crucial symbiotic relationship, with implications in various diseases, as well as important roles in homeostasis, energy production, and modulation of the immune response. Disrupting the balance of Treg/Th17 in the immune system can lead to disease and inflammation. Exposure to contaminants such as 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) can cause disruption by increasing the ratio of Treg/Th17 while two groups of microbial populations (segmented filamentous bacteria; SFBs and Clostridia clusters IV and XIVa) can prevent disruption. In this study, the relationship between environmental exposure, key microbial groups and the host immune response was investigated. Mice from four groups, including i. mono-associated (SFBs), ii. di-associated (Clostridia cluster IV and XIVa, and B. fragilis), iii. tri-associated (SFBs, Clostridia cluster IV and XIVa and B. fragilis), and control (germ-free), were dosed with 30 ug/kg of TCDD every four days. After 30 days, mice were sacrificed and tissues were collected. Blood and spleen samples were analyzed for Th17 and Treg cells while RNA was extracted from intestinal sections for microbiome transcriptomic analysis. Overall, the presence of bacteria in the gut modulated the immune response by maintaining the balance between Treg/Th17 between the control and treated groups. SFBs alone were responsible for increasing Th17 production, while Clostridia cluster IV and XIVa and B. fragilis together further increased the Treg/Th17 ratio. For the tri-associated groups, there was no change between the treated and control groups, suggesting that these microbial populations together are key modulators of the immune response.

This work was supported in part by This work is funded by the Superfund Research Program (P42ES04911) from the National Institute of Environmental Health Sciences.

**Poster Number:** ENE-15  
**Title:** Evaluation of First Flush Phenomena for Microbiological Pollutants and Dissolved Organic Carbon in Red Cedar River  
**Authors:** Huiyun Wu; Amira Oun; Thomas Voice; David Long; Irene Xagoraraki

**Abstract:** First flush refers to a phenomenon where the concentrations of contaminants increase dramatically before the peak of flow during a runoff event. Michigan climate is characterized by hot humid summers, cold winters with snowfall, and wet springs. The state receives an average of 30-40 inches of precipitation annually. This climate creates a long period of pollutant build-up deposited on land surfaces during dry weather (November -March) and then washed away in spring when the snow starts to melt into rivers and lakes. The initial storms of the spring season usually have higher pollutant concentrations. These pollutants can be from different sources such as de-icing salts, animal waste, manure and biosolid applications, pesticides, fertilizers, etc. During spring and summers of 2013-15
Water samples were collected from Red Cedar River, a stream flowing through farmland and receiving wastewater effluent from several municipalities in central Michigan. The samples were analyzed for fecal indicators (E. coli), human and bovine associated-Bacteroides markers and dissolved organic carbon (DOC). We observed high concentrations of microbiological contaminants in the Red Cedar river following first spring rainfall events and snow melt. The peak concentrations of E. coli and Bacteroides were associated with river discharge peaks. It was found that DOC exhibited first-flush behavior, and a concentration peak occurred before the discharge peak in melting events. Average DOC concentrations increased over the melting period, nearly doubling.

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

**Poster Number:** MSE-01  
**Title:** In situ Study of Defect Accumulation in Ti-6Al-4V Under Heavy Ion Irradiation: Influence of the Microstructure  
**Authors:** Aida Amroussia; Carl J. Boehlert; Frederique Pellemoine

**Abstract:** Due to their high specific strength, good fatigue and creep properties, corrosion resistance and their commercial availability, titanium alloys have been widely used in industrial, aerospace and biomedical applications. Ti-alloys are also extremely attractive for nuclear applications, being highly compatible with coolants (lithium, helium, water) and exhibiting low activation in radioactive environments. Ti-6Al-4V is considered as a structural material for the beam dump drum for the Facility for Rare Isotope Beams. The traditional manufacturing of titanium parts can be difficult, time consuming and have high material wastage and manufacturing costs. Additive manufacturing such as Direct Metal Laser Sintering presents an attractive alternative due to its capability to produce near net shape components with less production time and material waste. Successful prediction of the material’s performance over time and under irradiation requires an understanding of the basic formation mechanisms of radiation-induced defects at initial damage stages at lower doses and its accumulation at higher dose levels which results in the complex features in the microstructure. A unique in-situ TEM irradiation study was performed at the IVEM-Tandem Facility at Argonne National Laboratory. Three different Ti-6Al-4V samples (Powder metallurgy (PM) rolled, as received (DMLS) and DMLS then followed by Hot Isostatic Pressing (HIP)) were irradiated with 1 MeV Kr2+ at 350°C. The fluence was up to 1016 ions.cm⁻², equivalent to a dose of 24 dpa. In all irradiated samples, we observed the accumulation overtime of fine nanometer size black spots indicative of defects formed due to irradiation damage. A preliminary analysis of the results will be presented.

*This work was supported in part by This work was partially supported by the U.S. Department of Energy, Office of Science under Cooperative Agreement DE-SC0000661. This work was also supported by Michigan State University under the Strategic Partnership Grant "FRIB - Materials in Extreme En*

**Poster Number:** MSE-02  
**Title:** Carbon Fiber Epoxy Matrix Modified With Cellulose Nanowhiskers  
**Authors:** Mariana D. R. Batista; Lawrence T. Drzal

**Abstract:** Lightweight, high-strength and high-stiffness are often identified as desirable properties for aerospace and automotive applications. In order to achieve these engineering needs and meet the growing government requirement for fuel economy, carbon fiber reinforced polymer (CFRP) composites have gained attention because of their high strength-to-weight ratio. The global CFRP market is projected to reach USD 35.75 billion by 2020. However, one drawback of CFRP, typically epoxy-based CFRP, is its brittle fracture mechanism, which reveals low level of adhesion between the carbon fiber and the polymeric matrix. Therefore, to achieve good mechanical properties and resist crack propagation, a well-bonded interface is required. Cellulose nanowhiskers (CNWs) have attracted considerable attention due to their high mechanical properties, low cost, low density and sustainable nature. In this work, we developed a process to coat carbon fiber with CNWs where they would function as a nano-reinforcement to improve the adhesion between the carbon fiber and the epoxy matrix.

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CNWs were applied as part of a sizing agent to improve the stress transfer at the fiber-matrix interface. Scanning electron microscope (SEM) micrographs showed that CNWs uniformly coated the carbon fibers. Moreover, single fiber fragmentation specimens were fabricated to evaluate the interfacial shear strength of the CNW sized carbon fibers in the epoxy matrix with increasing CNW content. This research on modification of the fiber-matrix interface has the potential to improve the mechanical properties of these carbon fiber-epoxy composites and be utilized for interfacial optimization in biobased natural fiber composites as well.

This work was supported in part by CAPES Foundation (BEX:13655-13-2)

**Poster Number:** MSE-03  
**Title:** The Effects of Vacancy Substitution on CuGaTe2 for Thermoelectric Applications  
**Authors:** Winston D. Carr; Donald T. Morelli

**Abstract:** Thermoelectric generators offer the ability to convert waste heat directly into electricity through solid state processes. This has the advantage of requiring no moving parts and of being highly scalable, which are both important features for commercial applications. However, the wide spread use of thermoelectric generators has been limited by low device efficiency and dependence on toxic or rare elements such as lead and tellurium. The performance of a thermoelectric material is characterized by the dimensionless figure of merit, ZT, which depends on three inter-related material properties: the electrical conductivity, the thermal conductivity, and the thermopower, also known as the Seebeck coefficient. A high ZT requires a large electrical conductivity and a low thermal conductivity, an atypical combination. The following work is on the progress of optimizing the thermoelectric material CuGaTe2 through co-substitution of zinc atoms and vacancies on the copper atomic site. This approach offers a path to optimize both the thermal and electrical conductivity at the same time. By substituting both divalent zinc and vacancies for monovalent copper the total average valance can be maintained, which should keep electrical properties relatively unchanged, however the difference in mass of copper and zinc, as well as the vacancy sites, further scatters heat carrying phonons and lowers overall thermal conductivity.

This work was supported in part by the “Revolutionary Materials for Solid State Energy Conversion,” an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Basic Energy Sciences under Award # DE-SC0001054.

**Poster Number:** MSE-04  
**Title:** Unique Twinning in Orchestrated Deformation Mechanisms to Stiffen and Toughen Nacre Under Impacts  
**Authors:** Jialin Liu; Zaiwang Huang; Xiaodong Li; Yue Qi

**Abstract:** It has long been identified that nacre, natural body armor, has prominent mechanical properties such as high strength and eminent toughness. What’s more, under dynamic strain rate (~103 s⁻¹), both strength and elongation to break are significantly increased comparing with quasi-static strain rate (~10⁻³ s⁻¹). Currently, stiffen and toughen behavior under impact is attributed to nacre’s hierarchical macroscopic structures which lead to highly coordinated deformation mechanisms. However, the atomic origin of nacre’s high impact toughening behavior remains ambiguous. Recently, the unique deformation twinning observed in dynamic uniaxial compression tests provided new
understandings on atomic deformation mechanisms. To further explain the underlying mechanisms, Ab
initial calculation is carried out using density function theory (DFT) and nudge elastic band (NEB) method
based on experiment observation to calculate generalized stacking fault energy (GSFE) and fracture
energy. The atomic structure relaxation process are analyzed with details. The results showed nacre
have an extraordinary large unstable stacking fault energy (USFE) to SFE ratio. Under high strain rate,
this large ratio allow deformation twinning provide extra toughness while other mechanisms are
“frozen” and biopolymers are stiff. Comparing with other materials, this unique properties are
originated from its specific lattice parameter and sliding distance relationship, ionic bonding nature and
large number of neighbors.

**Poster Number:** MSE-05
**Title:** Influence of Novel Chemical Modifier Addition on the Solidification Kinetics of Aluminum-Silicon
Alloys
**Authors:** Yang Lu; Andre Lee

**Abstract:** Microstructures and solidification kinetics of nearly eutectic, Al-12wt%Si (A4047), casting
alloys modified with trisilanol phenyl polyhedral oligomeric silsesquioxanes (TSP) were investigated.
Optical microscopy was used to examine the microstructure of ingots made from A4047 powders with
and without TSP treatment. It was found the incorporation of TSP reduced the secondary dendrite arm
spacing of primary Al phase, and modified the morphology of eutectic Si from flaky to fibrous form.
Solidification of alloys was examined to further understand the observed changes in microstructure.
Both undercooling and eutectic growth temperature were depressed with TSP incorporation. In
addition, the thermal analysis of the Al-4047 ingots with different amount of TSP, which were obtained by
sequentially diluting TSP-treated with untreated samples, showed that these changes of undercooling
and eutectic growth temperature were dependent on the TSP content. Based on the observed reduced
undercooling and eutectic temperature with TSP incorporation, and the refinement of primary Al phases
and a flaky-fibrous transition in the eutectic Si morphology, it is proposed that nano-sized cage structure of
TSP served as heterogeneous nucleation sites to refine primary Al and modify eutectic Si.

**Poster Number:** MSE-06
**Title:** Oxygen Surface Exchange Curvature Relaxation Measurements Performed with Diffusion Barrier
Layers
**Authors:** Yuxi Ma; Jason Nicholas

**Abstract:** The Curvature Relaxation (KR) technique is a new, in situ, electrode-free method used to
measure the chemical oxygen surface exchange coefficient (kchem) of dense or porous, thin or thick film
samples. Typically, the KR technique determines kchem by fitting a solution of Fick’s 2nd Law to the
curvature response of mechano-chemically active film | inert substrate bilayers reacting to sudden
oxygen partial pressure changes. Unfortunately, undesirable chemical reactions between the film and
substrate can occur during film fabrication and/or measurement at high temperature. The resulting
impurities and/or secondary phases can unexpectedly alter the measured kchem and stress levels. The
object of this work was to accurately measure the oxygen surface exchange coefficient of
praseodymium doped ceria (PCO) by utilizing gadolinium doped ceria (GDC) barrier layers to prevent
interdiffusion between PCO and 9.5 mole % yttria stabilized zirconia (YSZ) substrates. to achieve this, a
PCO|GDC|YSZ multilayer sample was prepared by 1) sputtering GDC on (100) oriented single crystal YSZ
substrates, 2) sintering the resulting GDC|YSZ bilayers at 650oC for 1 hour to crystallize the sputtered
GDC, 3) sputtering PCO on the sintered GDC|YSZ bilayers, and 4) sintering the resulting PCO|GDC|YSZ trilayers at 725°C to crystallize the sputtered PCO. The PCO|GDC|YSZ samples were then KR tested from 300 to 600°C by rapidly switching the surrounding atmosphere from synthetic air (21% O2-79% Ar) to a 10% synthetic air-90% Ar mixture. After KR measurements, scanning electron microscopy and/or ellipsometry were used to determine the thickness of each layer. X-ray Photoelectron Spectroscopy and X-ray Diffraction measurements were also performed to examine the PCO surface chemistry and bulk crystal structure.

This work was supported in part by This material is based upon work supported by the Department of Energy under Award Number DE-FE0023315

**Poster Number:** MSE-07  
**Title:** Hydroforming of a Large Grain Niobium Tube  
**Authors:** Aboozar Mapar; Thomas R. Bieler; Farhang Pourboghrat

**Abstract:** Currently most of Niobium (Nb) cavities are manufactured from fine grain Nb sheets. As-cast ingots go through a series of steps including forging, milling, rolling, and intermediate annealing, before they are deep-drawn into a half-cell shape and subsequently electron beam welded to make a full cavity. Tube hydroforming, a manufacturing technique where a tube is deformed into a die using a pressurized fluid, is an alternative to the current costly manufacturing process. A whole cavity can be made from a tube using tube hydroforming. This study focuses on deformation of large grain Nb tubes during hydroforming. The crystal orientation of the grains is recorded. The tube is marked with a circle-grid which is used to measure the strain after deformation. The deformation of the tube is modeled with crystal plasticity finite element. The results of the simulation and experiments are compared.

**Poster Number:** MSE-08  
**Title:** Microstructure and Mechanical Behavior of High Pressure torsion Al 2139-T8 Alloy  
**Authors:** Uchechi Okeke; Hakan Yilmazer; Huihong Liu; Niinomi Mitsuo; Carl Boehlert

**Abstract:** Al 2139-T8 is a Cu based alloy which also contains Mg and Ag elements. The alloy previously underwent a T8 temper process which consists of solutionizing, cold working, and artificial ageing. This temper yields an ultimate tensile strength (UTS) of 430MPa and a strain-to-failure (ef) of 7.2%. High pressure torsion (HPT) is another processing technique that uses severe plastic deformation to refine the microstructure to submicron dimensions which leads to superplasticity and increased strength. In order to provide an objective analysis, the Al 2139-T8 was annealed at 460°C for one hour to remove the T8 tempering. HPT was performed at room temperature on the annealed Al 2139-T8. Samples were discs with a diameter of 20mm and a thickness ranging from 0.85-0.9mm. HPT was performed using revolutions of N=1, 2, 4, and 8 at 0.2RPM. A pressure of 5 GPa was applied to the anvil. High resolution scanning electron microscopy and electron backscattered diffraction revealed that all of the revolutions yielded submicron grains. Additionally, with each revolution, the precipitates were increasingly fractionated. At N=8, there was noticeable grain growth and the fractioning of the precipitates was the highest. Vickers hardness acquired from the center of the discs towards the full radius did not reveal a significant difference in hardness between the revolutions. Tensile tests revealed that HPT increased the UTS up to 900MPa.

This work was supported in part by 2015 NSF East Asia and Pacific Summer Institute Award, NSF Division of Materials Research (Grant # DMR1107117)
**Poster Number:** MSE-09  
**Title:** Enhanced Thermoelectric Efficiency of Ball Milled PtSb2 by Sn Doping  
**Authors:** Spencer Waldrop; Donald Morelli

**Abstract:** Many future and next-generation products will require not only passive heat dissipation, but also cooling to attain their required performance. Thermoelectric cooling modules will play an integral role in this due to their solid state nature which allows for their adoption in applications where large, vibrating, mechanically clunky coolers are not well suited. Utilizing PtSb2 in these modules for cooling below room temperature requires a reduction of thermal conductivity by ball milling to enhance the thermoelectric efficiency. Further enhancement of ball milled PtSb2 can be found by increasing the electrical conductivity and Seebeck coefficient by Sn doping. Samples with composition PtSb2-xSn x= 0, 0.005, 0.01, 0.02, 0.04, and 0.08 were studied. A slight increase in Seebeck coefficient, decrease in electrical resistivity, and decrease in thermal conductivity were found with increasing concentrations of Sn. This resulted in a large increase in efficiency at room temperature with modest increases at low temperatures.

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**Poster Number:** MSE-10  
**Title:** Introduction of Precisely Controlled Microstructural Defects into SRF Cavity Nb Sheet and their Impact on Local Superconducting Properties  
**Authors:** Mingmin Wang; Di Kang; Zuhawn Sung; Peter Lee; Anatoli Polyanskii; Christopher Compton; Thomas Bieler

**Abstract:** Formation of SRF cavity from Nb sheets introduces microstructural defects such as dislocations and low-angle grain boundaries that can serve as favorable sites for pinning centers for magnetic flux that may degrade cavity performance. Therefore, effects of grain boundary on magnetic flux behavior in carefully strained bicrystal Nb samples were investigated. Laue X-ray and EBSD-OIM crystallographic analyses were used to characterize microstructural defects and then predict which grain boundaries and orientations will produce desired model defects by tensile deformation. Grain boundaries and orientations were chosen to favor specific slip systems, which generate dislocations with special angles with respect to the grain boundaries of the bicrystal Nb samples. The generated defect structures were confirmed by OIM and ECCI. Cryogenic magneto-optical imaging was used to directly observe the penetration of magnetic flux into the deformed Nb. These model samples have deformation that is similar to that expected in typical cavity forming processes.

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

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**Poster Number:** MSE-11  
**Title:** Tetrahedrite Thermoelectrics: Mechanical Alloying versus SPS Solid-State Reaction Synthesis  
**Authors:** Daniel P. Weller; Junchao Li; Wei Lai; Donald T. Morelli
Abstract: Thermoelectric (TE) materials are capable of converting thermal energy to electrical energy by a phenomenon known as the Seebeck effect. These materials could play an important role in alleviating the world’s energy crisis by recovering waste heat and transforming it into usable electric power. However, there are many setbacks which are impeding the widespread use of thermoelectrics in our society. For example, numerous TE materials are comprised of toxic elements, such as lead, or costly elements like tellurium. Additionally, numerous thermoelectrics involve complicated synthetic procedures that hold them back from being used in large-scale commercial applications. Nevertheless, one promising material has emerged as a potential solution to all of these issues. Tetrahedrite, a common mineral that occurs naturally in the earth, has been shown to demonstrate good electrical and thermal properties for TE applications. This material is entirely composed of inexpensive and environmentally friendly elements such as copper, antimony, and sulfur. Typical synthesis of tetrahedrite consists of a slow heating process with a lengthy annealing time, usually on the order of one to two weeks total. In this work, results will be shown for samples made by mechanical alloying and by direct reaction via spark-plasma-sintering (SPS). Mechanically alloyed samples can be synthesized in approximately forty eight hours, while those made via SPS can be prepared in less than two hours. The properties of the samples made with the different techniques will be presented for both zinc and nickel doped samples.

This work was supported in part by NSF-CBET Award No. 1507789

Poster Number: MSE-12
Title: Understanding the Superior thermoelectric Performance of Sb Precipitated Ge17Sb2Te20
Authors: Jared B. Williams; Donald T. Morelli

Abstract: Phase change materials are based on Ge-Sb-Te alloys and named so because of their memory storage applications, which exploit the large optical/electrical contrast between the amorphous and crystalline phases. They are being researched as a nonvolatile replacement to RAM-based memory systems which are volatile and limited in storage capacity. Recently these materials have also been identified as high-performance thermoelectric materials. Thermoelectric materials are utilized in waste-heat recovery applications ranging from large scale, such as diesel generators, down to small scale applications, such as microelectronics and flexible electronics. When alloys from the GeTe-Sb2Te3 pseudo-binary tie-line are quenched from the melt they exhibit a highly disordered metastable phase with low thermal conductivity and high Seebeck coefficient. Upon heating, the compounds undergo an ordering transition to a stable rhombohedral phase which is metallic in nature, all while maintaining a low thermal conductivity and high Seebeck coefficient. The following work examines the effects which Sb precipitates have on the thermoelectric properties of Ge17Sb2Te20. It was found that the precipitation of Sb within the matrix of Ge17Sb2Te20 lowers thermal conductivity and enhances the Seebeck coefficient, which leads to an optimization of ZT, a dimensionless figure-of-merit based on the electrical conductivity, thermal conductivity, and Seebeck coefficient, which is used to quantify the efficiency of thermoelectric materials.

This work was supported in part by Department of Energy's Energy Frontier Research Center; National Science Foundation

Poster Number: MSE-13
Title: Crystal Plasticity Analysis of Polycrystalline Ti-5Al-2.5Sn Using Realistic 3D Microstructure
Abstract: to investigate damage nucleation in polycrystalline materials with computational analysis, it is crucial to numerically represent the heterogeneous slip activity induced by plastic deformation, which is affected by both the intrinsic material properties and the spatial arrangement of grains. A previous study of a Ti-5Al-2.5Sn sample deformed in uniaxial tension at room temperature demonstrated that the combination of a realistic 3D microstructure and a simple phenomenological power-law based constitutive model can successfully capture the plastic deformation induced crystal reorientation. An improved version of this computational framework is presented here with automated microstructure reconstruction and a faster solver for the stress analysis simulation using the spectral solver provided by the DAMASK package.

This work was supported in part by This research was supported by DOE/BES grant DE-FG02-09ER46637, and the DAXM characterization at the Advanced Photon Source was supported by DOE contract DE-AC02-06CH11357.

Poster Number: MSE-14
Title: The Performance and Long-Term Stability of SOFC Cathodes Under Different Infiltration Conditions
Authors: Yubo Zhang; Jason D. Nicholas

Abstract: With the growing demand of high-efficiency, environment-friendly energy conversion technology, reversible Solid Oxide Fuel Cells (SOFCs) are becoming one of the most promising chemical to electrical conversion technologies because of 1) their high gravimetric and volumetric power densities and 2) ability to use either traditional fossil fuels or hydrogen as fuels. Unfortunately, the poor oxygen surface exchange kinetics of SOFC cathodes have hindered this technology by restricting commercial SOFC operating temperatures to greater than ~650°C. The infiltration method has been shown to be an effective way to produce nano-composite SOFC cathodes that can operate at temperatures as low as 550°C. In this technique, nano-sized Mixed Ionic and Electronic Conductor (MIEC) oxygen exchange catalyst particles are generated by infiltrating MIEC nitrate precursor solutions into porous Ionic Conducting (IC) scaffolds. Unfortunately, past studies have shown that it is difficult to control the size of the MIEC nanoparticles produced by infiltration. Furthermore, the relationship between particle sizes, structure, performance and long-term cathode stability remains to be fully understood. It’s been proved that desiccation can affect the particle size, performance and long-term stability of La0.6Sr0.4Co0.8Fe0.2O3-δ (LSCF) particles. The present work highlights how different infiltration conditions (nitrate precursor solution chemistries, desiccant strength, etc.) will affect the infiltrate particle size and phase purity, electrical resistance and long-term stability of La0.6Sr0.4FeO3(LSF) and La0.6Sr0.4Co0.2Fe0.8O3 (LSFC) cathodes.

Poster Number: MSE-15
Title: New Braze Materials for Planar Solid Oxide Fuel Cell (SOFC) Applications
Authors: Quan Zhou; Yuxi Ma; Tridip Das; Yue Qi; Jason D. Nicholas; Thomas R. Bieler

Abstract: A stable hermetic seal is crucial to the functionality and durability of planar solid oxide fuel cell (SOFC) stacks. Reactive air brazing (RAB) has become very popular and Ag-CuO brazes are commonly used in joining yttrium stabilized zirconia (YSZ) with stainless steels. However, despite the acceptable wettability and good ductility of Ag-based brazes, the high diffusivity of hydrogen and oxygen in silver...
makes Ag-based brazes vulnerable to internal water vapor bubble formation, which significantly shortens their lifetimes in SOFC stacks. Here, samples with compositions obtained from computational studies were fabricated using arc-melting. Optical/electronic microscopy, energy dispersive X-ray spectroscopy, differential scanning calorimetry, and thermal gravimetric analysis were performed to characterize the microstructure, chemistry, melting and oxidation behavior of new, computationally-suggested braze compositions. In addition, wetting studies with/without surface pre-treatments were carried out on both YSZ and alumina in a controlled atmosphere optical tube furnace.

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Poster Number: MSE-16
Title: Exceptionally High Strength Beta Titanium Alloy at Elevated Temperatures Achieved by Thermomechanically-Induced Phase Transformation
Authors: Vahid Khademi; Carl J. Boehlert

Abstract: Titanium alloys have been used in diverse fields, such as aerospace, biomedical, energy, and chemical equipment, due to its combination of good mechanical properties, chemical and oxidation resistance, and biocompatibility. Furthermore, titanium alloys have been used for elevated temperature applications, for example in jet engine parts, and power plant equipment. However, the cost still could be considered as a major limitation on the expansion of new titanium alloys and their applications. In the current work, a new method was introduced which results in the highest measured tensile strength for a titanium alloy in the temperature range between 400 °C to 500 °C. The results indicated that the elevated temperature strength was significantly higher than the room temperature strength, i.e. the room temperature strength was 940 MPa, while the strength was 1435 MPa at 410 °C. It should be mentioned that strength usually decreases with increasing the temperature. The transmission electron microscopy, in-situ scanning electron microscopy experiments, and dynamic mechanical analysis investigations relieved that thermomechanically-induced phase transformation plays an essential role on this exceptional phenomenon. Importantly, this method which was applied on a low-cost titanium alloy, might open a new window for the current state of titanium alloy applications and research.

This work was supported in part by DOE
MECHANICAL ENGINEERING

Poster Number: ME-01
Title: Fully Stressed Design Evolution Strategy for Layout Optimization of Truss Structures
Authors: Ali Ahrari; Kalyanmoy Deb

Abstract: Despite a huge number of publications on structural optimization, practitioners still prefer to rely on intuition-based try-and-error methods instead of rigorous optimization techniques. One of the critical factors that prompts such preference is that conventional test problems employed in academic research are too simple to simulate complexity of real structures. Furthermore, majority of optimization methods can handle the size optimization only, the potential saving from which is highly limited, when compared to the most sophisticated, and obviously the most challenging scenario, simultaneous topology, shape and size (TSS) optimization. In a recent study a method based on combination of optimality criteria and evolution strategies, called fully stressed design based on evolution strategies (FSD-ES), was proposed for TSS optimization of truss structures. In this research, an improved version of FSD-ES method, called FSD-ES-II, is proposed which can explicitly handle the displacement constraints and design requirements governed by standard design codes such as AISC-ASD. Performance of FSD-ES-II is compared with the best results available in the literature, often showing a significant superiority of the proposed approach. Second, realistic and large-scale test problems are developed to address a critical pitfall in academic research on structural optimization: the simplicity of conventional test problems. It is also demonstrated a huge saving in the cost can be achieved by more reliance on a potent optimization tool instead of human intuition. This study demonstrates a significant contribution of optimization in structural engineering and reduce the gap between academic research and practice on this topic.

Poster Number: ME-02
Title: Asynchronous Activation of a Canine Left Ventricular Model
Authors: Seyedborhan Alhosseinihamedani; Lik Chuan Lee

Abstract: Abnormal electrical activation of the left ventricle (LV) due to malfunction of bundle branches results in an asynchronous mechanical activation of the myocardium. Consequently, during several heart beats, different regions of the myocardium experience either an early (preexcitation) or a delayed electrical, and consequently, mechanical activation. This abnormality presents itself in the prolonged QRS complex in electrocardiography, and is associated with the conductivity of the tissue. This study investigates the effect of asynchronous activation of the myocardium in a canine left ventricle. The model was geometrically simplified to an ellipsoidal with constant thickness based on an existing literature. The simulation included an electrophysiology and a mechanics mesh which were coupled togethered. In the synchronous model, the LV was activated in endocardium in the septum region, whereas in the asynchronous model, activation occured in the epicardium in an opposite direction to that of the synchronous model. In the asynchronous model, the conductivity tensor was modified to present a prolonged activation. Results show that asynchronous activation of the heart slightly increased end systolic volume, while maintaining the same end diastolic volume. This resulted in a drop in stroke volume. Furthermore, the complete activation of LV was delayed from 20 msec in the synchronous model to 100 msec in the asynchronous model. This prolonged activation resulted in higher and more asymmetric strains in the asynchronous model. The results of strain at different locations are also
presented and compared between two models. As a long-term goal we are looking for the possible growth stimuli that produce such an asymmetric pattern.

**Poster Number:** ME-03  
**Title:** Gain Scheduling Control  
**Authors:** Ali K. Al-Jiboory; Guoming Zhu

**Abstract:** This work develops a synthesis procedure for Static Output-Feedback (SOF) Gain-Scheduling (GS) controllers with guaranteed H2 performance for Linear Parameter Varying (LPV) systems, where the measurement of the scheduling parameters are affected by uncertainties. Unlike existing synthesis methods from literature, our conditions can handle the most general case where the time-varying parameters could affect all the open-loop matrices since the controller gain is synthesized via extra slack variables independently of the open-loop matrices. This is the main novelty of the developed approach. All scheduling parameters and associated uncertainties are modeled through multi-simplex framework, i.e., the Cartesian product of multiple unit simplexes. The control problem is solved through two-stage design procedure in terms of Parametrized Linear Matrix Inequalities (PLMIs). In the first stage, a state feedback GS is determined, then, this controller is used as an input parameter for the second stage, which synthesizes the Robust Gain-Scheduling (RGS) static output-feedback gain. Numerical examples demonstrate the effectiveness of the developed approach.

**Poster Number:** ME-04  
**Title:** Micro-Structurally Motivated Constitutive Model for Human Skin  
**Authors:** Sheng Chen; A. Ni Annaidh; Sara Roccabianca

**Abstract:** The purpose of this work is to describe skin from the mechanical perspective by employing a constrained mixture theory approach. Skin can be described as a nonlinear, anisotropic, nearly incompressible elastic material. Families of collagen fibers aligned along preferential directions endow skin with its nonlinear, anisotropic behavior, while elastin gives skin its elastic response. To describe the nonlinear, orthotropic behavior of skin we employed a mass averaged strain energy function (SEF). We considered 3 collagen fiber families, one fiber family in the direction of the Langer’s line and the other two in diagonally symmetric direction with respect to the Langer’s Line. Collagen fibers’ mechanical behavior has been described by using a Fung-type exponential SEF. Elastin has been described by using a Neo-Hookean constitutive model. 43 samples from 6 human subjects were collected and mechanically tested by means of a quasi-static uniaxial tensile test. Samples were grouped based on subject and direction with respect to the Langer’s line (i.e., 0°, 45°, 90°). Nonlinear least-squares regression was used to determine best-fit values of the material parameters for the averaged data of each direction. The best-fit material parameters show that the mechanical behavior of skin is dominated by the presence of collagen fiber, represented by the mechanical parameters of collagen being several orders of magnitude bigger than the one for elastin. Root mean square errors show that the model proposed in this work gives a good fit to experimental data.

**Poster Number:** ME-05  
**Title:** Non-Uniform Mapping in Genetic Algorithms  
**Authors:** Yashesh Dhebar; Kalyanmoy Deb
Abstract: Genetic Algorithms (GA) come under the category of Evolutionary Algorithms wherein a population of solutions (individuals) gets refined in every generation (iteration). After each iteration of GA, the population of solutions passes through three operators - 1) Selection, 2) Cross Over and 3) Mutation. Fitness of individuals of this mutated population is then computed. Greediness and biasing in algorithm is introduced in a "selection" operator, where good solutions get more priority over bad solutions. We, in our study have introduced an additional operator which operates on a mutated population (i.e. when population has passed through all three stages mentioned previously). Here, the population is pushed towards a "best-so-far" point. The amount of push each solution in a population experiences depends on a "non-uniform mapping" function, which is dependent on a parameter "eta". Research was conducted for various kind of "mapping functions"; on unconstrained and constrained single objective optimization problems. In every case, the "non-uniform" mapping approach outperformed standard GA in terms of convergence speed and accuracy.

Poster Number: ME-06  
Title: Quantifying Losses in Hand Function: A Model for Use in Rehabilitation  
Authors: Joshua P. Drost; Tamara Reid Bush

Abstract: Currently, the methods used to measure changes in hand function are primarily surveys which are 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; however, force data for each finger were not included. The goal of this work was to determine forces associated with the index finger and map these to the kinematic workspace of 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. The subject was asked to pull towards the wrist for ten trials and push normal to the palm for nine trials in different positions. After collection, the data were analyzed in terms of the position (x,y,z coordinate), direction and magnitude of the force applied. Arthritic subjects applied significantly lower forces than healthy subjects (ANCOVA, p<0.001), and used a smaller volume of 3D space (MANOVA, p<0.001) and used a smaller range of fingertip directions when applying force (ANCOVA, p=0.0199). Future work will include the measurement of forces for all fingers, and mapping to the 3D kinematic model. Clinically, this model is highly innovative and useful: Measures of motion and force will be gathered prior to intervention; mid-way through rehabilitation and after rehabilitation is complete to determine what level of function was restored.

Poster Number: ME-07  
Title: Role of Computational Modeling in Understanding Arterial Adaptation  
Authors: Hailu Getachew; Seungik Baek

Abstract: Adaptation of arteries, to sustained changes in blood flow and pressure, highly affects the cardiovascular circulation at different levels. Among many arterial adaptation studies that used mathematical models, a Constrained Mixture Approaches is becoming popular for modeling growth and remodeling of arteries, in which vascular walls are assumed to be made up of different constituents. By proper choice of the number of the constituents, we could predict arterial adaptation in various physiological ranges. Specifically, vascular smooth muscle proliferation and collagen turnover are critical for the vascular adaptation of arteries. In the computations, we investigate possible ranges of the kinetic parameters in collagen synthesis and several possible functions of degradation and their consequences; and then we narrow the possible relations between collagen turnover and arterial adaptation. This study
shows that we could incorporate the chemical reactions involving collagens and muscle cells for arterial responses to external stimuli using relatively idealized models and yet, capture the key changes in arterial mass and geometry. It also indicates that both rates of collagen synthesis and degradation are tightly regulated by the mechanical stress. We believe that the model used in our analysis is beneficial to cardiovascular researchers, in the sense that it could be used as a tool for studying, for example, the reaction of arteries in the human brain to hypertension and hemodynamics disorders. Further investigation of the causes that affect rates of collagen turnover and muscle mass changes could enable to develop treatments for cardiovascular patients.

This work was supported in part by National Science Foundation (CMMI-1150376 and CBET-1148298) for SB and for JH

Poster Number: ME-08
Title: Computational Fluid Dynamic Simulation of Human Carotid Artery Bifurcation Based on Anatomy and Volumetric Blood Flow Rate Measured with Magnetic Resonance Imaging
Authors: Hamidreza Gharahi; Byron A. Zambrano; David C. Zhu; J. Kevin DeMarco; Seungik Baek

Abstract: Blood flow patterns and local hemodynamic parameters have been widely associated with the onset and progression of atherosclerosis in the carotid artery. Assessment of these parameters can be performed noninvasively using cine phase-contrast (PC) magnetic resonance imaging (MRI). In addition, in the last two decades, computational fluid dynamics (CFD) simulation in three dimensional models derived from anatomic medical images has been employed to investigate the blood flow in the carotid artery. This study developed a workflow of a subject-specific CFD analysis using MRI to enhance estimating hemodynamics of the carotid artery. Time-of-flight (toF) MRI scans were used to construct three-dimensional computational models. PC-MRI measurements were utilized to impose the boundary condition at the inlet and a 0-dimensional lumped parameter model was employed for the outflow boundary condition. The choice of different viscosity models of blood flow as a source of uncertainty was studied, by means of the axial velocity, wall shear stress, and oscillatory shear index. The sequence of workflow in CFD analysis was optimized for a healthy subject using PC-MRI. Then, a patient with carotid artery stenosis and the hemodynamic parameters were examined. The simulations indicated that the lumped parameter model used at the outlet gives physiologically reasonable values of hemodynamic parameters. Moreover, the dependence of hemodynamics parameters on the viscosity models was observed to vary for different geometries. Other factors, however, may be required for a more accurate CFD analysis, such as the segmentation and smoothness of the geometrical model, mechanical properties of the artery’s wall, and the prescribed velocity profile at the inlet.

Poster Number: ME-09
Title: Analysis and Modeling of a Turbulent Jet Ignition System for Internal Combustion Engines
Authors: Masumeh Gholamisheeri; Gerald Gentz; Bryce Thelen; Elisa Toulson

Abstract: The behavior of transient, compressible and combusting premixed methane-air jets was experimentally studied with high speed imaging in a Rapid Compression Machine (RCM). The jets were generated with a turbulent jet ignition system, which is a prechamber initiated combustion system. Prechamber combustion systems are advanced ignition systems which are under investigation in order to replace current automotive ignition systems. In the last several decades various prechamber combustion systems have been produced and investigated to increase efficiency and reduce pollutants through lean, low temperature combustion. The prechamber is a small volume chamber where an
injector and spark plug are located and is connected to the main combustion chamber via one or multiple small orifices. Experiments were completed for turbulent jet ignition system orifice diameters of 2.0, 2.5 and 3.0 mm each at lean-to-stoichiometric equivalence ratios of 0.67, 0.8 and 1.0. The jet velocity at the orifice exit was calculated using mathematical correlations. The Mach number and Reynolds number were also computed. In addition, three-dimensional numerical simulation of the turbulent jet ignition combustion process of a premixed methane-air mixture in a RCM was performed using the Converge computational software. This research investigated the impacts of an auxiliary fueled prechamber on the burn rate and on the lean or dilute limit extension of the RCM. The numerical results are compared to data and optical images obtained from high speed imaging of combustion in the optically accessible RCM.

This work was supported in part by United States Department of Energy and National Science Foundation Partnership on Advanced Combustion Engines

Poster Number: ME-10
Title: Decoupling of Diameter and Pitch in Nanostructure Arrays Made by Colloidal Self Assembly
Authors: Xiaolu Huang; Matthew Bjork; Jack Jongwon Kim; Junghoon Yeom

Abstract: This paper reports the fabrication of ordered nanostructure array using colloidal self-assembly. Colloidal lithography, also known as nanosphere lithography (NSL), has been extensively and exhaustively utilized to create various nanostructures with the limitation in the resulting morphology and array spacing. Especially, independent control over the individual nanostructure size and array pitch remains a challenge and is the subject of this paper. Here, we show three different methods that expand the type of the nanostructure array produced from NSL. First, the combined technique of NSL and metal-assisted chemical etching (MACE) is shown to generate vertically-aligned Si nanowire (SiNW) array with the unprecedented dimensional control. Second, a stretchable elastomer with transfer printing is utilized to control the pitch of the original NS arrays, and with a custom-designed radial stretcher, a hexagonal symmetry of the resulting nanostructures is conserved. An array of sparsely ordered silicon or quartz nano pillars is obtained along with metallic nanostructures on NSs as etch masks. Finally, a double lift-off method is introduced to create an array of metallic nanodots that are not conventionally realized using the NSL template.

Poster Number: ME-11
Title: Nanorod Formation in a Gas Phase Plasma
Authors: Alborz Izadi; Rebecca J. Anthony

Abstract: Silicon (Si) nanocrystals have been the focus of much attention in recent years for their tunable optical properties, which arise due to quantum confinement. While spherical Si nano crystals have been explored in depth, Si nanorods (SiNRs) have the potential to exhibit different optoelectronic properties compared to their spatially isotropic counterparts, including polarized light emission and enhanced charge transport. There are several solution techniques including vapor-liquid-solid growth in which a gas flow contains silicon ions forms an optimized eutectic alloy with a metal nanodroplet in a batch process. In this study we present a method to streamline SiNR growth even further by combining hot-wire gold nano particle synthesis with plasma-based nanorod growth for freestanding SiNRs produced entirely in the gas-phase. Our preliminary work confirms formation of gold nano particles...
(AuNPs) in the hot-wire method. We supply a thin platinum wire, coated in gold, with electrical power at 10-15 W under argon flow and reduced pressure.

**Poster Number:** ME-12  
**Title:** Probabilistic Collocation Method in Parameter Estimation Applied on an Abdominal Aortic Aneurysm Computational Model  
**Authors:** Zhenxiang Jiang; Huan N. Do; Jungeun Choi; Seungik Baek

**Abstract:** Abdominal aortic aneurysms (AAAs) is one of vascular diseases that could lead to a more than 90% of mortality rates. There is a crucial need for developing a patient-specific computational model of AAAs which can describe the growth and remodeling process for predicting the rupture. However, there are some parameters that can neither be measured in experiments nor estimated directly from the computational model. Therefore, the research for estimating those parameters indirectly based on large amount of data that are obtained from time dependent CT scan of AAAs are necessary. In the presented research, we employ bayesian calibration combined with a probabilistic collocation method to refine the damage function parameters. This work is expected to provide a better prediction of the growth and remodeling process and the probability of rupture.

*This work was supported in part by NIH R01HL115185*

**Poster Number:** ME-14  
**Title:** Multi-Physics Modeling and Simulation of Anomalous Transport Using Distributed Order ODEs/PDEs  
**Authors:** Ehsan Kharazmi; Mohsen Zayernouri

**Abstract:** Anomalous transport and nonlocal/history dependent effects in multi-physics systems are abundant in nature. Examples in many systems in science and engineering include: electrochemical processes, non-Brownian transport phenomena in porous and disordered materials, viscoelastic materials, bioengineering applications, non-Gaussian (Le'vy flights) processes in turbulent flows, non-Newtonian fluids and rheology, non-Markovian processes in multi-scale complex fluids and multi-phase applications. Fractional differential equation (FDEs) and, more generally, distributed order differential equations, open up new possibilities for robust modeling of such complex problems. In distributed order operators, the differential orders are distributed over a range of values rather than being just a fixed fraction as it is in standard/fractional ODEs/PDEs. In this work, we first provide an introduction to fractional calculus and distributed order models. Subsequently, we obtain the corresponding variational forms and set up the underlying function spaces and associated norms inorder to discretize the resulting weak form of the problem. Then, we develop a novel Petrov-Galerkin spectral method followed by the corresponding stability and error analyses. In anomalous physical processes, the distribution function can be obtained from experimental data, where the data uncertainty are incorporated through the distribution function, obtained from the observed data, hence, leading to a robust data-driven simulation framework for multi-physics problems.

**Poster Number:** ME-15  
**Title:** Residual Limb Displacements within a Prosthetic Socket for Below Knee Amputees  
**Authors:** Amy L. Lenz; Katie A. Johnson; Tamara Reid Bush
Abstract: In amputees, pressure ulcers are deep penetrating wounds that occur on the residual limb at the socket interface. Skin movement and residual limb loading coupled with deformation and strain on the skin plays a role on ulcer formation. Little work has been conducted to understand the circumferential and longitudinal displacements that occur on the residual limb during a walking activity. The current research assesses displacements occurring on the residual limb for individuals with a transtibial amputation while wearing a prosthetic. We hypothesize that larger localized displacements occur distally due to uneven limb motion within the socket. Four patients (4 M, age: 56.8 ± 9y) with unilateral transtibial amputation participated in the study (MSU IRB #14-089M). Data collection was accomplished by the development of a clear prosthetic for each patient, attaching 14 thin markers to the gel liner (which adheres to the residual limb) and tracking markers using a 12 camera Vicon system. Patient regions of high displacement vary greatly with different trends being observed. High displacement was considered as values above 3mm. Two patients demonstrate high displacement in the distal tibia region during stance whereas two other patients exhibited high displacement along the fibular head during stance. However, these regions of high displacement correspond respectively to patient reported regions of potential discomfort over prominent bony landmarks. Knowledge of this within socket displacement data will be valuable to clinicians for improving socket design and fit for the hope of reducing the occurrence of pressure ulcers.

This work was supported in part by None

Poster Number: ME-16
Title: Liquid Activated Textile Batteries for Wearable Biosensing Systems
Authors: Xiyuan Liu; Peter B. Lillehoj

Abstract: Wearable technology has become increasingly mainstream in recent years and offers great potential for many important applications including human health monitoring, environmental sensing and bio-agent detection. One of the main challenges with wearable sensors is the need for flexible, lightweight batteries that can be easily integrated with wearable materials and fabrics. In this paper, we demonstrate a unique liquid activated Ag-Al battery fabricated using textile. This battery is comprised of dry electrolyte layers sandwiched between Ag and Al electrodes. Upon application of an aqueous sample, the electrolyte layers become hydrated and generate an electrochemical reaction, thereby activating the battery. Using this scheme, we developed a single-cell battery that can produce an open-circuit voltage of 1.3 V. By connecting cells in series, higher voltages were achieved with minimal modification to the fabrication process. To demonstrate the functionality of this technology, we fabricated a dual-cell battery and used it to power a 1.6 V LED.

This work was supported in part by the National Science Foundation CAREER award (ECCS-135056)

Poster Number: ME-17
Title: Gas-Phase Synthesis of Gallium Nitride (GaN) Nanocrystals Using Non-Thermal Plasma
Authors: Rajib Mandal; Michael Bigelow; Branton Toback; Rebecca J. Anthony

Abstract: Bulk Gallium Nitride (GaN) is the standard light-emitting material, very efficient for Light Emitting Diodes (LEDs) and has been in use for many years. This material is very attractive due to its high-brightness and thermal stability. GaN is a direct band gap semiconductor with 3.4 eV band gap energy enabling its use in ultraviolet/blue light emission technologies. Relative non-toxicity of GaN
compared to other popular semiconductors such as Cadmium selenide (CdSe) gives it distinct advantage. The applicability of GaN nanoparticles lies in high-brightness solid-state lighting devices. Here we present a study on synthesis of high-quality GaN nanocrystals using a fully gas-phase process. We have used a low-pressure nonthermal plasma reactor for the synthesis of GaN directly from gaseous precursors and deposited onto the glass substrate without any additional steps. The plasma reactor has some advantages over other available methods, namely, size monodispersity, easy control on nanocrystal size and the ability to deposit the NCs from the gas phase without removal from the reactor. It is also inexpensive and can be processed rapidly. Some studies have been performed with microwave plasma but it is very complex in nature. Thus, radiofrequency (RF) plasma could be an attractive alternative. An RF nonthermal plasma reactor is comprised of a borosilicate glass tube with dual ring electrodes encircling the tube externally. Vapor-phase precursors and carrier gases were flown through at relatively low pressure (typically 5-15 torr) with RF power ranging from 60W-100W. Our study has shown that small (3-5nm) crystalline GaN nanoparticles were produced.

**Poster Number:** ME-18  
**Title:** Crystal Plasticity Finite Element Modeling of Multiphase Third Generation Advanced High Strength Steel (Q&P980) Undergoing Large Plastic Deformation  
**Authors:** Bassam Mohammed; Taejoon Park; Farhang Pourboghrat

**Abstract:** Designing multiphase metals based on their constituent phase properties and using these metals for manufacturing automotive parts is a challenging process. A multiphase and multiscale model is strongly beneficial in achieving this goal since such a model can play an important role by connecting the material response at the macroscopic scale with the microstructural properties such as texture. In this study, a computationally efficient Crystal Plasticity Finite Element Model (CPFEM) was used to simulate the bulging and stamping of a three-phase (ferrite, martensite, and retained austenite) quenched and partitioned Q&P980 steel sheet, and to predict the corresponding crystallographic texture evolution. The CPFEM model was developed to capture the mechanical properties of steel phases based on their individual plastic deformation (hardening parameters), slip systems (BCC crystals for ferrite and martensite with 24 slip systems 12 {110} <111> and 12 {112}, FCC crystals for austenite with 12 slip systems (111) <110>), and the volume fraction of the constituents phases in the material. The macroscopic behavior of a polycrystalline aggregate is evaluated by a volume averaged response of the representative phases. The comparison between the multiphase CPFEM model, experimental and anisotropic Hill’48 yield criteria was applied for further validation of the proposed model. The results based on the multi-phase CPFEM model was in better agreement with the experimental results than phenomenological models in terms of capturing the applied punch force-displacement curve, strain distribution, and localized necking location relative to the sheet rolling direction.

**Poster Number:** ME-19  
**Title:** On Confined Premixed Flames  
**Authors:** Younis M. Najim; Norbert Mueller; Indrek S. Wichman

**Abstract:** The objective of this study is to perform an experimental and numerical investigation of a premixed flame propagating in a constant volume channel. The mixture was prepared from stoichiometric methane/air, and initially at rest, had temperature 296 K and pressure 102.65 kPa. In the experimental study, a high speed camera and a pressure sensor captured the evolution of flame structure and monitoring the pressure time-history during combustion. For two dimensional model,
kinetic mechanisms is used to predict the reaction rate by direct integration using Reaction Design Scheme and by in situ adaptive tabulation. Since the kinetic mechanism is computationally expensive choice, the reaction progress variable is used for the three dimensional model in which the reaction rate is predicted using adaptive flame speed closure and algebraic flame surface density. The analysis of the numerical results revealed the effect of the interaction between flame front, pressure waves, and flame-induced flow on flame structure evolution. The numerical simulation conducted here for the three dimensional WDE channel uncovers an interesting behavior for the flame structure. We observed what may be defined as a “transverse tulip flame” which appeared in the direction perpendicular to the plane where the initial tulip flame is evolved after the latter underwent transition from cusped convex back to concave finger shape.

This work was supported in part by Higher Committee for Developing Education in Iraq.

Poster Number: ME-20
Title: Evolution of Solid Morphology Under Thermal Insult During Combustion
Authors: Thomas Pence; Indrek Wichman; Yen Nguyen

Abstract: Almost all flames interact strongly with nearby surfaces. For many materials, the surface undergoing pyrolysis (described as internal material thermochemical breakdown) and combustion is a growing, finite-thickness layer. This finite-thickness layer may exhibit voids, cracks, and other defects caused by heating and by material response to heating. One of these responses is extreme deformation. The surface layer structure of the degraded material varies enormously between materials. In addition, combustion alters surface morphology even as the surface morphology alters combustion. This occurs by (1) forming fissures that allow internal sample exposure to external heating; (2) allowing escaping volatiles into the gas to support further combustion; and (3) forming cracks and voids that weaken the material, making it susceptible to physical breakdown into smaller fragments consumed by the fire. Here, a model is examined that describes surface breakup for charring solids. This model incorporates stress development and stress relief as they occur during heating, pyrolysis and combustion.

This work was supported in part by CVRC

Poster Number: ME-21
Title: An Experimental Methodology for Creating Arbitrary Velocity Profiles in a Flow Facility
Authors: Alireza Safaripour; David Olson; Ahmed Naguib; Manoochehr Koochesfahani

Abstract:

This work was supported in part by AFOSR

Poster Number: ME-22
Title: Windkessel Approach for Venous Ulcer Risk Assessment
Authors: Wu Pan; Seungik Baek; Tamara Reid Bush

Abstract: Venous ulcers are sever skin wounds that affect 2.5 million people in US, however, no preventive measures had been developed to effectively identify and treat ulcer-prone population.
Experimental work has shown that blood flow response to locally induced external load varied between patients with venous ulcer and healthy population. Therefore, the goal of this study was to develop a model that represents the blood flow response to external loading and to compare model parameters across samples of healthy individuals and those with venous ulcers. A Windkessel based circuit model was proposed where the resistor and capacitor represented vascular resistance and vessel compliance respectively. The model parameters were then iterated and optimized to match with the experimental data, and the values of the parameters for each participant were obtained and analyzed statistically. Significant differences were found in localized vessel resistance and compliance between ulcerated legs and healthy legs. The model demonstrated its capability for identifying patient-specific parameters. The values of the parameters and the statistical trend between different populations suggested that there are thresholds for these values which could be identified and utilized to determine when a person moves to a high risk category for wound formation. Then, a “just-in-time” prevention strategy would be applied. Future work will be increase the sample size so that ranges of model parameter values can be established and identified for patient sub-groups. The modeling of skin blood flow will help us better understand the blood perfusion behavior pre- and post- venous ulcers.

**Poster Number:** ME-23  
**Title:** Material Characterization of Soft Tissue in Human Buttocks and Thigh Regions  
**Authors:** Wu Pan; Joshua P. Drost; Zachary Sadler; Tamara Reid Bush

**Abstract:** Accurate characterization of material properties of soft tissue is imperative to model human body and design devices that interact properly with people. The mechanical properties of buttocks and thighs are particularly important in medical seating (wheelchair design), automotive seating and prosthetic design for the lower limb. However, there is no data defining the properties of the multi-layer tissue system in vivo, especially for the buttocks and thigh regions which are sensitive and difficult to test. Hence, the goal of this study was to determine the in vivo material properties of the tissue in human buttocks and thigh regions. A special designed chair was built to allow the test to be performed in a seated position, which is critical to guarantee same tissue tension in seating applications. External force was applied via a load-cell implemented indenter to six different regions along the buttocks and thigh. The deformation of the soft tissue was measured by a 3D motion capture system. Based on the obtained force-deformation relationship, Mooney-Rivlin material model was adopted to characterize the material properties in the thigh region and the material parameters were reported. This material model was successfully able to characterize the soft tissue in thigh region. The material parameters are a must to improve models of the human body and have great potential in medical seating and automotive occupant safety and prosthetic design. Future work will include analysis of buttocks regions and tests of more diversified group with different age and Body Mass Index.

**Poster Number:** ME-24  
**Title:** Influence of Unsteady Effects on the Torque Generation of Rotors with Curved Channels  
**Authors:** Raul Quispe-Abad; Norbert Mueller

**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 analysis of torque generation for conventional turbines typically considers only steady effects. For the unsteady expansion process, an
unsteady component is added to this conventional analysis. This research is focused on the influence of the unsteady effect component on the torque generation. Using Computational Fluid Dynamic analysis and the integral form of the Angular Momentum equation, the contributions of steady and unsteady effects are quantified and presented. Two findings will be pointed out: the percentage of the contributions respect to the full amount of torque generated and some potential options to improve these contributions based on the channel geometry of the rotor. The outcome of this research contributes to maximizing the work extraction of Wave Disc Engine technology. This will be a step forward to a near future of the fabrication of the WDE for portable and residential scale power generation.

**Poster Number:** ME-25  
**Title:** Multi-Objective Optimization Using Variable-Length Genomes  
**Authors:** Matt Ryerkerk; Ron Averill; Kalyanmoy Deb; Erik Goodman

**Abstract:** Many optimization problems use solutions that consist of a number of analogous components. Examples include sensor coverage, wind farm, and laminate stacking problems. Using standard algorithms to solve these problems requires assuming a fixed number of sensors, turbines, or plies. However, if the optimal number is not known a priori this will lead to a sub-optimal solution. A better method is to allow the number of components to vary. As the number of components varies so does the dimensionality of the search space, making the use of gradient-based methods difficult. Genetic Algorithms (GAs) that utilize a variable-length genome to represent the solution are viable candidates. The traditional GA operators, designed to work with fixed-length genomes, are no longer valid. Notably, the recombination operators need to be modified such that they can operate on parents of varying lengths in a respectful manner. Additionally, it is observed that adding or removing components from a solution tends to become a destructive process as the algorithm progresses. In order to reach the optimal number of components the selection operator must be modified to include length-based niching of solutions. When considering multi-objective problems variable-length algorithms are required in order to fully characterize the Pareto front.

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**Poster Number:** ME-26  
**Title:** Efficient Spectral Methods for Anomalous Transport  
**Authors:** Mehdi Samiee; Mohsen Zayernouri

**Abstract:** Anomalous transport refers to nonequilibrium thermo-fluid processes that cannot be described and predicted by the old fashion methods of mathematical and statistical physics. Non-local models and fractional PDEs (FPDEs) provide a proper modeling framework, in which interesting applications of anomalous transport are investigated. FPDEs are emerging as a powerful tool for modeling multiscale phenomena including overlapping microscopic/macroscopic scales, and long-range time memory or spatial interactions. Such phenomena occur in reacting turbulent flows, rheology, anomalous transport phenomena in porous/disordered materials, complex fluids, and multi-phase applications. We develop a novel Petrov-Galerkin (PG) spectral method for a unified class of linear FPDEs subject to homogeneous Dirichlet initial/boundary conditions. Our general mathematical model seamlessly includes time- and space-fractional diffusion, advection, advection-dispersion, and wave equations. We prove the stability of our scheme, furthermore, we formulate a fast linear solver for the
resulting high-dimensional system, hence, lowering the computational complexity of the problem. To demonstrate the efficiency and spectral rate of convergence in our PG spectral method, we perform several computational test cases.

**Poster Number:** ME-27

**Title:** A Closed-Loop Circulatory Model Coupled with Cellular-Based LV Electromechanics: Assessment of Ventricular Mechanics Under Different Loading Conditions

**Authors:** Sheikh Mohammad Shavik; Lik Chuan Lee

**Abstract:** Cellular-based high-resolution LV finite element (FE) models are useful in understanding ventricular mechanics associated with normal and abnormal heart functions. These models are usually constructed using active contraction models that are developed based on experimental data at the cellular level. As such, it is unknown if these models are able to reproduce physiological behavior at the organ level. The goal of this work is to assess some fundamental physiological behaviors under different loading conditions in a cellular-based LV FE model that is coupled with a closed loop circulatory model. Specifically, we analyze the model predictions of (1) pressure-volume (PV) loops, (2) myocardial oxygen consumption (mVO2) and mechanical work relationship and (3) three-dimensional strain under different loading conditions. By consolidating the PV loops under different loading conditions, we 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). Furthermore, by assuming that mVO2 is proportional to the hydrolysis of ATP (Adenosine triphosphate) required to uncouple the actin-myosin bond, we show that the model is able to reproduce a linear relationship between mVO2 and the pressure-volume area. These findings are consistent with the physiological measurements in the LV across many species. Finally, our model predicts that the change of loading conditions affects the longitudinal, circumferential and radial strain – time behavior under different loading conditions. However, interestingly, the peak longitudinal strain is insensitive to the loading conditions. In future the circulatory model will be extended by incorporating the effect of LA and eventually including the RV to establish a bi-ventricular closed-loop circulatory model.

**Poster Number:** ME-28

**Title:** Shock-Turbulence Interactions in High Speed Multi-Fluid Flows

**Authors:** Yifeng Tian; Farhad Jaberi; Zhaorui Li; Daniel Livescu

**Abstract:** High-order numerical simulations of an isotropic multi-fluid turbulence interacting with a planar shock wave are performed using a hybrid numerical method, which combines a monotonicity-preserving scheme with a compact scheme. The main objective of this study is to investigate the effects of density variations due to compositional changes on the shock-turbulence interactions and mixing in very high speed flows. Convergence tests are conducted to establish the accuracy of results using different meshes with a wide range of grid sizes inside and outside the shock zone. The computed statistics are found to be independent of the grid when the turbulence after the shock is well resolved and the scale separation between numerical shock thickness and turbulent scales is adequate. A simulation of single-fluid turbulence is also conducted with similar conditions. Compared to the single-fluid case, turbulence amplification by the normal shock wave is found to be much higher and the reduction in turbulent length scales is much more significant in the presence of density variations due to compositional changes. Turbulent mixing enhancement by the shock wave is also more important in the
multi-fluid case. The mechanisms behind multi-fluid shock-turbulence interaction and scalar mixing are identified by analyzing the transport equations for the Reynolds stress, vorticity and scalar variance.

This work was supported in part by Los Alamos National Laboratory

Poster Number: ME-29  
Title: IC Engines for a Low CO2 World  
Authors: Sedigheh Tolou; Harold Schock; Matthew Brusstar; Thomas Veling; Ray Kondel; Greg Davis

Abstract: The importance of geopolitical and environmental issues associated with energy consumption are inevitable in today's global society. Power plants used in transportation must economically provide good power density, low exhaust emissions, and high fuel efficiency over a wide range of operation. Achieving one of these benefits does not guarantee optimum gain on others and in fact they are often contravening goals. The highly successful conventional spark ignition (SI) systems have limitations in efficiency potential due to the need for their stoichiometric operation. A viable option is lean burn engines which can provide significant improvements in fuel efficiency. The intent of this research is evaluating two of the most promising lean burn engine designs; Direct Injection Stratified Charge (DISC) and Dual-Mode Turbulent Jet Ignition (DM-TJI). The goal behind the study is comparing the DISC and DM-TJI engines based on engines' performance, exhaust emission characterization, combustion stability analysis and cycle-to-cycle variation, cost and manufacturability of the engines and their emission control system, deposit formation and the influence on long term performance, and multi-fuel tolerance (especially low carbon biofuels). Analysis involves both the experiments and numerical simulations. A single-cylinder metal engine is available at US Environmental Protection Agency (EPA) National Vehicle & Fuel Emissions Laboratory (NVFEL); cell#10. The engine has the Ford Eco-Boost 1.6L head. A single-cylinder metal engine will be constructed by MSU/EPA and be moved to one of EPA test cells. Complimentary optical engine work is being conducted at MSU. Additionally, a 1D GT-POWER model and 3D simulations will be used to simulate both DISC and DM-TJI engines as required.

This work was supported in part by US Environmental Protection Agency, Tenneco Inc., Michigan Economic Development Corporation, General Motors

Poster Number: ME-30  
Title: High Fidelity Numerical Study of Turbulent Jet Ignition and Combustion in Advanced Combustion Engines  
Authors: Abdoullahad Validi; Farhad Jaberi

Abstract: Turbulent Jet Ignition (TJI) is an efficient and novel method for initiating and controlling combustion in advanced combustion systems, e.g. internal combustion engines. It enables combustion in ultra-lean mixtures by utilizing hot product turbulent jets emerging from a pre-chamber combustor as the ignition source for the main combustion chamber. Here, we study the TJI-assisted ignition and combustion of lean methane-air mixtures in a Rapid Compression Machine (RCM) for various flow/combustion conditions with the hybrid large eddy simulation/filtered mass density function (LES/FMDF) computational model. In the LES/FMDF model, the filtered form of compressible Navier-Stokes equations are solved with a high-order finite difference scheme for the turbulent velocity, while the FMDF transport equation is solved with a Lagrangian stochastic method to obtain the scalar (species mass fraction and temperature) field. The LES/FMDF data are used to study the physics of TJI and
combustion in RCM. The results show the very complex behavior of the flow and flame structure in the pre-chamber and RCM and the ability of TJI to drastically change the engine behavior.

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

**Poster Number:** ME-31  
**Title:** Impact Testing and Analysis of Composite Fan Case Structures  
**Authors:** Andy VanderKlok; Jim Dorer; Andy Stamm; Ryan Dutour; Eryi Hu; Xinran Xiao

**Abstract:** High speed fans play a vital role in the aeronautical field, specifically in aero-engines for producing thrust in hi-bypass turbo-jet engines commonly seen in most commercial airliners. One of the challenges in engine design is the possible fan blade out event (FBO), which can occur from bird strike or fatigue. When this happens a blade is released at ballistic speeds which can cause catastrophic damage to nearby aircraft components. To prevent such damage, a fan case is constructed to contain the loose blade. Traditionally the fan case is made from a well characterized metallic material. An alternative material is composites. The major advantages of composites are corrosive resistant, light weight, tailorable, and high strength. However, little is known about how composites respond to high speed impact in FBO. Assessing the dynamic response and failure modes of composites in FBO is crucial in the design of composite fan case. The proposed work is focused on the development of gas gun testing method that can closely replicate the impact and damage caused by FBO on composite fan cases. To investigate FBO, a spin pit testing facility has been developed. A new, energy based method for the design of projectiles in gas gun test to replicate FBO has been proposed. The proposed method will be examined by comparison of the gas gun test with spin pit FBO test. This work will contribute to the development of a combined numerical and experimental approach for the design of a composite fan case.

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

**Poster Number:** ME-32  
**Title:** Investigation of the Chemo-Mechanical Coupling in Lithiation of Amorphous Si Using Finite Element Analysis  
**Authors:** Miao Wang; Xinran Xiao

**Abstract:** Si experiences large deformations during battery cycling, which has been cited as a primary cause for the electrode fracture and thus capacity fading. The problems caused by the electrode deformations can be remedied through electrode design, and the numerical models will greatly facilitate this design process. Understanding the stress evolution and its effect on Si lithiation is of great importance for Si electrode design. In this study, the chemo-mechanical coupling of Si lithiation was investigated by simulating two geometries, amorphous thin film and nanospheres, using finite element analysis. An asymmetric rate response between lithiation and delithiation has been observed in a-Si thin films, but not in Si nanospheres. The simulations reveal that, in a-Si thin film, the lithiation induced stress field is almost uniform and opposite in sign during lithiation and delithiation. During lithiation, the stress is compressive which leads to stress suppressed diffusion. During delithiation, it is vice versa. The stress state is an important factor for the asymmetric rate response observed in a-Si thin film. In Si nanospheres, on the other hand, the stress varies and its sign changes across the particles during lithiation and delithiation. The stress suppressed and enhanced diffusion happens simultaneously in a particle. The asymmetric rate response, if any, was not obvious.
Poster Number: ME-33  
Title: Image-Based Computational Modeling of the Ventricular Mechanics in Pulmonary Hypertension Patients  
Authors: Ce Xi; Lik Chuan Lee

Abstract: Pulmonary hypertension (PH) is a disease resulting from restricted flow in the pulmonary arterial circulation. This results in an increase in pulmonary vascular resistance. Left untreated, the disease leads to right ventricular (RV) failure, which is the most common cause of death in PH patients. To the best of our knowledge, there are currently no in vivo studies that determine the impact of PH on the regional ventricular mechanics and mechanical properties in the human heart. In our study, we have used a cardiac electromechanics model to quantify the regional ventricular mechanics between a PH patient and a normal human subject. By adjusting a few parameters in the model, we are able to match the experimentally measured pressure-volume (PV) loops of RV and LV for the PH patient and the normal subject. The differences of all quantified variables and parameters (e.g., regional ventricular strain and passive stiffness) were compared between the PH patient and normal subject. Regional differences between quantities obtained from LV and RV were also compared. Regional ventricular wall stresses and strains were computed for the PH patient and normal subject. Our findings indicate that the diastolic passive stiffness and the contractility of the PH patient are larger than that of the normal subject in both the LV and RV.

Poster Number: ME-34  
Title: Simulation of the 3 Omega Method for Measuring the Thermal Conductivity of Superconducting Niobium  
Authors: Peng Xu; Neil Wright; Thomas Bieler; Chris Compton

Abstract: Enhancing performance of Superconducting Radio Frequency (SRF) particle accelerators relies on improvements in metallurgy and manufacturing of their Nb walls. Informing improvements in Nb manufacture is understanding its thermal conductivity at about 2 K, where many accelerators operate. Measuring the thermal conductivity of single crystals or thin films of Nb is challenging. The 3 omega technique has proved to be versatile for measuring the thermal conductivity of thin films and small samples, especially of semiconductors and dielectrics. Here, extension of the technique to superconductors is studied. Simulation of temperature-dependent thermal conductivity showed that the 3 omega method can be applied to measure the thermal conductivity of Nb at low temperature. Finite element simulation of the 3 omega method was used to parameterize the roles of heater geometry, anisotropic thermal conductivity of thin films, and temperature dependent thermal conductivity on the reported values of Nb. Variation in heater thickness resulted almost the same slope and axis intercept, indicative of thermal conductivity and diffusivity, respectively. Variation in the width of the heater resulted in the same slope, but different axis intercepts. Cross-plane thermal conductivity of thin film is always more important, however, in-plane thermal conductivity cannot be neglected. From the 3 omega simulation, the conditions (e.g. sample geometry, frequency range) can be predicted when conventional analytical formulas are suited to determine the thermal conductivity of bulk and thin film materials from the data measured.

This work was supported in part by This research is supported by the US DOE Cooperative Agreement through grant number DESC0000661 and Michigan State University.
Poster Number: ME-35
Title: Characterization of the Through Thickness Mechanical Property of Thin Polymer Films
Authors: Shutian Yan; Xinran Xiao

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 for through thickness behavior characterization. Our preliminary study shows that this method can achieve a resolution of 0.5 micron. The measured nominal compressive modulus is comparable to the reported values in literature. As shown in previous studies, both the in-plane and the through thickness mechanical properties are lower when tested in electrolyte solutions. In this work, to test samples in solutions, a special testing fixture with capacitance based displacement measurement has been designed to characterize the through thickness mechanical behavior.

Poster Number: ME-36
Title: Swelling Induced Burst in Hyperelastic Spheres and Cylinders
Authors: Vahid Zamani; Thomas J. Pence

Abstract: The conventional theory of hyperelasticity is generalized to incorporate a swelling effect. We consider the spherical symmetric deformation in which swelling has been taken into account and then the theory is used to study an abrupt inflation instability in pressurized shells. At fixed pressure, a slowly changing amount of swelling can suddenly cause a finite jump in the shell radius.

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Poster Number: ME-38
Title: Physics-Based Turbine Power Models for a Variable Geometry Turbocharger
Authors: Tao Zeng; Devesh Upadhyay; Harold Sun; Guoming G. Zhu

Abstract: Control-oriented models for Variable Geometry Turbochargers (VGT) typically calculate the turbine power based on isentropic assumptions with a fixed or a map based value for the turbocharger mechanical efficiency. While the fixed efficiency assumption is an obvious over simplification, the map based approach, on the other hand, may not be globally accurate due to the need for interpolation between varying vane positions and extrapolation when the turbocharger is operating outside the
mapped region. In this paper physics-based models of turbine power as well as the power loss are developed, utilizing the VGT vane position and the shaft speed. This makes it possible to define the mechanical efficiency as a function of the vane position thereby eliminating the above mentioned uncertainties as well as allowing a smooth extension over the entire operating range. The proposed model is validated against a few sets of test data from both steady state and transient operations.

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**Poster Number:** ME-39  
**Title:** Soft Lithographic Printing and Transfer of Photosensitive Polymers: Facile Fabrication of Free-Standing Structures and Patterning Fragile and Unconventional Substrates  
**Authors:** Yaozhong Zhang; Jea-Hyeoung Han; Likun Zhu; Mark A. Shannon; Junghoon Yeom

**Abstract:** Dry film photoresists (DF PRs) are widely used to perform photolithography on nontraditional substrates such as printing circuit boards, plastic sheets, or non-planar surfaces. Commercially available DF PRs are usually in a negative tone and rather thick, limiting lithographic resolution and versatility. The relatively large pressure required for lamination also prevents the technology from being used for delicate substrates. Here we present a modified soft-lithographic process, namely photoresist blanket transfer (PR BT), transferring a spin-coated PR film from a flat elastomeric stamp to a substrate. The elastomeric stamp is highly compliant, bringing the PR film into intimate contact with the substrate and eliminating the need for a large lamination pressure. Photolithography on unconventional substrates such as etched, fragile, and porous ones is demonstrated. Single or multiple transfers of PRs by BT are utilized to fabricate multilayer, free-standing, and re-entrant polymeric microstructures. A fragile and porous substrate such as an anodized aluminum oxide membrane can also be patterned using PR BT. Moreover, a reliable method to create metal electrodes and high surface area catalysts inside microchannels is discussed for novel microfluidic applications.

**Poster Number:** ME-40  
**Title:** Peridynamic Simulation of Crack Propagation in Orthotropic Materials  
**Authors:** Wu Zhou; Dahsin Liu

**Abstract:** Peridynamic is a nonlocal numerical technique. With only two material constants, peridynamic has been employed for investigating damage processes of orthotropic fiber composite materials with Cf as stiffness along the fiber direction and Cm as that for all other directions. However, according to orthotropic theory, the stiffness of unidirectional fiber composites should change continuously with the fiber orientation. In this poster, bond-based peridynamic is modeled with a continuously changing modulus C for orthotropic materials. That is, C changes continuously from along the fiber direction to transverse to the fiber direction with a very similar manner as the change of Young’s modulus in a lamina from along the fiber direction to transverse to the fiber direction. Various ratios of Young’s modulus in fiber orientation to that in matrix orientation, i.e. E11/E22, ranging from 4 to 50, have been investigated. The modified peridynamic model is then employed to study the dynamic behavior of an orthotropic beam under three point bending. The beam has a length of 200mm and a thickness of 50mm. It has a fiber orientation of 135-degree with respect to the beam length. A notch is initially assigned at the bottom of the mid-span of the beam. Impact loading is added to the center of the top surface. Crack initiation and propagation are simulated by the continuous orthotropic peridynamic model. The numerical results match well with the experimental observations published in literature.
**Poster Number:** ME-41  
**Title:** Evaluation of Thumb Carpometacarpal Joint Laxity and Muscle Strength in Osteoarthritis: A Pilot Study  
**Authors:** A. R. Cussen; G. Shafer-Crane; E.E. Hornbach; T. R. Bush  

**Abstract:** Osteoarthritis (OA) of the thumb carpometacarpal (CMC) joint affects approximately half of U.S. adults over 55, and often causes pain and functional deficits like difficulty opening jars and medications. In this pilot study, we explore the potential of three dimensional (3D) kinematics to identify factors associated with thumb CMC joint instability in OA. We hypothesize that 3D motion capture and force measures can be utilized to detect a) reduced muscle strength during abduction/adduction and flexion/extension motions, b) reduced active range of motion (AROM), and c) increased time to complete a task in OA subjects compared to asymptomatic controls. The results of this proof on concept study suggest that motion capture is sufficient to detect decreases in AROM and increased duration to complete a task in OA subjects. Force application differences were not identified in this sample. Future studies will utilize larger subject populations to determine statistical significant of these pilot findings.