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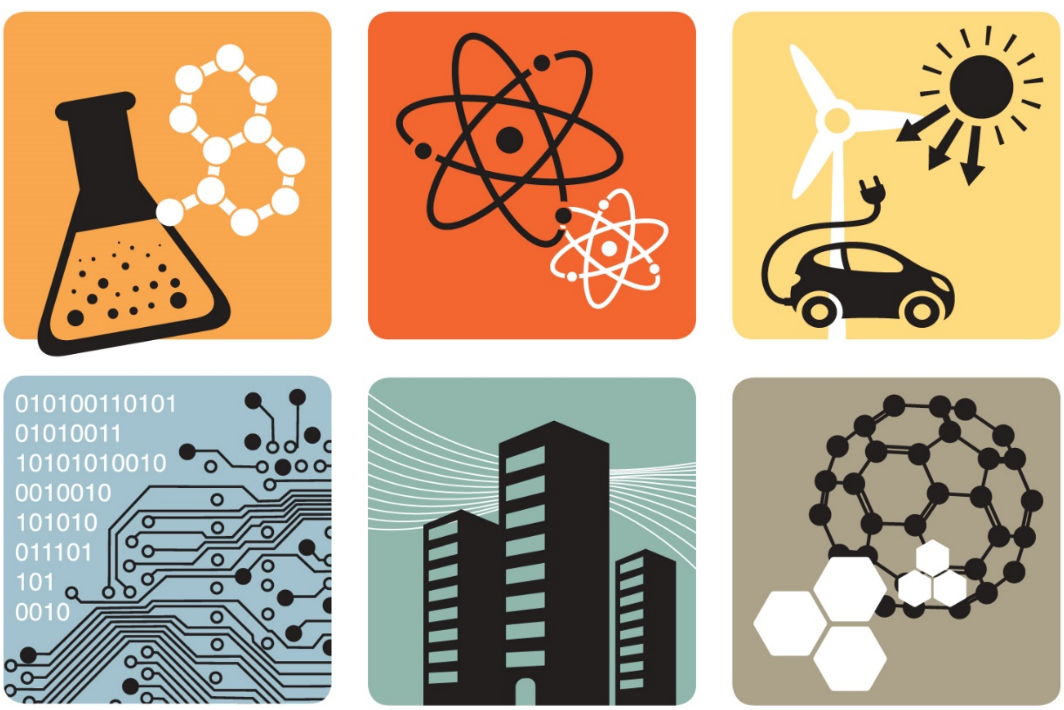

MICHIGAN STATE UNIVERSITY | COLLEGE OF ENGINEERING

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FITCH H. BEACH NOMINEE POSTERS

Poster Number: FB-01
Authors: Kaitlyn E. Casulli; Donald W. Schaffner; Kirk D. Dolan
Title: Developing Model-Based Tools for Quantifying Risk Mitigation and Validating Commercial Dry-Roasters

Abstract: The Preventive Controls for Human Foods Rule, a part of the Food Safety Modernization Act passed in 2009, mandates that food processing firms validate pathogen-reduction steps. Model-based tools can be used for process validation of commercial dry roasting processes. Several published models are available that can explain effects of temperature and moisture on Salmonella inactivation; however, not many include process effects, which have been shown to be important factors to consider. To better understand these effects, in-shell pistachios were roasted at multiple commercially relevant conditions and evaluated for process effects (initial a_w and/or presoaking treatment, process humidity, process temperature). Initial a_w did not have an impact on Salmonella inactivation, except when considering presoaked vs. dry pistachios. Increasing either process humidity or temperature increased inactivation. Future aims of this research include coupling a heat and mass transfer model with an inactivation model for Salmonella in a low-moisture food during dry roasting. This model will aid in explaining the impacts of process variability (in terms of temperature and moisture profiles of the product) on Salmonella inactivation. A better understanding of these relationships can lead to developments in automation engineering, allowing machine operators to monitor product in real time and have tighter control over product safety and quality, leading to greater profits, less waste, and lower risk of foodborne illness.

This work was supported in part by the Center for Produce Safety and the California Pistachio Board

Keywords: inactivation, risk, roasting, validation, modeling

Poster Number: FB-02
Authors: Aritra Chakraborty; Philip Eisenlohr
Title: Understanding Driving Forces and Mechanisms of Tin Whiskers from Thermally Strained Films Using Multi-Physics Simulations.

Abstract: Tin (Sn) coatings are frequently applied to electronic devices. From those, long filaments—called whiskers—grow by stress-induced diffusion of tin atoms. Stresses in these films can arise due to deposition, indentation, formation of voluminous intermetallics at the film–substrate interface, or due to thermal expansion mismatch with the substrate. Whiskers have been a serious concern for device reliability as they can bridge two components of the device leading to short circuit. Whisker formation was mitigated for a long time by alloying Sn with lead (Pb), but the ban of Pb from early 2000 caused the problem of tin whiskers to resurface.
In this work, the process of stress-driven diffusion in thermally strained Sn-on-Si films is investigated using multi-physics simulations to better understand whisker formation. Mass diffusion occurs only along the grain boundaries as Sn diffusivity through the boundaries is multiple orders of magnitude higher than the bulk. A novel coupled chemo-thermo-mechanical model is developed, which is capable of incorporating the critical effect of crystal orientation as the Sn lattice structure is highly anisotropic. Through this work the effect of i) film texture, ii) Sn anisotropy, and iii) kinematic consequence of atom diffusion on grain boundary stress is analyzed. It is predicted that the Sn anisotropy and plastic relaxation play a significant role in stress relaxation as compared to the diffusional mass redistribution.
With successful completion of this work, efficient crystallography-based whisker mitigation strategies can be proposed, thereby increasing the device reliability.

This work was supported in part by NSF-DMR1411102

Keywords: multi-physics models, crystal plasticity, stress-driven diffusion, tin whiskers

Poster Number: FB-03
Authors: Joshua P. Drost; Tamara Reid Bush
Title: Quantifying and Visualizing Hand Function

Abstract: Currently, the methods used to assess functional changes in the hand are primarily questionnaires and pain scales, which are subjective, or clinical methods such as dynamometers and goniometers, which only measure a small portion of hand function. The goal of this work is to develop new ways to quantify hand function, in terms of motions and forces, and visually display that function. This will allow clinicians to better understand patients disfunction and diagnose treatments.
Twenty young healthy participants were included in this study. Range of motion was collected through six hand motions. Maximum forces were measured in thirteen trials over the range of motion for each finger and the thumb. Then, an osteoarthritic patient was tested before and after hand surgery. Analysis looked at the range of motion for each digit and the forces that were applied to determine how this patient had lost function (i.e., range of motion and force production), and how surgery improved function.
These changes were also modeled in three-dimensions for visualization. Three dimensional plots were used to compare the patient's range of motion to the average healthy range of motion, and to compare the patients range of motion before and after surgery. Force and motion plots were used to display how the patient was able to apply force, and how it changed due to surgery.

Keywords: hand function, surgery, osteoarthritis

Poster Number: FB-04
Authors: Biyi Fang; Mi Zhang
Title: DeepASL: Enabling Ubiquitous and Non-Intrusive Word and Sentence-Level Sign Language Translation

Abstract: There is an undeniable communication barrier between deaf people and people with normal hearing ability. Although innovations in sign language translation technology aim to tear down this communication barrier, the majority of existing sign language translation systems are either intrusive or constrained by resolution or ambient lighting conditions. Moreover, these existing systems can only perform single-sign ASL translation rather than sentence-level translation, making them much less useful in daily-life communication scenarios. In this work, we fill this critical gap by presenting DeepASL, a transformative deep learning-based sign language translation technology that enables ubiquitous and non-intrusive American Sign Language (ASL) translation at both word and sentence levels. DeepASL uses infrared light as its sensing mechanism to non-intrusively capture the ASL signs. It incorporates a novel hierarchical bidirectional deep recurrent neural network (HB-RNN) and a probabilistic framework based on Connectionist Temporal Classification (CTC) for word-level and sentence-level ASL translation respectively. To evaluate its performance, we have collected 7,306 samples from 11 participants, covering 56 commonly used ASL words and 100 ASL sentences. DeepASL achieves an average 94.5% word-level translation accuracy and an average 8.2% word error rate on translating unseen ASL sentences. Given its promising performance, we believe DeepASL represents a significant step towards breaking the communication barrier between deaf people and hearing majority, and thus has the significant potential to fundamentally change deaf people's lives.

This work was supported in part by National Science Foundation 1617627, 1565604

Keywords: deep learning, sign language translation, assistive technology

Poster Number: FB-05
Authors: Amin Jourabloo; Xiaoming Liu
Title: Designing Convolutional Neural Networks for Face Alignment and Anti-Spoofing

Abstract: Pose-invariant face alignment is a very challenging problem in computer vision, which is used as a prerequisite for many facial analysis tasks, e.g., face recognition, expression recognition, and 3D face reconstruction. In the poster, I present a face alignment method that aligns a face image with arbitrary pose, by combining the powerful CNN regressors and 3D Morphable Model (3DMM). The core of the method is a novel 3DMM fitting algorithm, where the camera projection matrix and 3D shape parameters are estimated by CNN regressors. Also, I present a face anti-spoofing method based on RGB information. Face anti-spoofing is crucial to prevent face recognition systems from a security breach. We proposed a CNN-RNN architecture which utilizes both spatial and temporal auxiliary supervisions for detecting live/spoof images.

Keywords: face alignment, face anti-spoofing, deep learning

Poster Number: FB-06

Authors: Joseph Salatino; Bronson Gregory; Stefanos Palestis; Arya Kale; Mia Railing; Joseph Beatty; John Seymour; Steven Suhr; Charles Cox; Erin Purcell

Title: Coordinated Changes in Ion Channel and Synaptic Transporter Expression Surrounding Implanted Microelectrode Arrays in the Brain

Abstract: Poor biological integration remains a significant barrier to the longevity and stability of sensors and stimulators implanted in the brain. Recently, we showed that synaptic transporter expression is altered locally to the implanted interface, suggesting that changes in excitatory/inhibitory tone occur surrounding implants over time. Here, we report that shifts in voltage-gated sodium and potassium ion channel expression parallel our previous results, further supporting the hypothesis that changes in local intrinsic excitability accompany chronic devices. Sixteen-channel microelectrode arrays (Neuronexus) were bilaterally implanted in M1 of adult male rats for timepoints spanning 6 weeks. At terminal endpoints, brain tissue was collected and processed for immunohistochemistry, imaged, and analyzed. To mimic in vivo observations, rat cortical neurons were transfected with siRNA against ion channels and harvested after 3 and 7 days for qPCR. Results show a progressive elevation in potassium channel expression coupled with a reduction in sodium channel expression surrounding devices. These changes accompany loss of signal over the observed time course. Our results suggest an initial period of hyperexcitability surrounding devices followed by hypoexcitability at chronic timepoints. Furthermore, we demonstrate that siRNA-knockdown of ion channels in vitro impacts subsequent synaptic transporter expression. Our results show a dependent relationship between ion channel expression and resulting synaptic transporter expression that mimic our observations surrounding devices in vivo. The findings reveal a potential novel mechanism underlying the instability and signal loss which typically occur with chronically implanted recording arrays, as well as a previously-unreported form of plasticity associated with brain implants.

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

Keywords: neuroprostheses, tissue response, brain-machine interfaces, plasticity, microelectrode arrays

Poster Number: FB-07

Authors: Hadi Salehi; Saptarshi Das; Shantanu Chakrabartty; Subir Biswas; Rigoberto Burgueño

Title: Energy-Efficient Data Driven Structural Health Monitoring Strategy Employing a Novel Probabilistic Approach and Machine Learning with Sparse and Missing Self-Powered Sensor Signals

Abstract: This study presents a new methodology for energy-lean structural health monitoring (SHM) using sparse and missing signals provided by a through-substrate ultrasonic self-powered sensor network, which has been demonstrated as an effective means for minimizing energy consumption in wireless sensor networks. Experimental vibration tests were conducted on a cantilever plate to validate the method. The proposed data-driven self-powered-based SHM methodology is based on the integration of pattern recognition (PR), a novel probabilistic approach, and support vector machine (SVM) algorithm. An image-based PR approach is used to represent sensor nodes responses as a pattern, whereas missing signals are reconstructed using a probabilistic approach. Finally, SVM algorithm is used to identify damage and to determine damage classification accuracy from the reconstructed sparse signals. Hyper-parameters for the SVM algorithm were determined through an optimization process. Results demonstrate that the proposed data-driven SHM methodology is efficient in detecting damage with sparse and noisy signals from an energy-aware through-substrate self-powered sensor network in plate-like structures.

This work was supported in part by NSF

Keywords: structural health monitoring, machine learning, support vector machine, missing signals, self-powered sensors

Poster Number: FB-08
Authors: Hao Wang; Honejie Ke; Binbin Huang; Anshul Kendaje; Michael Bassik; Jianrong Wang
Title: Machine Learning Algorithm Development to Decipher Context-Dependent Regulatory Networks in Human Diseases

Abstract: Machine learning is becoming the driving force for efficient and robust discoveries in biomedical research, given the vast amount of functional genomics datasets generated by high-throughput techniques. These heterogeneous panels of genome-wide 'omic' data provide the unique opportunity to systematically annotate the functional roles of specific genomic locations in diverse cellular contexts, differentiation stages and environmental conditions, which is a critical step to decode human disease mechanisms. In the meantime, sophisticated statistical models and machine learning algorithms are needed to address the 'big-data' challenges, such as pervasive correlations across high-dimensional data, non-linear associations, missing values, weak statistical power, biased samples and low signal-to-noise ratios. To address these challenges, we aims to decipher context-dependent gene regulation networks using novel probabilistic graphical models and machine learning inferences. The primary aim is to efficiently predict and characterize combinatorial grammar of gene regulation at different layers. The cutting-edge CRISPR genome-editing signals, along with diverse omics dataset, will be integrated. Based on our computational modeling innovation, we will decode the sophisticated architecture of large-scale networks of gene regulation with an unprecedented resolution, including new predictions of long-range interactions, 3D chromatin structures, hierarchical dependencies among biomedical factors and combinatorial regulatory grammar. Our predictions are extensively supported by biomedical evidence and have stimulated new exciting studies on human diseases and drug discovery. The developed new machine learning algorithms and the large-scale network predictions will provide better mechanistic insights on systems biology, biological networks, 3D chromatin architecture, and disease mechanisms, leading to novel genomics-based therapeutics and precision medicine.

This work was supported in part by NIH NIGMS, NSF BEACON, NSF NRT-IMPACT

Keywords: machine learning, probabilistic model, big data integration, biomedical network construction, systems biology, functional genomics, human diseases, causal inference

ELECTROSYSTEMS

Poster Number: ES-01
Authors: Yangyang Fu; Janez Krek; Peng Zhang; John P. Verboncoeur
Title: Engineered Surface Control of Microdischarge Breakdown Voltage

Abstract: Gas breakdown in atmospheric pressure microgaps with a cathode surface protrusion is highly sensitive to the protrusion geometry. The breakdown voltage is identified when the discharge enters the subnormal region, according to voltage-current curves calculated by a two-dimensional fluid model. The effects of the protrusion size and the aspect ratio on the gap breakdown voltage are examined. It is found that the protrusion size can have a more profound effect on the breakdown voltage than the protrusion's aspect ratio. The breakdown voltage versus the protrusion aspect ratio will show a minimum value if the aspect ratio varies in a wider range. Shrinking the size of cathode protrusion can increase the breakdown voltage faster than enlarging the gap distance in the absence of a protrusion in the same scale. The effect of the aspect ratio of the microgap on the breakdown voltage is also presented.

This work was supported in part by Air Force Office of Scientific Research (AFOSR) Grant No. FA9550-18-1-0062, the DOE Plasma Science Center Grant No. DE-SC0001939, and an MSU Strategic Partnership Grant.

Keywords: gas breakdown, microdischarge, Paschen curve

Poster Number: ES-02
Authors: Asif Iqbal; John P. Verboncoeur; Peng Zhang
Title: Time Dependent Multiparticle Monte Carlo Simulations of Dual Frequency Single Surface Multipactor

Abstract: This work investigates the temporal physics of the dual frequency single surface multipactor by Monte Carlo (MC) simulations [1, 2]. We propose a novel multiparticle MC model for the time dependent study of multipactor. Our study reveals that for a single tone rf electric field acting parallel to the surface, the normal surface field saturates at the lower multipactor susceptibility boundary with a temporal oscillation at twice the rf frequency, agreeing with previous works of Kim and Verboncoeur [3]. The temporal relationship between the fields normal and parallel to the surface traces a closed curve in the ac saturation state. The shape of the curve depends on the amplitude of the rf envelope. For the two-tone case of the rf electric field, the rf envelope and the susceptibility boundaries [4] are modified from those of the single tone case. These modifications result in significant changes of the saturation level and oscillation pattern of the normal electric field for the two-tone case.
[1] R. A. Kishek and Y. Y. Lau, Phys. Rev. Lett. 80, 193, 1998.
[2] L. K. Ang, Y. Y. Lau, R. A. Kishek, and R. M. Gilgenbach, IEEE Trans. Plasma Sci. 26, 290, 1998.
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[4] A. Iqbal, J. Verboncoeur, and P. Zhang, Physics of Plasmas 25, 043501, 2018.

This work was supported in part by AFOSR MURI Grant No. FA9550-18-1-0062, MSU Foundation Strategic Partnership Grant.

Keywords: multipactor, single surface, dual frequency, multiparticle Monte Carlo, time dependent physics

Poster Number: ES-03
Authors: Janez Krek; Yangyang Fu; John P. Verboncoeur
Title: temporal evolution of EEDFs in KGMf using Boltzmann Equation Solver

Abstract: Global (volume-averaged) models are known for their simplicity and high efficiency. They present powerful tools for investigating macroscopic parameters in various plasma discharge systems, using a predefined electron energy distribution function (EEDF). With a reduced spatial complexity, a large number of chemical reactions can be implemented in the model, which provides insight into the importance of the individual reactions and chains. The reduced set of the most influential reactions can be later used in fluid or particle-in-cell (PIC) simulations to reduce their computational expense.
The Kinetic Global Model framework (KGMf) is a simulation tool developed to explore complicated plasma chemistry in multi-species systems. The KGMf is coupled with various Boltzmann equation solvers (BOLOS and MultiBolt) to compute EEDFs self-consistently. This enables the KGMf to capture the temporal evolution of the EEDF, improving fidelity even for dynamic systems, balanced by the cost of computational time.
The reduction of EEDF evaluations is imperative and is implemented based on the dynamics of systems variables, i.e., electron temperature, electron density, and reduced electric field. The dependence of electron density, electron temperature, and reaction rate coefficients on different EEDF evaluation frequencies in high-pressure low-temperature argon discharges is presented and
discussed.

This work was supported in part by Department of Energy Plasma Science Center grant DE-SC0001939

Keywords: plasma discharge, EEDF, global model, Boltzmann solver

Poster Number: ES-04
Authors: Lucas Stanek; Kristian Beckwith; Jeffrey Haack; Michael Murillo
Title: Hybrid Quantum-Hydrodynamics/Kinetics Model for Dense Plasma Mixtures

Abstract: Fusion energy promises nearly unlimited, clean energy; one approach to fusion energy production employs lasers to compress fusion fuel to conditions similar to those in the sun. Unfortunately, in the presence of a wide variety of energy loss mechanisms, obtaining a net gain in energy remains a challenge. The mixing of cooler materials into hot regions can spoil the production of fusion energy. Two ways that cooling occurs is from the mixing of two ion species, or by conduction from the electron species. An existing kinetic model for studying the mixing of ions, is the multi-component BGK (McBGK) equation which describes the ionic heat transfer. One way to add the effects of heat conduction from the electrons is by solving a kinetic equation which is not a computationally tractable approach due to the considerable difference in timescales for the electron and ion species. Instead, hydrodynamic equations of motion for the electron species are derived directly from the McBGK equation and are used to determine how the electrons transfer heat to the ion species. We plan to use our model to aid in the design and interpretation of experiments at Sandia National Laboratories that are being performed on the Z Machine, a large pulsed-power facility.

This work was supported in part by Air Force Office of Supporting Research (AFOSR)

Keywords: kinetic theory, plasma physics, hydrodynamics

Poster Number: ES-05

Authors: Yang Zhou; Peng Zhang

Title: Comparisons of Three-step Model, Fowler-Dubridge Model and a Quantum Mechanical Model for Photoemission from Metal Surfaces

Abstract: Photoemission is one of the fundamental processes to produce charged particles and of significance to many applications [1]. Recently, an analytical model for electron photoemission from metal surface illuminated by a laser field and an applied dc electric field was proposed by solving the time-dependent Schrodinger equation exactly, which shows good agreement with experiments [2,3]. The model includes the effects of dc field and laser electric field (of arbitrary frequency and strength), as well as metal properties (Fermi energy, work function). In this study, we compare this quantum model with existing classical models for photoemission, including the three-step model and Fowler-Dubridge model [4-7]. The validity and limitations of each model will be examined.
The work is supported by the Air Force Office of Scientific Research (AFOSR) YIP Award No. FA9550-18-1-0061.

[1] P. Zhang, and Y. Y. Lau, J. Plasma Phys. 82, 595820505 (2016);
[2] P. Zhang, and Y. Y. Lau, Sci. Rep., 6, 19894 (2016);
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This work was supported in part by Air Force Office of Scientific Research (AFOSR) YIP Award No. FA9550-18-1-0061

Keywords: Photoemission, Three-step model, Fowler-Dubridge model, Quantum model, time dependent Schrodinger equation

Poster Number: ES-06

Authors: Adamantia Chletsou; Ibrahim Kagan Aksoyak; John Papapolymerou; Ahmet Cagri Ulusoy

Title: UHF Rectenna for Implanted and Free Space Communications in Biomedical Applications

Abstract: The design of a UHF rectenna that is able to communicate with an RFID reader at a distance of 50 cm when it is implanted in human muscle phantom, and at a distance of 6 m when in free space, is described. The antenna has a size of 38 mm by 12.7 mm. An experimental prototype of the rectenna was fabricated on a Rogers R3010 substrate that is optimized to operate with a commercial RFID tag IC. The optimal rectenna was tested in a liquid phantom mimicking the properties of muscle. Experi-ments showed successful detection when the designed tag was submerged by 5 cm of liquid phantom at a detection distance of 50 cm.

Keywords: RFID, biomedical applications, implantable antenna, human muscle model

Poster Number: ES-07

Authors: Cristian Herrera; Xenofon Konstantinou; Timothy Grotjohn; John Albrecht; John Papapolymerou; Michael Becker; Aaron Hardy

Title: High-Power, High-Frequency Diamond RF Schottky Barrier Diodes

Abstract: CVD Diamond is one of the most promising semiconductor materials for RF applications, because of its exceptional mechanical, electronic and thermal properties, such as wide band-gap, high breakdown electric field, high mobility and high thermal conductivity. As a material ideal for high-power, high-frequency and fast switching applications. The Schottky potential barrier at a metal-semiconductor interface is good for fast switching and it has a low voltage drop in the forward biased regime of a Schottky Barrier Diode (SBD). SBDs are fast because the dynamic response of the switching operation is dominated by the extraction and injection of the majority carrier into the depletion region of the Schottky/diamond junction and no minority carrier recombination is involved.
In this work, Schottky Barrier Diodes were fabricated on layered lightly/highly boron doped (p-/p+ respectively) epilayers on High-Pressure, High-Temperature (HPHT) diamond substrates. High-quality diamond epitaxial layers were grown at MSU by Microwave Plasma-Assisted Chemical Vapor Deposition (MPACVD) using 2.45 GHz microwave resonant cavity systems. The implementation of gold co-planar waveguide (CPW) transmission lines with the SBDs and Thru-Reflect-Line (TRL) structures were achieved using a pulsed-DC electroplating method. The capacitance-voltage, the S-parameters and high-power measurements of the SBDs are presented.

This work was supported in part by Defense Advanced Research Projects Agency (DARPA)

Keywords: diamond, power electronics, Schottky diodes, CVD.

Poster Number: ES-08
Authors: Yuxiao He; Eric Drew; Z. John. Zhang; Timothy Hogan; John Papapolymerou
Title: Compact BandStop Filter Utilizing Low Cost Solution Cast Nanomagnetic Thin Films

Abstract: A compact integrated microstrip bandstop filter(BSF) with low cost magnetic nanoparticle thin film loaded in the air substrate has been designed, fabricated and characterized. First, an optimized microstrip BSF patterned on a thin Liquid Crystal Polymer (LCP) was mounted on a partially 3D printed air substrate through a lego-like process to have the rejection of 41 dB at 8.5 GHz. To achieve the compactness, various magnetic nanoparticles were deposited within the air substrate to have the magnetic film thickness of 30 um and 100 um, which gave the self-resonances of the BSFs from 7.6 GHz to 8.3 GHz. The filter can also operate at higher center frequency with a rejection over 30 dB by applying an external DC magnetic bias of 2500 Oe that is normal to the filter. Detailed comparison of the filter performance in terms of types of magnetic materials, film thicknesses and magnetic bias strength was provided. This work demonstrated a low cost and compact BSF utilizing the magnetic nanoparticle film which could find many applications in the RF and microwave circuits and devices.

This work was supported in part by National Science Foundation

Keywords: bandstop filters, magnetic thin films, microstrip filters

Poster Number: ES-09
Authors: Hongyang Shi; Mohammed Al-Rubaiai; Christopher M. Holbrook; Jinshui Miao; Thassyo Pinto; Chuan Wang; Xiaobo Tan
Title: Screen-Printed Soft Capacitive Sensors for Spatial Mapping of Both Positive and Negative Pressures

Abstract: Soft pressure sensors are one class of the essential devices for robotics and wearable device applications. Despite the tremendous progress, sensors that can reliably detect both positive and negative pressures have not yet been demonstrated. In this work, we report a soft capacitive pressure sensor made using a convenient and low-cost screen-printing process that can reliably detect both positive and negative pressures from -60 kPa to 20 kPa. The sensor is made with an Ecoflex 0030 dielectric layer, conductive and stretchable poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (PEDOT:PSS) (with ionic additives) electrodes and polydimethylsiloxane (PDMS) encapsulation layers. Air gaps are designed and incorporated into the dielectric layer to significantly enhance the sample deformation and pressure response especially to negative pressure. The sensor exhibits repeatable response for thousands of cycles, even under bending or stretching conditions. Lastly, to demonstrate the practical application, a 12x12-pixel sensor array that can automatically measure both positive and negative pressure distributions has been reported.

This work was supported in part by Great Lakes Fishery Commission (2018-Tan-54069), the Office of Naval Research (Grant N000141512246) and an MSU Strategic Partnership Grant (16-SPG-Full-3236)

Keywords: soft capacitive pressure sensor, negative pressure, air gap, printed electronics, PEDOT:PSS

Poster Number: ES-10
Authors: Michael Craton; John Albrecht; Premjeet Chahal; John Papapolymerou
Title: A Chip-First Approach to Millimeter- Wave Circuit Packaging

Abstract: In this poster, we demonstrate a fully additively manufactured packaging solution for the integration of millimeter-wave (mm-wave) devices. This technique employs a chip-first approach to packaging, where die and other components are positioned and a package and interconnects are subsequently built up. This work allows for the dense populations of components even when they do not share a common vertical height. To demonstrate this concept, we present the fabrication and measurement of two packaged 0-dB attenuators to characterize the performance of the interconnect strategy. These interconnects achieve a worst case loss of 0.290 dB at 40 GHz. Beyond the rated operating range of the device, which is from dc to 43.5 GHz, the interconnects achieve a worst case loss of 0.490 dB at 60 GHz. The approach that we present provides a flexible mm-wave capable and broadband packaging solution that enables the next- generation system-in-package technology. This work demonstrates performance that is not possible with conventional packaging techniques.

This work was supported in part by Honeywell

Keywords: additive manufacturing, aerosol jet printing, millimeter wave interconnect, system-in-package

Poster Number: ES-11
Authors: Deepak Kumar; Saikat Mondal; Saranraj Karuppuswami; Yiming Deng; Premjeet Chahal
Title: Harmonic RFID Communication using Conventional UHF System

Abstract: A harmonic RFID (hRFID) system is proposed to overcome the challenges that limits the capabilities of the conventional UHF RFID system such as self-jamming and multi-path interference without any extensive modifications to the existing infrastructure. The proposed system exploits the third harmonic generation from the existing RFID chips for communication. The system is realized by designing an additional RF interface layer between the conventional RFID interrogator and the RFID tag. The interface layer transmits the query signal at the fundamental frequency and receives the backscattered harmonic signal from the RFID tag. It down converts the backscattered third harmonic signal to the fundamental frequency, and feeds it back to the conventional UHF interrogator for extracting the information. A dual band antenna design is also shown for improving the radiation efficiency of hRFID tags using the conventional RFID ICs with improved signal to noise ratio (SNR) and increased read range. A path is shown for improving the hRFID system by performing a study that relates the read range, RFID IC's sensitivity, and the noise level with efficiency. The proposed system can be easily adapted to any of the current RFID applications.

Keywords: backscattering, conventional UHF RFID, hRFID, harmonics, Internet of Things (IoT), self-jamming cancellation

Poster Number: ES-12
Authors: Yi Luo; Peng Zhang
Title: An Analytical Model for Ultrafast Electron Emission Due to Two-Color Laser Fields

Abstract: Laser-driven electron emission from solids offers a method of coherently controlling electron motion in ultrashort spatiotemporal scales. It is important to the development of ultrafast electron microscopes, free electron lasers, and novel quantum nanocircuits. Recently, two-color laser pulses have been used to produce electron emission from a metal nanotip experimentally, showing a new way to control the emitted electron dynamics and distribution due to the interference effect [1]. We present an analytical model for ultrafast electron emission from a metal-vacuum interface due to two-color laser fields, by solving the time-dependent Schrödinger equation exactly [2,3]. Our exact solution is valid for arbitrary fundamental and harmonic laser frequencies, laser intensities, phase delays, metal work function and Fermi level. Different electron emission mechanisms such as multiphoton absorption, photon-induced over-barrier emission, and strong optical field emission are revealed in a single formulation. We found two-color laser fields can strongly modulate the emission current up to 99%. Using the same input parameters, our theoretical prediction for the photoemission current modulation depth (93.9%) is almost the same as the experimental result (94%) [3].
[1] M. Förster et al., Phys. Rev. Lett. 117, 217601 (2016).
[2] P. Zhang and Y. Y. Lau, Sci. Rep. 6, 19894 (2016).
[3] Y. Luo, and P. Zhang, Phys. Rev. B, 98, 165442 (2018).

This work was supported in part by AFOSR YIP Award No. FA9550-18-1-0061.

Keywords: Ultrafast photoemission, analytical model, time-dependent Schrödinger equation, electron energy spectra, current modulation depth

Poster Number: ES-13
Authors: Serge Mghabghcab; Jeffrey A. Nanzer
Title: Open-Loop Coherent Distributed Arrays with Widely Separated Nodes

Abstract: With the continuous need to improve wireless remote sensing and communications, wireless systems are moving towards distributed subsystems that act coherently for equivalent or better performance than individual systems can provide. Generally, the goal is to wirelessly coordinate collections of wireless systems such that they operate as distributed phased arrays. With such coherent distributed antenna arrays, the capability of wireless systems is directly scalable in that additional nodes can be added to the array with little cost, yielding increased sensitivity or greater information throughput. Open-loop coherent distributed arrays, which are distributed systems of nodes that coherently coordinate without external signal inputs from the destination, are capable of ensuring appropriate beamsteering with proper node-to-node coordination. Enabling coherent operation between separate mobile nodes at microwave frequencies requires accurate knowledge of the relative positions, proper frequency locking, and phase alignment of the nodes in the array. Approaches for achieving coherent open-loop distributed array using widely separated nodes is presented. High accuracy ranging, frequency locking, and phase alignment between nodes are achieved by the transmission of one well-designed waveform.

Keywords: coherent distributed arrays, distributed transmit beamforming, frequency locking, phase alignment, accurate ranging

Poster Number: ES-14
Authors: Anton Schlegel; Serge Mghabghab; Jeffrey Nanzer
Title: Crosstalk-Based Calibration for High Accuracy Ranging Using Software-Defined Radios

Abstract: Software Defined Radios (SDRs) are flexible hardware platforms that can transmit and receive user defined microwave signals. Since the SDRs have the capability of transmitting and receiving signals, they can be used as ranging radars. High accuracy range measurements are sensitive to systematic delays caused by the internal hardware. A calibration procedure for SDRs is designed to characterize the hardware delays. The procedure uses the crosstalk between the transmitter and and receiver. The crosstalk contains an attenuated and distorted version of the transmitted waveform. The received crosstalk is matched filtered with the transmitted signal to increase the processing gain which helps in estimating the delays caused by the internal systems. The delay that is calculated should remain constant throughout transmission so the calibration setup only needs to be run at startup. Proper customization of the waveform produces a more accurate delay estimation of the internal SDR hardware.

Keywords: crosstalk, software-defined radio, radar

Poster Number: ES-15
Authors: Stavros Vakalis; Jeffrey A. Nanzer
Title: Microwave Imaging Using Noise Signals

Abstract: Imaging systems in the microwave and millimeter-wave regions of the electromagnetic spectrum have gained significant interest in recent years for a wide range of applications, including contraband detection, security imaging, and medical imaging, among others. The problem with most current microwave imaging systems is that they either require electrical or mechanical scanning beams, or high computational loads. In this work, we illuminate the scene using independent noise transmitters, in an attempt to mimic the properties of thermal radiation, and alleviate the high sensitivity requirements and high cost of passive millimeter-wave imagers. Experimental results using a sparse antenna array with reduced elements are included to show the feasibility of the method proposed.

This work was supported in part by National Science Foundation Grant 1708820.

Keywords: microwave imaging, millimeter-wave imaging, noise radar, radar imaging.

Poster Number: ES-16
Authors: Saleh Almasabi; Atri Bera; Joydeep Mitra
Title: Dynamic State Estimation Aided By Machine Learning

Abstract: The control of power systems can be enhanced through wide area monitoring, where measurements from devices such as phasor measurement units are utilized to enhance the system awareness. These measurements can be utilized for dynamic state estimation, where the rotor angle and speed of the synchronous machine are estimated. %Estimating the dynamic states of power system has become feasible with the advancements of phasor measurements units (PMUs). This paper proposes a new scheme which utilizes the unscented Kalman filter (UKF) along with machine learning for dynamic state estimation. The machine learning algorithms are used as a support system for enhancing the robustness and quality of the UKF and the overall estimates. The new scheme is tested on the Western System Coordinating Council 3-machine 9-bus test system under different operating conditions.

Keywords: dynamic state estimation, machine learning, unscented Kalman filter.

Poster Number: ES-17
Authors: Sneha Banerjee; John Luginsland; Peng Zhang
Title: Two Dimensional Tunneling Resistance Transmission Line Model for Parallel Carbon Nanotube Contacts

Abstract: Contact resistance and current transport through the contacts between individual carbon nanotubes (CNTs) are important, as CNT fibers contain a very large number of such junctions and contacts; and on a macroscopic level, their electrical conductivity is not well understood. In this study, we used lumped circuit transmission line model (TLM) to get a self-consistent analysis of contact resistivity, current and voltage distribution across parallel contacts formed between two closely spaced CNTs or CNT and other metals. Electric tunneling effect between similar/dissimilar contacting members separated by a thin insulating gap was included [1, 2]. The properties of CNT contacts are examined in detail for various input parameters (i.e. input voltage, material work function, resistivity, and dimension of the contact) [3]. The results give insights on the macroscopic contact resistivity and current distribution across such contacts. Our model is also applicable to contacts formed from other novel two-dimensional materials (boron nitride, molybdenum sulfide, black phosphorus, etc.) as well as new nano-composites.
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This work was supported in part by AFOSR YIP Award No. FA9550-18-1-0061.

Keywords: tunneling, contact resistance, transmission line model, carbon nanotubes

Poster Number: ES-18
Authors: Yousef Gtat; Sina Parsnejad; Sidney Schrand; Heather L. Taylor; Andrew J. Mason
Title: Absolute Detection Threshold of Vibrotactile Stimulation Pulse Width and Inter-Pulse Gap

Abstract: Vibrotactile stimulation is often used in sensory substitution systems and brain-machine interfaces for presenting information to the skin. This work identifies the temporal resolution required to achieve the absolute detection threshold of vibrotactile stimulation. A custom vibrotactile sleeve was designed to conduct two experiments with multiple trials on seven subjects. The results show that the absolute (50%) detection threshold for a single vibrotactile stimulus is 15ms pulse width with a proposed adequate (90%) detection threshold of at least 25ms pulse width for the average user. Furthermore, the absolute detection threshold for an inter-pulse gap between two vibrotactile stimuli is 15ms, with a proposed adequate detection threshold of at least 20ms inter-pulse gap. This work concludes that a single vibrotactile message should have a temporal resolution of at least 25ms pulse width in addition to 20ms inter-pulse gap. Hence, a single vibrotactile message requires a total of 45ms.

This work was supported in part by Partially by NIH

Keywords: vibrotactile, tactile, stimulation, human machine interfaces, HMI

Poster Number: ES-19
Authors: Zizhuo Huang; Peng Zhang
Title: Two-Surface Multipactor Susceptibility Based on Monte Carlo Simulation

Abstract: Multipactor is a nonlinear phenomenon in which an electron avalanche driven by a high frequency rf field sustains itself by an exponential charge growth through secondary electron emission from a metallic or dielectric surface. It is harmful to satellite communications and microwave systems. Here, Monte Carlo simulation is applied to study the susceptibility of multipactor in a gap between two parallel metallic electrodes. For a given fD (f is the frequency of the microwave field, D is the gap distance between the two plates), the average secondary electron yield is tested by scanning the magnitude of the input microwave voltage V, to generate the multipactor susceptibility in the V-fD plane. The electron trajectories between the plates are simulated with random emission velocity and angle, based on Vaughan’s model [1]. The results are compared with analytical theory [2]. Effects of space charge will also be studied.
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This work was supported in part by AFOSR MURI Grant No. FA9550-18-1-0062

Keywords: multipactor, secondary electron yield (SEY), susceptibility diagram, Monte Carlo simulation

Poster Number: ES-20
Authors: William Jensen; Shanelle Foster
Title: Robust Prognosis for Stator Insulation in Inverter-Driven Electric Machines

Abstract: One of the most common failures experienced by electric machines is caused by degraded stator insulation. Methods to detect insulation degradation are available; however, a prognosis avoids unexpected failures and allows a machine to remain in operation up to the point of failure. A technique to provide a prognosis online for an inverter-driven machine without using additional sensors is available. This technique, however, has issues to be improved upon. One assumption in this technique is constant voltage application from the switching devices. Switching devices such as power MOSFETs or Silicon-Carbide MOSFETs experience degradation in the gate oxide which modifies the voltage application. A variable voltage application from the device will mask any insulation degradation. Another issue with this prognosis technique being the Extended Kalman Filter (EKF), while able to provide and accurate remaining useful life estimate for stator insulation, is sensitive to the estimated initial values of the state variables and does not adapt well to changing rates of degradation. In practice the exact rate of degradation is unknown and can change; therefore, it is important for the RUL estimation technique to be adaptable. In this work, a more robust insulation failure prognosis technique is presented. This technique distinguishes between degradation effects from the switching device and insulation and a particle filter (PF) is applied for RUL estimation of stator insulation.

Keywords: Electric machines, insulation degradation, prognosis, particle filter

Poster Number: ES-21
Authors: William Stevers; Edward J. Rothwell
Title: Consumer Software-defined Radios for Pre-compliance Testing

Abstract: Electromagnetic Compatibility (EMC) is the study of how electronic products interact with their local radio frequency (RF) environment. Every electronic product is subjected to EMC testing to ensure that they meet regulatory standards. One such test is for radiated emissions, or RF signals created by the product being tested. Official EMC tests are always required but are very expensive and time consuming. Product designers therefore employ pre-compliance tests to understand if their product is likely to pass or fail an official test. Unfortunately, traditional pre-compliance testing requires expensive equipment such as a spectrum analyzer and EMC antennas. A software-defined radio (SDR) is a piece of RF equipment that allows for the sampling and generation of RF signals from a personal computer. Commercial SDRs have many features but are excessive when compared to a spectrum analyzer. Consumer SDRs are available and make use of limited RF hardware to maintain the ability to sample RF signals while keeping cost much lower than their commercial counterparts. Presented here is a method to use a low-cost consumer software-defined radio with commonly available very-high frequency (VHF) and ultra-high frequency (UHF) antennas in place of standard pre-compliance equipment. The performance of a specific consumer SDR with absolute power measurement capabilities is shown. The ability to use commonly available VHF and UHF antennas with the SDR for accurate radiated emission measurements in the 30 to 1000 MHz band is described.

This work was supported in part by Dennis P. Nyquist Endowed Professorship

Keywords: EMC, SDR, test equipment

Poster Number: ES-22
Authors: De-Qi Wen; Peng Zhang; Yang-Yang Fu; Janez Krek; John P Verboncoeur
Title: Effect of Obliquely Incident Linearly Polarized Electric Field on Multipactor Discharges

Abstract: Single-surface multipactor discharges negatively affect the electromagnetic wave transmission in high power microwave devices. Particle-in-cell simulation shows that multipactor discharges decay by adjusting the angle, theta, between the poynting vector and the dielectric surface normal. In case theta=0, the time-dependent electron number has two same oscillations over one rf period. One of them decreases in magnitude at theta=0.05pi and disappears at theta=0.15pi, due to that the perpendicular component of the rf electric field reinforces and reduces the restoring field, and decreases the oscillation of the electron impact energy in half rf period. In addition, the electrons are forced into a few branches in the space of velocity and position. Finally, multipactor suppression is investigated by developing a simple dynamic model, in which the susceptibility diagram is obtained and shows the upper and lower boundaries get close, implying no multipactor develop at larger theta.

This work was supported in part by Air Force Office of Scientific Research (AFOSR) MURI Grant 9550-18-1-0062

Keywords: multipactor, particle-in-cell simulation, suppression

Poster Number: ES-23
Authors: Esraa Al-sharoa; Mahmood Al-khassaweneh; Selin Aviyente
Title: Detecting and Tracking Community Structure in Temporal Networks: A Low-Rank + Sparse Estimation Based Evolutionary Clustering Approach

Abstract: Networks provide a powerful tool to model complex systems where the different entities in the system are presented by nodes and their interactions by edges. With the availability of network-type data, different community detection algorithms have been proposed to investigate the organization of the nodes within these networks. In particular, numerous graph-based community detection algorithms have been developed for static networks. However, most real complex systems vary with time. Consequently, it is important to develop graph-based community detection techniques for temporal networks. In this poster, a new low-rank + sparse estimation based evolutionary spectral clustering approach is proposed to detect and track the community structure in temporal networks. The proposed method decomposes the network into low-rank and sparse parts and obtains smooth cluster assignments by minimizing the subspace distance between consecutive time points. The extracted low-rank adjacency matrix is then used for clustering and the subspaces are defined through spectral embedding. The introduced framework is robust to noise and outliers and can detect the community structure in both binary and weighted temporal networks efficiently without making any prior assumptions about the network structure.
The proposed approach is evaluated on several weighted and binary simulated and real temporal networks. The results show that the proposed algorithm can detect and track the correct community structure over time efficiently and outperforms state-of-the-art algorithms.

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

Keywords: community detection, temporal networks, evolutionary clustering, spectral clustering, low-rank + sparse decomposition.

Poster Number: ES-24
Authors: Sylmarie Davila-Montero; Yousef Gtat; Sina Parsnejad; Andrew J. Mason
Title: Non-Visual Machine Recognition of Human Emotions

Abstract: Understanding the basis of human emotions, how it affects the human body, and how to design effective emotion recognition systems is of interest to advance depression therapy, social interactions, and work-place productivity. Emotion is a mental state that is triggered by conscious and unconscious perception of the surrounding environment. In fact, it has been shown that there is an interrelationship between the brain and physiological processes such as muscle movement, voice modulation, and heart rate variability, among others. Prior work have been done in the processing of speech signals to recognize emotions, but little have been done in studying the integration of physiological signals to the analysis of speech emotion recognition in real time. This presented work focuses on combining speech with physiological signals to improve real-time emotion prediction algorithms. Effective emotion recognition algorithms enable the creation of systems capable of providing real-time feedback to the user, thus helping an individual be more aware of their emotions and even provide means to manage human emotions in real time.

This work was supported in part by GRFP-NSF award number DGE-1424871

Keywords: emotion recognition, speech signals, physiological signals, real-time prediction

Poster Number: ES-25
Authors: Tamanna Tabassum Khan Munia; Selin Aviyente
Title: Time Frequency Based Phase-Amplitude Coupling Measure For Neuronal Oscillations

Abstract: Oscillatory activity in the brain has been linked to a range of cognitive functions including decision making, feedback processing, and working memory. Electroencephalography (EEG), which has a high temporal resolution, offers a way to examine the time course of neuronal activity, including oscillation power and coupling. Various forms of neural synchrony across frequency bands
have been proposed as the fundamental mechanism for neural binding. Recently, a considerable amount of attention has been given to phase amplitude coupling (PAC)– a form of cross-frequency coupling where the amplitude of a high frequency signal is modulated by the phase of low frequency oscillations. The existing methods for assessing PAC have some limitations including low frequency resolution and sensitivity to noise, data length and sampling rate due to the inherent dependence on bandpass filtering. In this paper, we propose a new time-frequency based PAC (t-f PAC) measure that can address these issues.
The proposed measure is based on a complex time-frequency distribution, Reduced Interference Distribution (RID)-Rihaczek distribution, to estimate both the phase and the envelope of low and high frequency components, respectively. As such, it does not require any bandpass filtering and possesses some of the desirable properties of time-frequency distributions such as high frequency resolution. The proposed technique is first evaluated on synthesized data and is then applied on an EEG speeded reaction task dataset. The results indicate that the proposed time-frequency based PAC is more robust to varying signal parameters and provides a more accurate measure of coupling strength.

Keywords: phase-amplitude coupling, time-frequency distribution, MVL, synthesized data, EEG

Poster Number: ES-26
Authors: Atri Bera; Yuting Tian; Saleh Almasabi; Joydeep Mitra; Carmen Borges
Title: Modeling of Battery Energy Storage Systems for System Reliability Studies

Abstract: Battery energy storage systems (BESS) are increasingly being used in recent times due to the changing nature of the modern electric grid. In this paper, the utility of a BESS has been investigated for reliability improvement of the system, while performing energy arbitrage. Maximization of revenue from the energy market has been prioritized while performing energy arbitrage. A multi-state model has been developed by tracking the state of charge (SOC) of the BESS. For generation adequacy assessment, the BESS states have been modeled both as generators and loads, since besides providing power to the grid while discharging, it also draws power from the grid while charging. The classification
has been done depending on the SOC of the device for a particular hour. The reliability improvement has been shown in terms of the various reliability indices obtained by construction of the generation reserve model. The IEEE Reliability Test System has been used to demonstrate the validity of the proposed model.
The results show significant reliability improvement of the system in presence of the BESS.

Keywords: battery energy storage systems, energy market, generation adequacy, multi-state modeling, reliability

MATERIALS AND MANUFACTURING

Poster Number: MM-01
Authors: Kirti Bhardwaj; Greg M. Swain
Title: Electrochemical Double Layer at the Interface of Nanostructured Carbon Electrodes and Ionic liquids

Abstract: Ionic liquids (ILs) are a unique class of electrolytes made up solely of cations and anions with no solvent. Their environmentally-benign characteristics (non-toxicity, no vapor pressure, low inflammability) along with excellent electrochemical stability make them a potential replacement of aqueous and organic electrolytes in energy storage technologies (e.g., supercapacitors, batteries, solar cells etc.). When an electrolyte contacts an electrode, they form a few nm thick 'double-layer' at the interface, whose structure governs the electrochemical reactions. Determining the structure and dynamics of these interfacial reorganization of ions in response to applied voltage bias is key to engineer IL-based devices. Addressing this challenge seeks a comprehensive understanding of how electrode properties (e.g., its bulk electrical properties, microstructure, surface functional groups) and the type and structure of electrolyte affect the interfacial organization.
We use electrochemical techniques (voltammetry and electrochemical impedance spectroscopy (EIS)) to study interfacial capacitance-potential trends for ILs of different structures in contact with carbon electrodes- glassy carbon (sp2), boron-doped nanocrystalline diamond (sp3), nitrogen-incorporated tetrahedral amorphous carbon(sp2/sp3). The morphology, microstructure and surface chemistry of electrodes is characterized using atomic force microscopy, Raman spectroscopy and X-ray photoelectron spectroscopy. RF-assisted surface modifications of electrodes reveal surface wettability trends. Frequency dependent electric response is studied by the use of extensions of EIS in the permittivity response. Many of the distinguishing features of such systems are someway associated with the slow decay of the Coulomb potential and the infinite range of the bare electrostatic interactions which leads to Debye screening and charge ordering effects.

This work was supported in part by Army Research Office

Keywords: electrochemical engineering, energy storage devices, interfaces, thin film electrodes

Poster Number: MM-02
Authors: Kanchan Chavan; Scott Calabrese Barton
Title: Molecular Dynamics Study of Intermediate Transport in Nano-Scaled Confinement

Abstract: Integrated multi-step reaction cascades can potentially increase the efficiency of energy storage/conversion devices such as biofuel cells.[1] Beyond catalytic activity, efficient intermediate transport between the catalytic sites is a vital process in such cascades. Molecular tunneling[2] is one mechanism that exists in natural reaction cascades to transport intermediates between active sites, preventing intermediate diffusion into the bulk. In this work, intermediate transport between two active sites confined by carbon nanotubes is studied, inspired by natural multi-step reaction cascades. Molecular dynamics simulations were performed for intermediates (oxalate, ethanol) inside a single walled carbon nanotube (SWCNT) with diameter of 1 nm to 4 nm. Due to the presence of solid-like water structures inside the smaller SWCNTs, the intermediate shows lower diffusivity than in the bulk.[3] We modified SWCNT's terminals with negatively-charged molecules that retain negatively-charged intermediates inside the SWCNT due to electrostatic repulsion, resulting in higher intermediate retention time. Smaller diameter with higher retention time can decrease diffusion rate of intermediate and increase the yield of multi-step reaction cascade.[4] References:
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Keywords: molecular dynamics, multi-step reaction cascade, molecular tunneling

Poster Number: MM-03
Authors: Manali Dhawan; Scott Calabrese Barton
Title: Electrocatalytic Hydrogenation of Furfural to Value Added Chemicals Using Low Cost Carbon-Supported Metal Catalysts

Abstract: There has been an increased interest in the production of fuels and chemicals from renewable resources like biomass, as the depletion of fossil resources continue [1]. The electrocatalytic conversion of biomass-derived platform chemicals into value added fuels and chemicals can be done using hydrogenation and oxidation processes. Furfural is one such chemical that can be converted to furfural alcohol and methyl furan by hydrogenation [2] and to furoic acid by oxidation [3]. This work focusses on the use of high surface area and low cost carbon-supported Cu and Ni metal catalysts for the selective electrocatalytic hydrogenation of furfural to produce furfural alcohol and 2-methylfuran.
The preliminary tests for screening the activity of the metals were performed on a rotating disk electrode using metal-nitrogen-carbon catalysts and cyclic voltammetry data was used to analyze their performance. In order to enhance the surface area to volume ratio and consequently their performance, the metals were supported on activated carbon in molecular and nanoparticle form, and their activity was screened on the basis of conversion and selectivity towards the desired products. The synthesized catalysts were characterized using BET surface area and pore volume measurements to determine the surface area, pore size and volume distributions.

Keywords: electrocatalysis, biomass, electrochemical hydrogenation, furfural

Poster Number: MM-04
Authors: Alex Mirabal; Scott Calabrese Barton
Title: Quantitative Analysis of Nanoscale Interfaces Using Atomic Force Microscopy – Scanning Electrochemical Microscopy (AFM-SECM)

Abstract: Experimental investigation of multi-step, multi-site reactions in nature to understand the source of efficiency is difficult due to the scale (~10 nm) of the site proximity and transport mechanisms [1]. Characterization of the nanoscale chemical phenomena often relies on the correlation of ex-situ analysis with in-situ bulk responses, often correlated with modeling [2]. However, in-situ local phenomena can be useful in the understanding and guiding the design of nanoscale features. One such technique that allows for in-situ measurements, SECM, can be used to map electrochemical responses over an interface [3]. A technique to find, and track, the surface is to use an AFM probe as an electrochemical probe, so called AFM-SECM [4].
Quantitative analysis of nanoscale interfaces requires an accurate representation of the tip electrochemical response. Mapping of the response as the tip changes position allows for qualitative and quantitative comparisons across positions. Common techniques include 2D mapping of the electrochemical responses and approach curves, in which the electrochemical response is tested as a function of tip-surface separation. The effect of tip shape and tip and surface kinetics on the tip response have been individually reported [3,5-6].
The use of analytically derived equations as well as a finite element model have been used to examine the combined effect of tip shape and surface kinetics. Additionally, the effect of the electrochemical tip on the local environment was diagnosed through the finite element model. This can be used to deconvolute SECM responses for small features and their local effects. Experimental study of a gold interface electrode shows strong correlation with modeling results, indicating a proper description of positive and negative feedback.
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This work was supported in part by Army MURI

Keywords: electrochemistry, finite element, catalysis, transport, mapping

Poster Number: MM-05
Authors: Schneider Mitchell ; Shao Jiahang; Chen Gongxiaohui ; Nikhar Tanvi; Baryshev Sergey
Title: Benchmarking of Planar (N)UNCD Field Emission Cathode: Charge, Breakdown and Spatiotemporal Characteristics

Abstract: Nitrogen-incorporated UNCD ((N)UNCD) with high electron doping was investigated recently as an efficient electron field emission source due to its high potential advantages for industrial, medical and scientific applications [1-3]. Some specific applications include THz radiation and medical isotope production, and time-resolved electron microscopy. (N)UNCD can be grown on bulk metal substrates and directly incorporated into normal conducting or superconducting electron radiofrequency injector and has both high charge and low emittance (i.e. high spatial emission coherence) [2, 4]. Due to limited amount of experimental database, we still know little about emission stability and intrinsic (N)UNCD stability under extremely high electric fields when UNCD is operated inside a MW RF injector over extended periods of time.
At the Argonne Cathode Test-stand (the Argonne National Lab), a systematic benchmarking of a planar (N)UNCD FE cathode (18 mm in diameter) was performed in an L-band 1.3 GHz single-cell RF gun, with the cathode gradient conditioned from 5 MV/m to 40 MV/m. Our study revealed high charge of ~20 nC during 2 μs emission period. Emission was stable demonstrating only ~3% charge decrease after ~30,000 pulses. Using an in-situ FE imaging system, it was also revealed that emission comes from isolated emitters that are uniformly distributed across the cathode surface. Field emission properties, including the current, the field enhancement factor, and the maximum microscopic gradient, have been studied and recorded systematically during conditioning in strong fields. The full set of results will be presented at the Symposium.

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Keywords: accelerator,field emission, diamond

Poster Number: MM-06
Authors: Mohammed Al-Rubaiai; Ryohei Tsuruta; Umesh Gandhi; Chuan Wang; Xiaobo Tan

Title: 3D-Printed Stretchable Strain Sensor with Application to Wind Sensing

Abstract: Stretchable strain sensors with large strain range, high sensitivity, and excellent reliability are of great interest for applications in soft robotics, wearable devices, and structure-monitoring systems. Unlike conventional template lithography-based approaches, 3D-printing can be used to fabricate complex devices in a simple and cost-effective manner. We report 3D-printed stretchable strain sensors that embed a flexible conductive composite material in a hyper–plastic substrate. Three commercially available conductive filaments are explored, among which the conductive thermoplastic polyurethane (ETPU) shows the highest sensitivity (gauge factor of 5), with a working strain range of 0% – 20%. The ETPU strain sensor exhibits an interesting behavior where the conductivity increases with the strain. In addition, an experiment for measuring the wind speed is conducted inside a wind tunnel, where the ETPU sensor shows sensitivity to the wind speed beyond 5.6 m/s.

This work was supported in part by Office of Naval Research (Grant N000141512246) and Toyota Motor Engineering & Manufacturing, North America.

Keywords: 3d-printed sensor, conductive filaments

Poster Number: MM-07
Authors: Hoa Nguyen; Luca Milloco; Haseung Chung; Patrick Kwon
Title: Development of Innovative, High speed and Large-scale Metal Additive Manufacturing Process Utilizing Digital Light Projection

Abstract: Metal additive manufacturing (AM) processes have been developed for the past 30 years and while tremendous efforts have been made to optimize these processes, they remain to be extremely complex and small scaled with a low production rate. In order to resolve the aforementioned disadvantages of AM in general, and metal AM in particular, a large scale, high speed, and more accessible AM system for fabricating metal parts, utilizing stereolithography (SLA) principle is being developed. This system integrates a digital light projection engine which allows printing on a large surface area with relatively fast speed, while maintains a high resolution and fine details. The material used is an ultraviolet curable mixture of the metal powder and traditional resin for SLA process. The composition of this mixture will be optimized based on manufacturing needs and capability of the system. A single bed material delivery system is utilized for the deposition of the mixture onto the build platform in a layer by layer manner to a micron level of accuracy. Preliminary experiments have been performed on the initial prototype of the system and yielded very promising results with excellent part density and resolution. The design of the system and the characterization of materials that can be adapted are being studied to construct a fully functional system for a high speed and large-scale fabrication of complex and practical metal components.

Keywords: additive manufacturing, metal 3d printing, stereo-lithography, digital light projection

Poster Number: MM-08
Authors: Rajendra Prasath Palanisamy; Suhail Hyder Vattathurvalapil; Oleksii Karpenko; Yiming Deng; Mahmoodul Haq
Title: Process Monitoring of Induction-based Adhesively Bonded Lap-Joints

Abstract: Adhesively bonded joints are an excellent replacement of traditional mechanical joints in the automobile industry. In comparison to mechanical joints, adhesively bonded joints are lightweight and cost-effective in fabrication. Induction-based bonding is gaining popularity as they are relatively quicker than conventional oven techniques. However, the temperature distribution, phase change, and cure time are not as straightforward as conventional oven prepared joints. Thus, it is necessary to understand these parameters in an induction based heating method to produce better joints. In this research work, stress waves are transmitted between adherents that pass through the adhesive interface. The changes in transmission coefficient and Time of Flight (TOF) of guided waves (GW) helps in understanding joint conditions properties such as adhesive phase transition and time of cure during fabrication. A qualitative analysis is reported in this paper to prove the application of guided waves in process monitoring.

This work was supported in part by Professor's startup funds and American Chemistry Council (ACC)

Keywords: lap-joints, guided waves, reversible adhesive, induction heating.

Poster Number: MM-09
Authors: Bibek Poudel, Haseung Chung
Title: Experimental and Numerical Study Of Magnetic-Field Assisted Finishing Using Nano-scale Solid Lubricant and Abrasive Particles

Abstract: Magnetic-Field Assisted Finishing (MAF) is the magnetic-field controlled surface-finishing technique, which uses the flexible abrasive brush to polish the exposed workpiece surfaces. As MAF can be used for the hard materials even with complex geometries, it has been gaining a lot of attentions in many industrial applications. In this article, we have demonstrated how the nano-scale solid lubricant and intensity of magnetic field affect the MAF process by comparing the surface roughness value of finished work surfaces. Also, we have tried a novel approach to understand the exact phenomenon of the material flow and cutting phenomenon during the MAF. A 3D computational model for MAF process to track the flow of the iron and cubic Boron Nitride (cBN) particles that act on the workpiece during the process has been developed. The model is created based on the exact composition that has been used in the experiment. Finally, the validation of simulation model developed here using experimental results is planned in the future.

This work was supported in part by LG Electronics

Keywords: magnetic-field assisted finishing, abrasive particles, nano-scale solid lubricant, computational model, surface roughness

Poster Number: MM-10
Authors: Yaozhong Zhang; Lucrezia Poli; Aljoscha Roch
Title: The Optimization of Post-Treatments for 3D Printed Stainless Steel Structures

Abstract: AM (Additive Manufacturing) has the potential to revolutionize the global parts manufacturing and logistics landscape. It enables distributed manufacturing and the productions of parts-on-demand while offering the potential to reduce cost, energy consumption, and carbon footprint. As one of the technology classes, the FFF has been widely used to rapid prototyping systems throughout the world. Comparing to other technologies, FFF is able to manufacture a part with multi materials. Besides, the forming of micro structures in FFF parts offer new possibilities for the material sciences to investigate new material properties. Therefore, a considerable efforts are being devoted both from industries and research institutes. In 2016 more than 420,000 FFF printer were assembled, around 50-70% of which were sold to industry followed by research institutions.
In this project, we used FFF to print metal filaments, whose post treatments were investigated and optimized. A variety of structures, which was composed of stainless steel microparticles were fabricated.

Keywords: 3D metal printing, stainless steel structure

Poster Number: MM-11
Authors: Alborz Izadi; Mayank Sinha; Rebecca Anthony; Sara Roccabianca
Title: Manufacturing Silicon Nanocrystal-PDMS with Enhanced Optical and Mechanical Properties

Abstract: Silicon Nanocrystals have been used for many application including, light emitting devices (LEDs), solar cells, microelectronics. It is important to consider these material for energy harvesting, energy storage, health monitoring systems and bio compatible sensors. Many studies have been dedicated to composite materials of Nanocrystals and polymer based structures. Due to higher level of flexibility and durability that polymers can provide, comparing to traditional rigid substrates, many application for nanocrystals-polymer composites arise. Studies showed that addition of Silicon nanoparticle to the polymer mixture (poly dimethyl siloxane), like PDMS, before curing will improve mechanical properties and will enhance optical properties as well.
Here, we introduce a new plasma gas phase techniques for making size-dependable Silicon Nanocrystals. We used different imaging technique to measure change in mechanical properties and calculating the volume fraction of surface functionalized silicon nanocrystals.

This work was supported in part by RC106038

Keywords: nanomaterials, composites, gas phase plasma

Poster Number: MM-12
Authors: Areej Almalkawi; Mahmoodul Haq
Title: Green Composites: Bio-based Resins Reinforced with Cotton-Gin and Hemp Fibers

Abstract: Fiber-reinforced polymer (FRP) composites are increasingly used in mass-produced automotive applications due to their high strength to weight ratio, enhanced fracture toughness and non-corrosive property. Most high-performance FRPs are made of synthetic fibers and petroleum based resins which have limitations such as: (i) non-recyclable (ii) non-renewable; (iii) high energy demand in the manufacturing process; (iv) toxicity of materials and negative impact on health; and (v) non-biodegradable. Green composites using plant-based fibers and resins have gained interest in structural applications as alternates to conventional FRP.
In this work, green composites made of cotton-gin fibers, which are a byproduct of textile industry. A bio-based (30% soy-bean oil) epoxy was reinforced with cotton gin and hemp fibers were manufactured using compression molding. For all composites in this work, the fiber length fiber volume fraction was maintained as 1” (25.4 mm) and ~35 wt.%, respectively. The mechanical (tensile and impact) properties were experimentally evaluated. Initial results show reduced strength in cotton-gin composites relative to hemp composites. This is attributed to reduced aspect ratios in cotton-gin composites and clumping of fibers. Future work focuses on nano-reinforcement of resin to enhance moisture and impact resistance.

Keywords: green composites , sustainbility , natural fibers , polymers, bio-resins

Poster Number: MM-13

Authors: Shengyuan Bai; Elias Garratt

Title: Mesoscale Interface and Surface Characterization by μ-XRD Mapping on Mosaic and Lateral Grown Single Crystal Diamond

Abstract: For decades, diamond has shown superior properties that make it desirable for novel electronic materials. However, fabricating large size high quality single crystal diamond wafers faces multiple challenges. Lateral outgrowth and mosaic growth of CVD diamond make it highly possible for large size diamond wafers to be realized. Mesoscale characterization on the interface and surface of the grown CVD diamond is key to understanding how to eventually fabricate large size high quality single crystal diamond wafers. In this work, mosaic and lateral single crystal diamonds were grown by Microwave Plasma Assisted Chemical Vapor Deposition (MPACVD) on High Pressure High Temperature (HPHT) seeds and characterized by a micro x-ray diffraction (μ-XRD) mapping technique with a 300 μm slit to show the evolution of diamond crystal structure information during growth and provide feedback on growth strategies. By understanding how crystal structure evolves during growth we can understand the mechanisms linking processing conditions the structure and properties of grown material. Our results demonstrate after growth and regrowth by MPACVD, variation in the structure and distributions of these variations evolves towards

homogeneity. Measurements of the (400) phase for mosaic and lateral growth samples by high-resolution x-ray rocking curve (HRXRC) and 2θ-ω μ-mapping technique. The overall misorientation of the merging CVD layers is shown to decrease with the regrowth from 0.225° (bottom layer plate) to 0.092° (uppermost layer plate). μ-HRXRC mapping results show a low mosaicity and μ-HR 2θ-ω scans show a low average Full Width at Half Maximum (FWHM), 0.032° and high crystallinity. Typically lateral outgrowth shows a uniform misorientation at the growth front, ranging from 0.092°to 0.035°. In contrast, our mosaically joined samples show a non-uniform distribution in misorientation at the merging interface, displaying a biaxial deviation parallel and perpendicular to the interface. The preliminary data shows that after regrowth, this biaxial distribution tends toward uniformity, with regions of independent preferred orientation overtaken by a single, new orientation. We will discuss this phenomenon in terms of step-flow overgrowth and energetically favorable states of the diamond crystalline phase during epitaxial lateral overgrowth in the extreme plasma environment.

Keywords: single crystal diamond; CVD; micro-XRD; ,mesoscale characterization; surface and interface

Poster Number: MM-14

Authors: Mariana Desireé Reale Batista; Sun Jin Kim; Lawrence T. Drzal; Jin-Woo Han; Meyya Meyyappan;

Title: Flexible Ultraviolet Sensor Based on Metallic Carbon Nanotubes

Abstract: Carbon Nanotubes (CNTs) were used to develop a sensor to detect Ultraviolet (UV) radiation, which is important for space communication, monitoring climate change and human exposure to UV light. Flexible substrates and paper electronics are attracting attention since they offer new capabilities for devices that are not possible with conventional rigid substrates. In this study, UV sensors were made not only on glass substrates but also on flexible substrates such as Polyimide Film (PI) and Cellulose Paper for comparison purposes. 'As received' CNTs in aqueous solution were diluted to varying concentrations and drop-casted onto the active region between the electrodes of the sensor on each substrate. An optimum CNT concentration was identified and the dispersion and topographies of nanoparticles on the sensor substrates were investigated by Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM). All sensors respond immediately to UV On/Off cycles with a change in resistance due to the ability of the CNTs to adsorb and desorb oxygen on their surface. The PI substrate yields the sensor with the highest response, followed by glass and cellulose paper. After mechanically bending the flexible sensors at a curvature radius of 10 mm for 1000 times their functionality is maintained, which is an advantage for practical applications. Therefore, the PI sensor was selected for wearable applications in which electrodes were printed on PI substrate and tailored for wristband use. Outdoor testing under natural sunlight shows that the sensor accurately detects UV radiation and could be further developed for potential commercial applications.

This work was supported in part by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) through the Brazil Scientific Mobility Program [99999.013655/2013-02]; Agência Espacial Brasileira (AEB); NASA International Internship (NASA I2) program

Keywords: ultraviolet sensor; flexible sensor; ultraviolet radiation; carbon nanotubes

Poster Number: MM-15
Authors: Harish N Chakravarty; Carl Boehlert
Title: Effect of Alloying Addition of Aluminium and Iron on Creep Resistance of Titanium-Chromium Alloy

Abstract: Titanium and its alloys are among the highly desired metallic materials in bio-material applications, chemical applications, and marine environments due to their excellent corrosion resistance and bio-compatibility. High specific strength and good stiffness of these alloys help reduce the weight of aerospace structures. However, the high cost of titanium alloys has limited its use. Cost is a major driving factor in titanium research. There has been a lot of effort to replace high cost alloying elements currently being used in the industry, like V, Sn, Mo, and Zr, with cheaper ferro-chrome substitutes. The main goal then becomes achieving comparable mechanical properties. Beta titanium alloys with the omega phase usually tend to exhibit higher strengths and hardness than the ones that don't contain omega. In this study, the creep properties of 3 different beta titanium alloys – Ti-13.0Cr-1.0Fe-3.0Al, Ti-13.0Cr-3.0Al, T-13.0Cr (%wt) were experimentally obtained. Creep tests were conducted at different loading and temperature conditions and were compared. The relationship between microstructure and creep property were investigated before and after thermo-mechanical processing. Analysis techniques like X-ray diffractometer (XRD), optical microscope (OM), scanning electron microscope (SEM) were used to determine the phases present during creep. The average grain size was determined and compared to existing alloys. After heat treatment for 48 hrs at 410 C, it was found that the elastic modulus and hardness of alloys went up due to presence of alpha and omega phases. The creep test study indicates that Ti-13.0Cr-1.0Fe-3.0Al was the most creep resistant followed by Ti-13.0Cr-3.0Al and then T-13.0Cr.

Keywords: creep resistance, Beta titanium alloys, Omega phase, X-ray diffractometer

Poster Number: MM-16
Authors: Ramón D. Díaz; Aaron Hardy; Shengyuan Bai; Elias Garratt; Timothy Grotjohn
Title: Developments on the Mosaic Technique for Producing Single Crystal Diamond Plates by Microwave Plasma Assisted Chemical Vapor Deposition

Abstract: The electrical, mechanical, and thermal properties of diamond make it a promising material for new generation electronic devices. This research area requires two fundamental conditions for accelerated progress: high crystalline quality and large area diamond substrates. In this study, single crystal diamond plates were successfully grown based on the mosaic technique. The approach is summarized by tiling 3.5 mm x 3.5 mm x 1.4 mm High Pressure High Temperature diamond seeds using our newly developed alignment process proven to produce maximum initial misalignments in the range of 0.5 ± 0.3 degrees. The diamond plates are grown by Microwave Plasma-Assisted Chemical Vapor Deposition at a rate of 25 ± 5µm/h. The overall process is based on controlling a series of design parameters, including sample holder dimensions and temperature stabilization directed toward successful growth of a continuous single crystal layer across the mosaic seed. Defect densities measured along the grown interfaces were analyzed by etch pit counting and birefringence measurements. X-ray rocking curve mapping of the sample shows a confirmed reduction in misorientation as the sample thickness is increased over time. Preliminary results show an effective elimination of the initial relative misalignment along at least one of the three possible misorientation axis, demonstrating the feasibility of our process by applying the mosaic technique toward increasing the area of grown single crystal diamond wafers.

This work was supported in part by MIT Lincoln Laboratory

Keywords: diamond, substrates, CVD, XRD

Poster Number: MM-17
Authors: Preetam Giri; Nathan Arnold; Alper Kiziltas; Deborah Mielewski; Ramani Narayan
Title: Polylactide and Natural Fiber Based Long-Fiber Thermoplastics (LFTs) for Automotive Interiors

Abstract: The goal of this project is to develop biobased long fiber reinforced thermoplastic (LFT) composites for targeted automotive components, based on the polylactide (PLA) resin, as well as modified PLA that can contribute to enhanced performance and address the well known issues of melt strength, toughness, and low softening temperature. We have established that biobased cellulosic fibers such as viscose and rayon have key mechanical properties that allow them to function effectively as reinforcing fibers, especially for ductility and toughness. Composites based on these reinforcing fibers will be produced using the LFT technology. Apart from cellulosic fibers, basalt fiber will also be used to create a portfolio of novel biobased composites to replace currently used automotive interior parts.

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

Keywords: polylactide natural fiber composites

Poster Number: MM-18
Authors: Songyang Han; Philip Eisenlohr; Martin Crimp
Title: ECCI Based Characterization of Dislocation Shear in Polycrystalline Arrays During Heterogeneous Deformation in Commercially Pure Titanium

Abstract: The present study outlines an approach for characterizing how the plasticity of a polycrystalline array develops due to dislocation nucleation, slip, and shear accommodation across grains and at grain boundaries. This characterization uses ECCI to investigate the details of the dislocations involved in grain boundary shear accommodation and the nature of the slip bands associated with heterogeneous deformation. An important aspect of this work is that it not only studies grain boundary shear accommodation in relation to slip propagating into and piling up at grain boundaries, but also considers the shear accommodation necessary in neighboring grains when dislocations nucleate from an unknown source at a boundary.

This work was supported in part by Department of Energy, Office of Basic Energy Science Division, Grant No. DE-FG02-09ER46637

Keywords: ECCI, dislocation shear motion

Poster Number: MM-19
Authors: Alexander Ho; Rebecca Anthony
Title: Synthesis and Additive Manufacturing of Nanomaterials with Atmospheric Plasmas

Abstract: Additive manufacturing and nanomaterial synthesis often exist as decoupled processes. Combination of additive manufacturing and nanomaterial synthesis offers the opportunity for enhanced processes and deposition schemes. The use of plasmas for nanoparticle synthesis is well established and provides significant operation range which readily accommodates the tunable properties of nanoparticles. The use of atmospheric plasmas allows for small reactors and ease of operation, aiding the integration of nanomaterial synthesis and additive manufacturing.
Presented here is our work on additive manufacturing with silicon nanoparticles synthesized with an atmospheric pressure plasma. The plasma reactor consists of a glass capillary tube with two ring electrodes placed around the tube and supplied with power from a 13.56 MHz RF power supply. Silane and argon gas are flown to the reactor for silicon nanoparticle synthesis and are collected on a substrate underneath the reactor. Through the use of a computer-controlled machine predetermined deposition patterns are achieved in all spatial dimensions. Fourier-transform infrared spectroscopy displayed the presence of an oxynitride shell at the surface of the nanoparticles. Transmission electron microscopy indicates nanoparticles with sizes reaching 5 nm as well as a mixture of amorphous and crystalline silicon. Deposition linewidths with a resolution of 180 microns have been achieved at deposition rates of 1 mm2 per minute. Current work includes further characterization of nanoparticles, increasing the resolution of the deposition, and displaying functionality from the nanoparticles.

Keywords: nanoparticle, plasma, synthesis

Poster Number: MM-20
Authors: Genzhi Hu; Yuxi Ma; Quan Zhou; Jason D. Nicholas
Title: High Performance Circuit Pastes for Solid Oxide Fuel Cell Applications

Abstract: Solid Oxide Fuel Cells (SOFCs) are a unique green technology capable of providing high efficiency for today's hydrocarbon-based economy. Unfortunately, degradation and delamination of electrical contact, especially upon thermal and/or redox cycling, are crucial to SOFC lifetimes. It has been found in previous studies that porous nickel interlayers could be used to promote the wetting and spreading of silver on a variety of ceramic substrates. In this work, the same preparation procedure was adopted to produce silver-nickel circuits. The microstructure and performance, specially the a) contact resistance b) sheet resistance c) oxidation resistivity of Ag Ni circuit paste and commercially available ones will be discussed. This work will result in a new, cost effective thick-film circuit pastes for use by the entire SOFC community and produce analysis of electrical and mechanical performance of today's commercially available silver based circuit pastes.

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

Keywords: solid oxide fuel cell, circuit, silver paste

Poster Number: MM-21
Authors: Yang Lu; Larry A. Godlewski; Jacob W. Zindel; Andre Lee; Tyler Johnson
Title: Use of Reactive Nanostructured Chemicals for Si-Eutectic Modification in an Aluminum Casting Alloy

Abstract: Trisilanol phenyl polyhedral oligomeric silsesquioxane (TSP) was added to a commercial aluminum alloy, AlSi10MnMg, to investigate its influence on microstructure, mechanical properties, and solidification behavior. TSP modification did not change the grain size of the primary alpha-Al but was successful in modifying the morphology of the eutectic Si into a fine lamellar type of structure. There is no fading observed of the Al-Si refinement up to 96-hour furnace hold time, suggesting a possible reaction between TSP and the metal alloy. The ductility of TSP modified AlSi10MnMg alloy was consistent with Sr-modified alloy at room, 423 K, and 573 K elevated temperature while maintaining similar strength. Cooling curve analysis showed the Al-Si eutectic arrest temperatures during solidification were decreased with the TSP addition, suggesting TSP bonds with Al to slow down the Al segregation from Al-Si melt during the eutectic reaction, leading to the microstructural refinement of Al-Si eutectic.

This work was supported in part by This work is funded by Ford-MSU alliance program.

Keywords: TriSilanol POSS; microstructure modification; fading; tensile performance; solidification

Poster Number: MM-22
Authors: Jiyun Park; Jason Nicholas; Yue Qi
Title: Computational Study of Ag-Ni Brazes for Solid Oxide Fuel Cell (SOFC) Applications

Abstract: Sealing between cell components in SOFCs is crucial because poor mechanical adhesion limits SOFC performance. By far the most popular method is a silver-based reactive air brazing (RAB) method which has good wetting properties on SOFC substrates. However, the RAB joint have fatal flaws such as pore formation during operation. For better brazing performance, a new Ag-Ni braze system was developed. It was shown that the Ag-Ni joint remained pore-free and had high bonding strength between SOFC substrates. Along with this experimental study, computational study is useful to unveil the theoretical background. Therefore, this study aims to investigate wetting behavior of Ag on yttria-stabilized zirconia (YSZ) surfaces decorated with Ni particles using molecular dynamics simulations. Understanding wettability of Ag-based brazes is an important endeavor in need of robust and durable sealant for SOFC applications.

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

Keywords: molecular dynamics, braze, wetting

Poster Number: MM-23
Authors: Young Kim; Qi Hua Fan

Title: Nano-Indentation Finite Element Analysis for Thin Film Coating Mechanical Properties

Abstract: Hard coatings, such as tetrahedral amorphous carbon (ta-C) thin films, provide enhancement to the surface properties of soft substrates. Accurately predicting the performance of a coating assembly is essential to optimizing the deposition process. Using finite element analysis (FEA), nano-indentation on coating assembly was modeled to study the mechanical properties of the coating. In order to increase the accuracy of the model and obtain mechanical characteristics of the coating, a hybrid coating/substrate/spring model was developed. The elastic and plastic deformation behavior of the system under indentation was studied by analyzing the force–displacement curves.

This work was supported in part by Department of Energy Award DE-EE0008320

Keywords: diamond-Like carbon coating, finite element analysis, nanoindentation

Poster Number: MM-24
Authors: Kyle O'Shea; Alborz Izadi; Rebecca Anthony
Title: A Low-Pressure RF Plasma Method for Gold Nanoparticle Synthesis

Abstract: There are many applications for gold nanoparticles (AuNPs) due to their interesting optoelectronic properties such as tunable optical absorption and plasmonic resonance behavior. While synthesis and stabilization of colloidal AuNPs is well-established, new synthesis routes can lead to enhanced versatility of applications for AuNPs, particularly if the methods allow avoidance of solution processes or surfactants. Here, we introduce a plasma-based synthesis of AuNPs , using a consumable gold wire and a radiofrequency (RF) power source, operated at reduced pressure. We collected the AuNPs at the exhaust of the reactor for analysis. The AuNPs are monodisperse in size with an average diameter of 4 nm. We compared this method also to a hot-wire production method, also at low pressure. While production yield is low, the narrow size distribution of the AuNPs and the avoidance of solution processing in this method are promising for future syntheses of metal NPs based on plasmas.

This work was supported in part by NSF CAREER Grant CMMI-1651674

Keywords: Nanoparticles, Plasma, RF, Vacuum, Gold

Poster Number: MM-25
Authors: Geeta Kumari; Carl Boehlert; S. Sankaran; M. Sundararaman
Title: Microstructural Evolution with Varying Solutionizing Temperature in Allvac 718plus

Abstract: Alloy Allvac 718Plus is relatively new superalloys developed to improve upon the properties of the widely used superalloy Inconel 718. It shows improvement in service temperature up to 704ºC (55ºC more than IN718) because of its chemical composition, microstructure and major strengthening phase, gamma prime. It is a well-known fact that the strength of a material is determined by its microstructure. High temperature preferably at service temperature, stability of microstructure determines the life and mechanical properties of these alloys. Therefore, it is necessary to understand the phase evolution as a function of temperature. In the present work, the solutionizing temperature has been varied during heat treatment and a detailed microstructural analysis has been performed. Solutionizing at different temperature will lead to varied grain size and amount of phase. The as-received samples were solution annealed at 1100, 1050, 1000, 954 º C followed by ageing at 788ºC for 8 hr then furnace cooled to 704ºC for 8 hr (two-step ageing). Metallographic samples of as-received and heat treated samples were prepared to identify different phases using optical microscopy & scanning electron microscopy (SEM). Electron Backscatter Diffraction (EBSD) and Energy dispersive spectroscopy (EDS) was performed in the SEM to investigate the composition of the various phases. All the data obtained were rationalized and compared with the existing data. This data will help in investigating the dependency of the changes occurring with time and temperature.

Keywords: Allvac 718plus, solutionizing, gamma prime, characterization, SEM

Poster Number: MM-26
Authors: Mingzhe Li; Weiyi Lu
Title: Competition Between Liquid Infiltration and Pore Crushing at Nanoscale

Abstract: Inspired by capillary effect, liquid infiltration into hydrophobic nanopores has been employed as an advanced energy absorption mechanism in liquid nanofoam (LN) systems. The energy dissipating mechanism is to force a non-wetting liquid to flow into hydrophobic nanopores, converting the external mechanical energy into solid-liquid interaction energy and heat. However, upon extremely high rate impacts, whether liquid infiltration or nanopore crushing dominates the deformation of the LN is fundamentally unanswered. Here, we present an experimental investigation of the competition between liquid infiltration and pore crushing at nanoscale using a solid nanofoam (SN) and its LN counterpart. The SN and LN samples are compressed at wide range of strain rates. Our results show that the nanopores in SN are permanently crushed under both quasi-static compression as well as dynamic impact, while the nanopores in LN remain the same and the liquid infiltration behavior is rate independent. The distinct behaviors of the SN and the LN demonstrate that the deformation process of the LN is dominated by liquid infiltration rather than permanent mechanical deformation of nanopores under impacts. This is attributed to the ultra-fast activation of liquid infiltration and the suppression of nanopore crushing by the intruded liquid molecules in LN systems. This finding offers mechanistic explanation for the ultra-fast energy dissipation rate and high energy absorption efficiency of LN at high strain rate impact and blast scenarios.

This work was supported in part by NSF CBET-1803695

Keywords: liquid infiltration, nanoscale, liquid nanofoam, pore crushing

Poster Number: MM-27
Authors: Tanvi Nikhar; Robert Rechenberg; Sergey V. Baryshev

Title: Nitrogen Doping and Graphitization Effects on Conductivity of Ultra-nanocrystalline Diamond

Abstract: Diamond has many superior properties over other materials, yet its application in electronic devices is severely limited due to difficulties in producing n-type conduction in diamond due to high activation energy of available dopants at room temperature. The substitutional doping of nitrogen in grain boundaries of granular graphitic-rich ultra-nanocrystalline diamond (UNCD) films provides for high conductivities even at room temperature with an apparently low activation energy. It also leads to the formation of new electronic states associated with carbon and nitrogen near and above the Fermi level. However, the relative contribution of sp2 graphitic phase and incorporated nitrogen to the conduction of the films remains unclear. In the present work, structural and electrical properties of nitrogen-incorporated UNCD films are studied as a function of deposition temperature and nitrogen concentration in the precursor synthesis gas mixture consisting of H_2, CH_4 and N_2. Three sets of N-UNCD films with 5%, 10% and 20% nitrogen concentration in the synthesis gas were produced by microwave assisted chemical vapor deposition on intrinsic (100)-oriented Si substrates. Measurements from visible (probe laser 532 nm) Raman spectroscopy indicated that sp2/sp3 ratio increased with nitrogen content; this agrees with previous results. It was found that addition of nitrogen did not contribute to the conductivity of the films as much as the increase of sp2-bonded carbon content. It was also found that by varying growth parameters, the room temperature conductivity of (N)UNCD films can be tuned by 5 orders of magnitude.

Keywords: UNCD, nitrogen-doping, thin films, electron emission

Poster Number: MM-28
Authors: Aditya Patil; David Vogelsang; Jonathan Dannatt; Robert Maleczka Jr.; Andre Lee

Title: A Precursor Synthesis for High Temperature Thermosets

Abstract: Octaphenyl Tetrasilanol Silsesquioxanes (DDSQ-(OH)4) are partially condensed double decker shaped polyhedral oligomers composed of $RSiO_{1.5}$ monomers. These molecules are a model for hybrid organic-inorganic structures with size varying between 1-3 nm. The four silanols can be further functionalized by condensation with chlorosilanes. The functionalized DDSQ structures can be used as building blocks for polymers. In this work DDSQ-(OH)4 was functionalized with Phenylethynylphenylmethyldichlorosilane. The triple bond in the phenylethynylphenyl moiety can be polymerized to produce thermosets that can sustain high temperatures. Initially bromophenyletynylbenzene was synthesized using the Sonogashira coupling. The concentration of catalyst, base and temperature conditions were adjusted to achieve optimal yields and reaction time. Then, a Grignard reagent was prepared starting with bromophenylethynylbenzene and further transfer via canula to an organo-trichlorosilane to produce the corresponding organo-dichlorosilane. DDSQ-(OH)4 was capped with the dichlorosilane to get cis and trans forms of the product. Fractional crystallization was made to separate the cis and trans forms of the compound. Physical properties such as melting point and the crystallinity of the structure were studied. Future work will be focused on synthesizing thermostats from the current compound.

Keywords: Silsesquioxanes, thermosets, Sonogashira coupling, funtionalized DDSQ

Poster Number: MM-29
Authors: Taha Y. Posos: Steve B. Fairchild; Jeongho Park; Sergey V. Baryshev
Title: Field Emission Microscopy of Looped CNT Fiber

Abstract: Field emission cathodes have many areas of application: electron microscopy, X-ray sources, vacuum electronic devices (terahertz sources and high-power microwave tubes), etc. These applications require high current density and high brightness electron beams. For the development of terahertz sources specifically, it is crucial to obtain field emitter material and morphology which is capable of emitting 10 mA DC electron beam with energy of 20-30 keV and energy deviation less than 10 eV. To travel along the tube, emitted electrons must be confined in a 50 µm diameter, so small beam divergence angle is necessary. Electron source also needs to sustain emission current for thousands of hours with less than 0.5% fluctuations. In addition, it needs to be durable against extreme temperature and ion back bombardment [1]. Carbon nanotube (CNT) fibers have great potential for development of future field emitters due to its relatively high current emission capability in relatively small electric field, current stability, large aspect ratio, and high electrical and thermal conductivities. CNT fibers are also flexible, and bending does not prevent conductivity. This is important because current induced heating causes extreme heating of conventional vertical CNT fiber. Different geometries can lead to better heat removal. This poster presents a looped CNT configuration. This geometry has double contact with cathode base, which leads to decrease in maximum temperature on fiber [2]. The performance of looped CNT was tested experimentally for various gap between anode and cathode. The experiments were accomplished by field emission microscopy [3]. The data analyzed and Fowler-Nordheim (FN) plots are produced. The experiment result shows that although it emits relatively high and stable current, the beam divergence angle is not small.
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[3] Baturin, S. S., & Baryshev, S. V. (2017). Electron emission projection imager. Review of Scientific Instruments, 88(3), 033701.

Keywords: field emission, looped carbon nanotube fiber

Poster Number: MM-30
Authors: Ruikun (Quinn) Sun; Jie Yang; Matthew Melton; Shiwang Cheng
Title: Unraveling the Origin of the Nano-Reinforcement Effect of Polymer Nanocomposites in Elongational Flow

Abstract: Polymer nanocomposites (PNCs) are widely used as structural and functional materials for packaging, construction, medication, etc., due to their light weight and good mechanical performance. Despite decades of intensive study, the origin of the mechanical enhancement of PNCs remains unclear, especially in the nonlinear region when flow occurs. Here, we investigated the effects of nanoparticle loadings on the nano-reinforcement of PNCs during elongational flow. Our results show that both adsorbed polymers and polymer bridges contribute significantly to the macroscopic flow stress. At nanoparticle loadings below the gelation threshold, the adsorbed polymers with delayed relaxation time provide a sluggish constrain release with their surroundings. Consequently, only slight reinforcement effect can be observed. At nanoparticle loadings slightly above the gelation threshold, the contribution of polymer bridges to the stress emerges at small strain and maximizes at an elongation ratio □ ~ 4, signifying a second stress maximum in the engineering stress-elongational representation. Furthermore, the yield stress and yield strain of the polymer bridges depend strongly on the applied elongational rate, indicating an activated destruction of the polymer bridges over flow. At loadings when polymer bridges dominate, the PNCs become very stiff and cannot sustain to large deformation. Thus, brittle failures dominate and the toughness of the PNCs reduces significantly. Our results demonstrate that the interplay among the free polymers, the adsorbed polymers, and the polymer bridges leads to the trade-off between the modulus and the toughness of PNCs.

Keywords: polymer nanocomposites; nano-reinforcement; non-linear rheology; elongation

Poster Number: MM-31

Authors: Erik Stitt; Mahmood Haq; Lee Silverman; Lawrence Drzal

Title: Preparation of Graphene Nanoplatelet (GnP) Polyamide Copolymer Nanocomposite Utilizing a Hybrid Solvent/Melt Compounding Methodology

Abstract: The degree of dispersion and exfoliation of 2D graphene nanoplatelets (GnP) within polymer composites has a direct impact on the material properties of the resulting GnP nanocomposite. To fully realize the benefits of GnP within thermoplastic polymer matrices, a uniform distribution of GnP sheets is desired. It is challenging to achieve this degree of dispersion in high viscosity melt compounding without altering the particle morphology. Additionally, traditional melt compounding utilizing powder may result in size reduction of the GnPs. Solvent blending can produce a dispersion superior to melt compounding by mixing in a low-viscosity system but introduces the complexity of solvent removal. A combination of these approaches has potential for producing a nanocomposite which exhibits properties superior to a dry powder melt compounded composite without the presence of residual solvent.

In this work a GnP/polyamide nanocomposite is made via melt compounding of a high GnP content master batch material prepared using solvent blending. GnP is well dispersed in an azeotropic blend of isopropyl alcohol and water which has low toxicity, creates a low viscosity polymer solution, and is easily removed. The mechanical properties and microstructure of this hybrid processed nanocomposite are compared to that of nanocomposite produced via melt compounding of dry GnP powder. Results show superior mechanical properties in the hybrid processed nanocomposite over dry compounded GnP nanocomposite. Micrographs are presented to illustrate the microstructural differences created by the two preparation methods and how they influence mechanical properties.

This work was supported in part by U.S. Army TARDEC

Keywords: nanocomposite, GnP, polyamide, processing, dispersion

Poster Number: MM-32

Authors: Yang. Su; Claudio. Zambaldi; David. Mercier; Philip. Eisenlohr; Thomas Bieler; Martin Crimp

Title: Grain Boundary Resistance in Alpha-titanium Quantified by Nanoindentation and Boundary-aware Crystal Plasticity Modeling

Abstract: To understand how grain boundaries modulate plastic deformation of commercially pure titanium, sphero-conical nanoindentations were placed near preselected grain boundaries where corresponding grain orientations had been mapped by electron backscatter diffraction (EBSD). The resistance of grain boundaries to dislocation slip was characterized by comparing bi-crystal and single crystal nanoindentation surface topographies. The effects of grain boundary misorientation and subsurface inclination (determined by focused ion beam sectioning) on the topography were categorized by a number of slip transmission criteria. A crystal plasticity finite element (CPFE) model was built for simulating bi-crystal indentations using STABiX, a Matlab toolbox developed for converting orientation data into a variety of outputs, and used as input for simulations performed with MSC.Marc/Mentat. The accuracy of the simulations was quantified by comparing with experimental indentation topographies at multiple grain boundaries. Two layers of elements with the same orientation of the grain on each side but with different slip parameters were built into the computational model by assigning new slip parameters (different from those in the grain interiors) to each layer. The boundary layer slip parameters were optimized by minimizing the difference in the topography between experimental and simulated indents. In general, the accuracy of indent simulations was improved with the implementation of the explicit grain boundary layers. Nevertheless, the boundary parameters necessary to achieve good matches vary for different boundary misorientation and grain orientations.

This work was supported in part by National Science Foundation (NSF) through the Materials World Network Grant DMR-1108211 and corresponding Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) grant ZA523/3-1, as well as NSF grant DMR-1411102.

Keywords: titanium, grain boundary, finite element model, crystal plasticity, dislocation

Poster Number: MM-33
Authors: Michael W. Swift; Yue Qi
Title: First-Principles Prediction of Potentials and Space-Charge Layers in All-Solid-State Batteries

Abstract: As all-solid-state batteries (SSBs) develop as an alternative to traditional cells, a thorough theoretical understanding of driving forces behind battery operation is needed. We present a fully first-principles-informed model of potential profiles in SSBs and apply the model to the Li/LiPON/LiCoO2 system. The model predicts interfacial potential drops driven by both electron transfer and Li+ space-charge layers that vary with the SSB's state of charge. The results suggest lower electronic ionization potential in the solid electrolyte favors Li+ transport, leading to higher discharge power.

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

Keywords: batteries, modeling, computation, electrochemistry, thermodynamics

Poster Number: MM-34
Authors: Suhail H Vattathurvalappil; Rajendra P Palanisamy; Mahmoodul Haq
Title: Healing Behavior of Thermoplastic Bonded Multi-material Joints Subjected to Impact Loads

Abstract: The efficiency of bonded joints is dependent on the adhesive bond-line that transfers the loads between the two adherends. Any flaw within the bonded area can have significant effect on load carrying capacities. If the damage in the adhesive layer can be healed, such losses in structural behavior can be recovered. One such healing technique is the use of thermoplastic ‘reversible’ adhesives, wherein thermoplastics are reinforced with conductive nanoparticles. Such materials have been shown to heal through exposure to electromagnetic fields.
In this work, combinations of glass-fiber/epoxy (GFRP) and aluminum substrates were bonded with ABS thermoplastic adhesive reinforced with ferromagnetic nanoparticles. The joints were subjected to low-velocity impacts (10J) to introduce damage in the bond-line. The damaged joints were then healed through either electromagnetic fields or oven-heating for non-conductive (GFRP) and conductive substrates respectively. Pristine, damaged and healed joints were tested in quasi-static lap-shear configuration as per ASTM D5868 specifications. The effect of impact-damage and healing efficiency was obtained by comparing with pristine joints. The extent of damage and healing was measured using ultrasonic C-Scan techniques and optical microscopy. Preliminary results comparing the peak loads of pristine joints with impact-damaged and healed joints show ~35% reduction and ~90% recovery respectively. Overall, the technique shows promise in use of reversible bonded joints. Nevertheless, statistically significant testing is in progress to fully exploit the benefits offered by these novel adhesives.

This work was supported in part by American Chemistry Council

Keywords: thermoplastic polymer, iron oxide particles, electromagnetic induction, transverse impact, Ultrasonic C Scan

Poster Number: MM-35
Authors: Tony Wente; Wu Zhou; Xinyu Mao; Xinran Xiao
Title: Interlaminar Fracture Toughness of Unidirectional and Quasi 3D Braided Composites

Abstract: Fiber reinforced composite materials are a heavily sought-after material for next generation vehicles for light-weighting components due to their high specific strength and stiffness. However, when these composite materials are manufactured into laminates, they have relatively weak interlaminar strength. Quasi-3D (Q3D) braided composites seek to solve this issue by weaving the bias tows into the immediately adjacent plies. The plies are physically connected through the fiber tows as opposed to being bonded simply by the epoxy, and the composite will achieve a higher interlaminar strength. The [0/60/-60] UD and Q3D carbon composites are investigated in this study for their better in-plane isotropy. Both laminates were manufactured using the vacuum assisted resin transfer molding (VARTM) method with API SC-15 toughened epoxy. They were tested for in-plane tensile properties to investigate any degradation in strength and tensile modulus, along with the change in Poisson ratio due to the weaving of the yarns. The tensile property of the Q3D composite is competitive to the UD composite.
Mode I and Mode II interlaminar fracture toughness tests were also conducted. In Mode I experiments, the samples were continuously loaded to failure to obtain the fracture toughness throughout the sample. The Q3D composite shows a large increase in fracture toughness once the crack began to stabilize and the interlaminar tows become engaged. In Mode II, the Q3D laminate shows a significant increase in fracture toughness after a pre-crack has been formed and the interlaminar tows have been engaged.

This work was supported in part by Ford Alliance Project

Keywords: composites, fracture toughness, 3D braiding

Poster Number: MM-36
Authors: Lijiang Xu; Mingzhe Li; Weiyi Lu
Title: The Driving Force for Spontaneous Liquid Outflow from Hydrophobic Nano-Channel

Abstract: It has been demonstrated that pressure induced liquid flow in nanoporous material converts incompressible liquid into highly compressible liquid sponge. Although the spontaneous liquid outflow (SLOW) behavior during unloading is a critical part to fully define the functionality of the material system, its mechanism is still not fully understood. In the current study, one type of hydrophobic nanoporous particle (Fluka 100 C8) has been selected to investigate the driving force of SLOW. The particles have been mixed with six different aqueous electrolyte solutions (LiCl, NaCl, KCl, LiBr, NaBr and KBr). The molar concentration of the electrolytes has been precisely controlled to make the excessive solid-liquid interfacial tension exactly the same in all six samples. All samples have been compressed under quasi-static condition for 3 consecutive cycles at room temperature. Due to the same excessive solid-liquid interfacial tension, all the systems have same infiltration behavior, which ensures the SLOW takes place at same initial condition. By comparing the reusability of these samples, which is a direct measure of the degree of SLOW, we are able to reveal the driving force for SLOW. The SLOW is primarily promoted by the size of the cations and anions. Different from bulk phase scenario, the anions have more profound effect than cations. More importantly, both ion species have impact on the gas solubility in the liquid phase. From the literature, we have found that the degree of SLOW is correlated with the gas solubility in different electrolyte solutions. However, the bulk phase gas solubility is much lower than the values measured in our experiments, which indicates the gas solubility in the nano-environment is much enhanced. The gas concentration gradient between the confined and bulk liquid phases determines the transportation speed of the gas phase from the nano-channel to the bulk liquid phase. In summary, lower gas solubility and smaller concentration gradient between nano- and bulk- environment lead to higher degree of SLOW. This fundamental understanding on the mechanism of SLOW combining with the pressure induced liquid flow mechanism, we can functionalize the nanofluidics-based system to be viscoelastic springs, one-time use energy absorbers and reusable damping systems.

This work was supported in part by NSF CBET-1803695

Keywords: gas solubility, defiltration, effect of ions, hydrophobic nano-channel

Poster Number: MM-37
Authors: Peng Xu; Thomas R. Bieler; Neil T. Wright
Title: Monte Carlo Simulation of the Lattice Thermal Conductivity of Deformed Superconducting Niobium

Abstract: Large values of the thermal conductivity of Nb used for constructing superconducting radio frequency (SRF) cavities is critical to mitigate local temperature excursions caused by small imperfections. The conventional model of thermal conductivity in superconductors requires estimating several parameters from experimental results. Here, the lattice thermal conductivity of superconducting Nb before and after deformation is predicted by considering phonon-electron scattering, phonon-boundary scattering, and phonon-dislocation scattering. The resulting Boltzmann Transport Equation (BTE) incorporating the phonon dispersion relation is solved using an energy-based variance-reduced Monte Carlo simulation.
The model was first verified by comparing the predicted thermal conductivity of bulk Si and Si nanowires with experimental results. When applied to Nb, the results of undeformed, deformed, and heat treated Nb match well with data available in the literature. The results show that boundary scattering dominates for T smaller than 2 K, where the phonon mean free path is comparable to the size of the sample, and that phonon-electron scattering is important when T is greater than 2 K. A local maximum in thermal conductivity (i.e., the phonon peak) appears at temperatures of approximately 2 K in undeformed samples. Phonon-dislocation scattering decreases the lattice thermal conductivity and destroys the phonon peak. Appropriate heat treatment may recover the phonon peak by reducing the dislocation density.
The simulation method presented here may be extended to predict the thermal conductivity of Nb thin films, such as in the application of Nb cladding on Cu, to provide guidance for designing future generations of SRF cavities.

Keywords: superconductivity, Niobium, lattice conduction, deformation, Monte Carlo Simulation.

Poster Number: MM-38
Authors: Chi-Ta Yang; Yu-Xiao Lin; Yue Qi
Title: From Atomistic Understandings to the Estimation of Interfacial Binding of Li and PAA Polymer Interface

Abstract: The popularization of vehicle electrification requires current lithium ion battery (LIB) with higher energy density to make possible the extended driving range at a lower cost. One promising approach is to adopt the lithium (Li) metal as the anode due to its ultrahigh capacity and lowest reduction potential; however, Li dendrite growth is an inevitable downside that can lead to capacity loss and short circuit. It is recently shown that Li polyacrylic acid (Li-PAA) polymer as the passivation layer or solid electrolyte interphase (SEI) can exhibit high elasticity, high binding, and excellent stability to mitigate the Li dendrite growth during Li plating/stripping processes. However, the experimental limitation to measurement of the interfacial binding of the Li and PAA polymer (Li|PAA polymer) and of common passivation layers and PAA has retarded the corresponding advancement. In this work, we employ DFT calculations to investigate the atomistic understandings at the Li|PAA polymer interface via the model systems consisted of Li and PAA oligomers. The observed interfacial interactions and phenomena are then utilized to estimate the interfacial binding, and also give insights into the Li ionization of PAA utilized in the experiment. We have proposed a methodology to approximate the binding of PAA polymer at the interface. The study of SEI film containing any other polymers and composites of polymers and inorganic materials is expected to be benefited from our study for advanced Li ion batteries.

This work was supported in part by Department of Energy

Keywords: DFT, polymer, Li ion battery, interface

Poster Number: MM-39
Authors: Jie Yang; Matthew Melton; Wei Yang; Shiwang Cheng
Title: Network Aging Leads to the Arrhenius-Like Dynamics of Polymer Nanocomposites

Abstract: Polymer nanocomposites (PNCs) are important building blocks for emerging challenges related to environment, energy, food, and medication, whose linear viscoelastic properties plays the deterministic role in their design and performance evaluation. Recent studies showed the shift factor log(aT) from linear rheological test changes from a William-Landel-Ferry (WLF) type to an Arrhenius-like with the activation energy of around 200 - 400 kJ/mol. Moreover, the absolute values of aT spanned over 25 decades at a finite temperature range between their glass temperature Tg and Tg + 150 K [1,2]. These observations can hardly be understood within current framework of our understandings on nanocomposites. In this contribution, we aim to unravel the origin of the Arrhenius-like dynamics of PNCs through a combination of rheology and dielectric spectroscopy. The dielectric measurements show both the segmental and the chain dynamics of PNCs follow the same WLF behavior as the neat polymer, while the shift factor log(aT) from rheology of the same PNCs exhibits Arrhenius-like temperature dependence, suggesting a strong decoupling between the polymer dynamics of PNCs and the overall dynamics of the PNCs. Further analyses suggest that the aging dynamics of the nanoparticle network through bridges that dominates the low-frequency and long-time behavior of PNCs is the origin of the shift from WLF to Arrhenius-like temperature dependence.
[1]. Baeza, G. P.; Dessi, C.; Costanzo, S.; Zhao, D.; Gong, S.; Alegria, A.; Colby, R. H.; Rubinstein, M.; Vlassopoulos, D.; Kumar, S. K. Nature Communications 2016, 7, 11368.
[2]. Mujtaba, A.; Keller, M.; Ilisch, S.; Radusch, H. J.; Beiner, M.; Thurn-Albrecht, T.; Saalwächter, K. ACS Macro Letters 2014, 3 (5), 481-485.

Keywords: polymer nanocomposites, Arrhenius-like dynamics, shift factor, aging, nanoparticle network

Poster Number: MM-40
Authors: Weiyang Yang; Jiajia Wu; Qi Hua Fan; Wen Li
Title: Highly Conductive, Transparent, and Antireflective Pedot:PSS/ITO/Ag/ITO on Parylene C with Tunable Peak Transmittance

Abstract: Transparent and flexible conductive thin films are critical components in optoelectronics, such as wearable electronics, biosensors, and displays. Traditional transparent electrodes made of a single layer of indium-tinoxide (ITO), ultrathin metal, graphene or poly-(3, 4ethylenedioxythiophene)/poly(styrenesulfonate) (PEDOT: PSS) hardly possess the desired combination of high transmittance, low electrical resistivity, mechanical flexibility, and biocompatibility. Although ITO/Ag/ITO multilayer thin films have been studied for solar cell applications, the deposition of high-quality ITO usually requires high-temperature processes incompatible with polymers. In this work, we successfully fabricated an ultraflexible, conductive, transparent thin film using a PEDOT:PSS/ITO/Ag/ITO multilayer structure on Parylene C at room temperature. Compared to single-layer ITO of an equivalent thickness, the multilayer film exhibited significantly enhanced sheet conductivity, reduced electrochemical impedance, remarkable transmittance, excellent adhesion, and flexibility. The peak transmittance of the combined films can be tailored to a specific wavelength for particular applications, such as optogenetics. Besides Parylene C, our high-quality ITO/Ag films can be deposited on a wide variety of heat-sensitive substrates over large scales.

Keywords: transparent electrode, oxide/metal/oxide, ultrathin metal, optogenetics, indium-tin-oxide

Poster Number: MM-41
Authors: Chi Zhan; Weiyi Lu
Title: Effect of Hollow Nanoparticles on Mechanical Properties of Hybrid Polyacrylamide Hydrogels

Abstract: Hydrogels are polymeric materials that consist of three-dimensional cross-linked networks swollen by large amount of water. Hydrogels are appealing materials for tissue engineering, drug delivery and so on due to their extraordinary biocompatibility. However, the major challenge in these applications is the poor mechanical properties of traditional hydrogels. There are urgent demands on advanced hydrogel systems with enhanced mechanical properties, especially the strength and toughness. Among existing efforts, nanocomposite hydrogels have shown improved strength by introducing nano-fillers into the polymer networks. The mechanism of nano-reinforcement is attributed to the extra chemical or physical interactions between the nano-fillers and the polymer chains.
In the present work, a new type of nano-fillers, hollow nanoparticles (HNPs), has been introduced into polyacrylamide (PAAm) network to improve the mechanical properties of the parental hydrogel. Three kinds of silica nano-fillers with different particle sizes and different nanostructures (hollow vs solid) have been selected for hydrogel nanocomposites. Quasi-static mechanical tests including compression tests, tension tests, and rheology measurements have been conducted to characterize the mechanical properties of the synthesized hydrogel systems. We aim to reveal the relationship between morphology, nanostructure and loading fraction of the nano-fillers and the mechanical properties of hydrogel nanocomposties. We expect that the nanoporous structure of HNPs can have a better reinforcement effect on hydrogels than traditional solid silica particles. To date, our experimental results have shown that HNPs can significantly improve the strength and toughness of PAAm hydrogels network.

Keywords: hydrogel; nanoparticles; reinforcement

Poster Number: MM-42
Authors: Yubo Zhang; Yeting Wen; Kevin Huang; Jason D. Nicholas
Title: Degradation & Performance Studies of Atomic Layer Deposition Stabilized Nano-Composite Solid Oxide Fuel Cell Cathodes

Abstract: Solid Oxide Fuel Cell (SOFC) is a potential candidate for future energy generation technologies due to its high power density, high energy conversion efficiency and fuel flexibility. The high resistance and degradation rate for its cathode, however, have become a barrier to its further development and commercialization. As a thin film deposition method, Atomic Layer Deposition (ALD) has drawn attention for SOFC applications because of its low deposition temperature and high film conformity. Here, ZrO2 thin film overcoat was deposited on La0.6Sr0.4Co0.8Fe0.2O3-Gd0.2Ce0.8O2 (LSCF-GDC) SOFC Nano-Composite Cathode (NCC) with ALD and was shown to improve the long-term stability of LSCF-GDC cathode without hurting its performance. LSCF-GDC NCCs with 1nm, 2nm and 5nm ZrO2 overcoat all showed improved degradation rate with slightly improved initial polarization resistance compared with standard cells. 5nm ZrO2 overcoat showed the best long-term stability and decreased the degradation rate of LSCF-GDC NCCs at 650C by about 70%.

This work was supported in part by Department of Energy

Keywords: SOFC, ALD, energy

Poster Number: MM-43
Authors: Matthew Melton; Shiwang Cheng
Title: Unraveling the Role of the Interfacial Polymer Layer to the Nanoreinforcement Effect of Polymer Nanocomposites Through Atomic Force Microscopy and Rheology

Abstract: As the global importance of the search for renewable and sustainable plastics increases, a fundamental understanding of polymer network interactions is necessary. Adding inorganic nanoparticles to a polymer matrix can lead to the enhancement of mechanical properties with strong temperature and frequency dependence among the polymer nanocomposites (PNCs) formed, but the PNC interactions are not well understood. Recent studies proposed that the dependence on temperature and frequency of the dynamic modulus of PNCs correlate with the thickness and modulus of the interfacial polymer layer between the polymer matrix and the surface of nanoparticles; however, no direct evidence has yet been provided. To demonstrate this correlation between the interfacial modulus and the temperature/frequency dependent dynamics modulus, this work proposes a combination of atomic force microscopy (AFM) and rheological measurements. We show unmistakably that the interfacial polymer layer exists with a high modulus between the polymer matrix and the surface of the nanoparticles at the nanoscale, and whose thickness and modulus hold a strong anti-proportional relationship with temperature. Interestingly, the amplitude of this reduction in the interfacial modulus correlates well with the softening in the dynamic modulus from macroscopic rheological measurements. These results provide direct evidence of the origin of nanoreinforcement effect in PNCs with well-dispersed nanoparticles.

MECHANICS AND STRUCTURES

Poster Number: MS-01
Authors: Gaurav Chauda; Daniel J. Segalman
Title: Significance of the Elastic Decoupling Assumption in Frictional Contact

Abstract: A numerical contact study of a rigid indenter on an elastic half-plane has been performed to assess the mechanical significance of a decoupling assumption commonly used in elastic, frictional contact analysis. The decoupling simplification is the assertion that the normal tractions in the interface are unaffected by shear loads applied to the indenter. This study required development of a contact algorithm capable of employing the decoupling assumption or accommodating fully coupled elasticity. Prediction of this algorithm is compared with analytic results where they are available, including multiple cases where decoupling assumption is employed and a few where it is not. (Extreme analytic complexity results when the decoupling assumption is not employed.) With the new framework, we can study the model predictions of coupled and uncoupled systems and by examining the difference in those predictions, assess the significance of the elastic decoupling approximation. One very interesting observation is that where the decoupling assumption is used, the resulting mechanical system appears to comply with Masing's plasticity formulation. Where there is elastic coupling, the force-displacement behaviors do not appear to conform to any simple relationships. In the future, we are interested in using this testbed for understanding partial slip behavior with other friction models (Dynamic Coulomb, Stribeck, LuGre).

This work was supported in part by NSF under grant CMMI-1561628

Keywords: friction, contact mechanics, numerical, elasticity, dissipations, damping

Poster Number: MS-02
Authors: Sheng Chen; Justin Scott; Tamara Reid Bush; Sara Roccabianca
Title: A Nonlinear Finite Element Model of Human Thigh with High Anatomical and Mechanical Fidelity

Abstract: Pressure ulcers are a severe condition developed from prolonged external pressure over bony prominences, mostly occurring in the thigh and buttock areas of people who have impaired mobility. Finite element (FE) analyses have long been used to study the formation mechanisms of pressure ulcers. We identify two critical issues in pressure ulcers investigation using finite element method: the accurate three-dimensional (3D) geometric representation and the validation of the nonlinear mechanical behavior of soft tissues. To resolve these issues, we constructed a subject-specific human thigh model with high anatomical and mechanical fidelity. An indentation test was performed on the posterior side of the thigh on three locations (i.e. proximal, middle, and distal), with the participant (male, 26 years old, 185cm, 185lb) being in a quadruped position. Force and deflection measurements were collected. The 3D geometry of different components of the thigh was constructed using thigh MRI images of the participant and then meshed using TET10 elements. Ogden material was used to represent the nonlinear mechanical behavior of fat and muscle. The femur was modeled as a rigid body. Material parameters of muscle and fat tissues were optimized employing the simplex search method implemented. The goal of the optimization process was to minimize the difference between the FE simulated force-deflection curves and the experimental data at each location. The optimized results of the FE simulation show a good agreement with experiments: NRMSD between simulated and experimental data at the proximal, middle, and distal thigh locations are 5.47%, 1.48%, 8.96%, respectively.

This work was supported in part by NSF CBET 1603646

Keywords: finite element method, nonlinear mechanical behavior, material properties, biological soft tissues

Poster Number: MS-03
Authors: Eduardo Moraes; Mohsen Zayernouri; Mark Meerschaert
Title: An Integrated Sensitivity-Uncertainty Quantification Framework for Stochastic Phase-Field Modeling of Material Damage

Abstract: Materials accumulate energy around voids and defects under external loading, causing the formation of micro-cracks. With increasing or repeated loads, those micro-cracks eventually coalesce to form macro-cracks, which in a brittle material can cause catastrophic failure without apparent permanent deformation. At the continuum level, a stochastic phase-field model is employed to simulate failure through introducing damage and fatigue variables. The damage phase-field is introduced as a continuous dynamical variable representing the volumetric portion of fractured material and fatigue is treated as a continuous internal field variable to model the effects of micro-cracks arising from energy accumulation. We formulate a computational-mathematical framework for quantifying the corresponding model uncertainties and sensitivities in order to unfold and mitigate the salient sources of unpredictability in the model, hence, leading to new possible modeling paradigms. Considering an isothermal isotropic linear elastic material with viscous dissipation under the hypothesis of small deformations, we employed Monte Carlo and Probabilistic Collocation methods to perform the forward uncertainty propagation, in addition to local-to-global sensitivity analysis. We demonstrate that the model parameters associated with free-energy potentials contribute significantly more to the total model output uncertainties, motivating further investigations for obtaining more predictable model forms, representing the damage diffusion. The numerical results qualify the framework to act as a self-assessment tool to robustly identify model discrepancies.

This work was supported in part by AFOSR Young Investigator Program (YIP) award (FA9550-17-1-0150) and the MURI/ARO (W911NF- 15-1-0562).

Keywords: uncertainty quantification; sensitivity analysis; phase-field models; damage; failure

Poster Number: MS-04
Authors: Kristina M. Kamensky; Ranjan Mukherjee; Aren M. Hellum
Title: Underwater Contactless Grooming Device for Stationary Marine Vessels

Abstract: The underwater grooming device proposed uses confined radial outflow to generate both a means of contactless grip to the hull of a vessel and enough wall shear to dislodge biofilm. When a clean and sterile surface is submerged in a marine environment, various bacteria will settle and colonize. Without any disturbance to this biofilm, the surface becomes a patchwork of competing species of biofoul. Since the rate of adhesion for biofoul is exponential, the grooming procedure requires enough inlet fluid power to generate sufficient wall shear stress as well as to determine the ideal frequency of cleanings to prevent macrofouling. A balance of fluid power and cleaning frequency becomes a successful part of routine maintenance. Bio-fouling pressure varies with the season, with summer being the peak. Thus, cleaning frequency would fluctuate alongside average water temperature. Computational Fluid Dynamics (CFD) modeling was utilized to design and build a prototype with a sufficient level of cleaning power. Preliminary field test studies were completed in the summer of 2018 in Narragansett Bay, Rhode Island. Plates were groomed at different frequencies, with more extensive field test studies planned for summer 2019. In addition to repeating the testing procedure of untreated sample plates, a duplicate set of plates have an anti-fouling paint both to test the difference in effectiveness and to observe possible surface wear to paint from contactless grooming.

This work was supported in part by Office of Naval Research

Keywords: computational fluid dynamics, biofoul, wall shear stress

Poster Number: MS-05
Authors: Puneet Kumar; Venkatesh Kodur
Title: Effect of Temperature Induced Restraint on Fire Resistance of Prestressed Concrete Beams

Abstract: Contemporary prescriptive based approaches for fire resistance evaluation of prestressed concrete (PC) structural members have numerous drawbacks, and do not account for critical factors governing fire resistance. Of these factors, restraint forces that develop under fire conditions play a major role in determining fire resistance of PC beams as the magnitude and location of such restraint forces vary throughout the fire exposure. Therefore, to evaluate the effect of restraint on fire resistance of PC beams, a generic three-dimensional finite element model is developed in ANSYS to evaluate fire performance under realistic fire, loading, and restraint conditions. Developed model accounts for critical factors governing fire behavior of PC beams; including restraint location, connection stiffness, cracking and crushing of concrete, member dimensions, temperature induced material degradation, and load intensity. This model is validated using appropriate experimental data, and validated numerical model is applied to undertake a series of case studies on PC beams. Results from

these case studies clearly indicate that restrained PC beams exhibit high fire resistance under realistic fire, loading, and restraint conditions. Results from these case studies are currently being utilized to propose a rational design approach for performance based fire design of PC beams.

This work was supported in part by PCI Jenny Fellowship

Keywords: PC beam, fire exposure, finite element model, fire resistance, restraint location

Poster Number: MS-06
Authors: Saratchandra Kundurthi; Mahmoodul Haq
Title: Effect of Hole Patterns on the Tensile Strength of Perforated, Multi-Material, Single Lap Joints

Abstract: Perforated adhesive joints have been explored in recent literature for enhancing the tensile and impact strength of double lap joints. This procedure involves drilling a pattern of holes in the adherends to allow the adhesive to ooze out and create a mechanical interlock. Since the double lap configuration is that of pure shear, the increase in joint strength can be attributed purely to a change of failure mode to shear-out of the resulting adhesive columns.
In contrast, single lap joints (SLJs) have the adhesive layer experiencing both shear and peel stresses, leading to a more complex failure mode if they are made perforated and subject to tensile loads. In multi-material SLJs, tensile strength can also be increased by reducing the effective bending stiffness of the stiffer adherend, and having perforated adherends is one way of achieving this. While perforated SLJs have these potential advantages, the strength is sensitive to hole locations, and they must avoid stress concentration zones.
This study aims to prove that the hole location and size is important in SLJs, and can even reduce performance if not optimized properly. For the same hole area, the preliminary results show that the strength can vary from -23% (worse than baseline) to +11% (improvement over baseline), thus highlighting the need for optimization.

Keywords: adhesive joints, multi-material joining, single lap joints, adhesive joint mechanics

Poster Number: MS-07
Authors: Hamid Mohammadi; Roozbeh Dargazany
Title: A Micro-Mechanical Approach to Model Thermal Induced Aging in Elastomers

Abstract: This poster presents a micro-mechanical approach to describe the effects of thermal induced aging on the constitutive behavior of aged elastomers at the long-range timescales. In particular, this model focuses on the effects of thermal induced aging on the quasi-static mechanical response of elastomer and their inelastic responses such as Mullins effect and permanent set over time. The model describes the aging induced damage with respect to experimental studies on the process of chemical aging which suggests high detachment of original covalent bonds and formation of new bonds. Accordingly, in the course of aging, the strain energy of the polymer matrix is divided from two independent sources, (i) a decomposing original matrix cross-linked by small number of strong original bonds, (ii) a newly formed matrix cross-linked by high number of weak reformed bonds. Each network has its own damage mechanisms which are induced based on the applied deformation and time. The proposed mechanism satisfies the Clausius–Planck inequality and is thus physically feasible. The model is validated with respect to a comprehensive set of experimental data designed by Johlitz et al. to capture thermal induced aging effect on constitutive behavior of elastomers. Besides accuracy, the model is relatively simple and easy to fit. It requires ten material parameters, all with clear physical meaning, which can be identified from only one set of experiment.

Keywords: elastomer, thermo-oxidation, constitutive behavior, degradation, micro-mechanical modelling

Poster Number: MS-08
Authors: Laura Nye; Sara Roccabianca
Title: Parameter Optimization and Finite Element Modelling of Urinary Bladder Tissue

Abstract: Finite Element Models of soft biological tissues are becoming more prevalent in biomechanical research. The potential of this type of structural analysis is patient-specific modelling of tissue-level behavior and organ-level behavior due to differences in geometry, constituent composition, age, etc.

Organ-level models currently neglect interactions with forces in the body. Surrounding tissues and organs add a significant boundary condition to the finite element model. The ultimate goal of this project is to create a more accurate model of the urinary bladder, taking into account not only the stresses due to expansion, but also stresses from the surrounding tissues.

The first step in this project is modelling stresses of tissue samples tested on a uniaxial machine. The geometry and mesh are created in the FEM solver FEBio. MATLAB is then used to perform parameter optimization with the experimental results from multiple samples. This process yields each specimen's approximate parameters as a viscoelastic material. In the future, the same methods will be applied to a 3D model of the urinary bladder.

Keywords: FEM, optimization, tissue mechanics, biomechanics

Poster Number: MS-09
Authors: Evan Patton, Mahmood Haq
Title: Predicting Poisson's Ratio Due to Geometric Variances in Auxetic Structures

Abstract: Auxetic structures are tailored structures that exhibit negative Poisson's ratio under a given loading. These structural geometries can behave differently than their material composition due to their unique geometric configurations. These tailored structures are able to undergo controlled deformations leading to immense capabilities of energy absorption (S. Mohsenizadeh, 2015). This work describes methods of predicting Poisson's ratio by altering a re-entrant honeycomb geometry produced by a sterolithography printer with an elastomeric resin. The interior geometric angles of these structures were modified, and finite element and unique analytical models were used to predict and correlate the Poisson ratio of the structural configurations.

This work was supported in part by Self-funded (SMART Student)

Keywords: auxetic, 3D printing, structural, energy absorbtion

Poster Number: MS-10
Authors: Mayank Sinha; Alborz Izadi; Rebecca Anthony; Sara Roccabianca
Title: Employing the Use of Bifurcations to Measure Mechanical Properties of Thin Films

Abstract: Silicon in its nanocrystal form has photoluminescent and semiconducting properties which make it an attractive option for use in different technologies. The study of mechanical properties of silicon nanocrystals to design such technologies has been done extensively over the past few decades. However, much of the earlier work focused on measuring the properties of Silicon Nanocrystals (SiNC) over hard substrates. Studying the properties of SiNC deposited on a soft and flexible substrate opens up new possibilities in device development like flexible displays and various medical devices.
For such systems with a flexible substrate, studying the formation of instabilities is an effective method to measure the mechanical properties of SiNC. Here we devise a novel method to evaluate the in-situ mechanical properties of the deposited SiNC, estimated by recording the onset of bifurcation during finite bending of the system.
Next, to validate the results from the previous method a theory is developed to perform an inverse test in which a thin film is wrapped around a rectangular substrate pre-stretched around a cylindrical surface. The onset of bifurcation on the surface of the thin film due to unwrapping of the substrate gives us an estimate for the mechanical properties of the thin films which can then be compared to the value obtained by the previous method.

This work was supported in part by NSF

Keywords: bifurcation, finite bending, prestretch, thin films, silicon nanocrystals

Poster Number: MS-11
Authors: Pegah Varghaei; Ehsan Kharazmi; Mohsen Zayernouri
Title: Nonlinear Vibration of Fractional Viscoelastic Cantiliever Beam: Application to Structureal Health Monitoring

Abstract: We investigate the nonlinear vibration of a viscoelastic cantilever beam with fractional constitutive relation, subject to base excitation. We consider the general form of distributed-order fractional differential equation and use extended Hamilton's principle to derive the governing equations of motion for fractional Kelvin-Voigt viscoelastic model, which is then solved via a spectral decomposition in space. By direct numerical integration of resulting temporal fractional ODE, we observe an anomalous power-law decay rate of amplitude in the linearized model. The nonlinear equation is solved by perturbation analysis, where we replace the expensive numerical time integration with a cubic algebraic equation to solve for frequency response of the system. We report the super sensitivity of response amplitude to the fractional element parameters at free vibration, and bifurcation in steady-state amplitude at primary resonance. We further use the observed vibration-based features of system response for different values of fractional derivative order to develop a parameter estimation framework, which can be used to assess the heath of considered beam by assuming a threshold in the model parameters.

This work was supported in part by AFOSR Young Investigator Program (YIP) award (FA9550-17-1-0150) and the MURI/ARO (W911NF- 15-1-0562).

Keywords: fractional viscoelasticity, machine learning, perturbation analysis, structural health monitoring, failure analysis

Poster Number: MS-12
Authors: Svetha Venkatachari; Venkatesh Kodur
Title: System Level Analysis of Braced Frame Structure under Design Fire Exposure

Abstract: In the event of fire, steel frame buildings are vulnerable to excessive damage or even collapse. Loss of strength and stiffness in steel members exposed to elevated temperature causes failure at a member level. The onset of instability due to failure of individual structural members can propagate through the building resulting in progressive collapse of the structure. Assessment at a system level is needed to capture the realistic response of the structure and potential collapse when subjected to fire conditions. This paper examines the system level behavior of a braced frame structure under design fire exposure scenarios. Numerical studies are conducted on a three-dimensional model of a 10-storey steel frame building with perimeter V bracing using the finite element software, ABAQUS. The effect of parameters such as location of fire, type of fire exposure and spread of fire from one compartment to another on the performance of the structure is examined. Nonlinear dynamic explicit analysis is carried out to trace the response beyond stages of local member failures. Stresses, deflections and axial forces are evaluated from the simulation. In addition, the nature of load path following an initial member failure is also studied. The study indicates that the failure time and likelihood of progressive collapse depends significantly on the location and type of fire exposure. Results show that the required fire rating for structural members as per the current provisions of IBC may not be sufficient under certain design fire exposure scenarios.

Keywords: braced frame, design fire, fire spread, progressive collapse, load path

Poster Number: MS-13
Authors: Shutian Yan; Jie Deng; Chulheung Bae; Xinran Xiao
Title: Characterization and Modeling of Polymeric Battery Separators

Abstract: For the safety design and integration of battery modules in vehicles, a thermo-electro-mechanical battery model for vehicle crash simulations is under development. The current research focuses on mechanical modeling of the battery separators. A separator is a porous membrane with a thickness of several dozen microns. It prevents physical contact between the positive and negative electrodes while enabling ionic transport. The integrity of the separator is critical to the safety of the batteries.Separator failure can lead to a thermal event.

Experimental methods have been developed for the measurements of the shear property and the Poisson's ratio for polymer films with a thickness of tens micrometers. In this work, these measurements were attempted with a DMA. Digital image correlation (DIC) was used for strain measurements. The shear property was measured using the off-axis tensile experiment. Based on the analogy for anisotropy between the elastic and linear viscoelastic domains, the shear creep response was also measured. The creep compliances in shear and in the principal material directions were determined. The mechanical model is developed on an orthotropic viscoelastic framework. A discretization algorithm has been proposed for the evaluation of a stiffness-based hereditary integral with a kernel of Prony series.The model has been implemented in commercial FE package LS-DYNA® as a user defined material model. The implemented model has been verified with analytical solutions and validated with experiments under uniaxial loading conditions. The model validation for biaxial loading cases is ongoing.

This work was supported in part by Ford Motor Company

Keywords: porous polymer film; orthotropic; viscoelasticity; digital image correlation; modeling

Poster Number: MS-14
Authors: Atacan Yucesoy; Thomas J. Pence; Ricardo Meija-Alvarez; Adam M. Willis
Title: Blast Wave Load Effect on the Key Morphological Features in the Brain.

Abstract: Blast-induced traumatic brain injury (bTBI) is a leading cause of mortality and morbidity for personnel deployed in conflicts overseas. Exploring the mechanics of brain tissue is critical to predict intracranial brain deformation and injury resulting from severe blast loading. This capability would help in obtaining a prognosis and choosing adequate neurosurgical procedures before a physical intervention takes place. The recent advancements in computational tools can give us an opportunity to explore neuropathological damages occurring within the brain that result from exogenous mechanical forces, such as bTBI. The goal of this study is to build a numerical model with the ability to capture the complex deformations induced by blast loading. To this end, we consider morphologically different brain structures by simulating blast effect with coupling method of Load Blast Enhanced (LBE) and (Multi-Material Arbitrary Lagrange Eulerian (MM-ALE). Along with seeking the effect of geometrical differences on the interaction between blast exposure and brain tissue, we investigate the effect of contact mechanisms and swelling on the interaction between different structures in particular, grey and white matter, and vasculature and surrounding tissue.

This work was supported in part by Qatar National Research Fund (QNRF)

Keywords: blast, brain, morphology, simulation, FSI

Poster Number: MS-15
Authors: Mansour Alturki; Rigoberto Burgueño
Title: Multistable Cosine-Curved Dome System for Elastic Energy Dissipation

Abstract: A new energy dissipation system comprised of multistable cosine-curved domes (CCD) connected in series is proposed. The system exhibits multiple consecutive snap-through and snap-back buckling behavior with a hysteretic response. The mechanical deformations of such systems are fully reversible since the total response is within the elastic regime of the constituent base material. Numerical studies and experimental tests were conducted on the geometric properties of the individual CCD units and their number in the system to study the force-displacement and energy dissipation properties. Finite element analysis (FEA) was performed to simulate the response of the system to develop multilinear analytical model for the hysteretic response that considers the nonlinear behavior of the system. The model was used to study energy dissipation characteristics of the system. Experimental tests on 3D printed specimens were conducted to analyze the system and validate numerical results. Results show that the energy dissipation mainly depends on the number and the apex height-to-span length ratio of the CCD units. The developed multilinear analytical model yields conservative yet accurate values for the dissipated energy of the system. The proposed system offered reliable high energy dissipation with a maximum loss factor value of 0.14 for a monostable (self-recoverable) system and higher for a bistable system.

Keywords: elastic instability, energy dissipation

Poster Number: MS-16
Authors: Sheryl Chau; Ranjan Mukherjee
Title: Kinetic to Potential Energy Transformation Using a Spring as an Intermediary: Application to the Pole Vault Problem

Abstract: The kinetic energy of a mass moving horizontally can be completely converted into potential energy using a spring as an intermediary. The spring can be used to temporarily store some of the energy of the mass and change the direction of motion of the mass from horizontal to vertical. A non-dimensional framework is used to study this problem for a point mass, first with a linear spring and then with a nonlinear spring that is an elastica. Solutions to the problems with the linear spring and elastica show many similarities and some dissimilarities. The dynamics of the point mass and elastica resemble the mechanics of a pole-vault; and, therefore, a non-conservative external torque is introduced to parallel the muscle work done by vaulters. For the non-conservative system, the problem is solved for complete transformation of the kinetic energy of the mass and the work done by the external torque into potential energy of the mass. The initial velocities for the two cases, with and without the non-conservative force, are quite similar; and, therefore, the maximum potential energy of the mass is higher in the presence of the non-conservative force. A realistic dimensional example is considered; the solution to the problem, despite several simplifying assumptions, is found to be similar to data of elite pole-vaulters presented in the literature.

This work was supported in part by NSF GRFP

Keywords: energy transformation, pole vault, mechanics, elastica

Poster Number: MS-17
Authors: Berk Can Duva; Lauren Chance; Elisa Toulson
Title: Experimental and Numerical Investigation of CO2 Dilution Effect on the Laminar Burning Velocities of Methane/Air Mixtures at High Temperature

Abstract: With increased interest in reducing emissions, the staged combustion concept for gas turbine combustors is gaining in popularity. For this work, spherically expanding flames were employed to measure the laminar burning velocities of premixed methane/air mixtures at 1 bar and 473 K with 0%, 5%, 10% and 15% CO2 dilution using the constant pressure method enabled via schlieren visualization of the flame front. The effect of CO2 dilution on the flame instabilities during combustion was investigated by observing the change in the burned gas Markstein length with the addition of the diluent. Numerical results were obtained with CHEMKIN using the GRI-Mech 3.0 and the San Diego mechanisms in order to test the performances of these mechanisms at high temperature and high dilution ratios. Additionally, the dilution, thermal-diffusion, and chemical effects of CO2 on the laminar burning velocities of methane/air mixtures were investigated numerically by diluting the mixtures with both chemically active and inactive CO2 following the determination of the most important elementary reactions on the burning rate through sensitivity analysis.

Keywords: combustion, gas turbine, laminar flames, flue gas recirculation, chemical mechanism

Poster Number: MS-18
Authors: Fuming Yang; Mingzhe Li; Weiyi Lu
Title: Enhanced Compressive and Bending Performance of Liquid Nanofoam-Filled Thin-Walled Tubes

Abstract: Thin-walled metal tubes have become one of the most widely used energy absorption structures in automotive, aerospace, and military applications due to their light weight and high energy absorption efficiency. Upon external impact, the input energy is typically mitigated through progressive axial folding or bending collapse of the tube wall. However, the large difference between the initial buckling strength and the post-buckling plateau of the tube has limited the energy absorption efficiency of thin-walled tubes. In this study, we have employed liquid nanofoam (LN), a novel nanofluidics-based energy absorption material, as a filler in this study. We hypothesize that the resulted LN filled tubes (LNFTs) have high energy absorption efficiency due to the extremely large energy absorption capacity of the LN and the much enhanced filler-tube wall interaction. To test this hypothesis, we have characterized the mechanical behavior of LNFTs by quasi-static compression and three-point bending tests.
Our results show that the LN filler significantly promotes the energy absorption efficiency of the nanofluidics-based composite structure under both axial and side impact conditions. The LN-filler changes the buckling and bending modes of the tube wall, which indicates that the filler-tube wall interaction is much enhanced in LNFTs. These findings have demonstrated that LN is a promising filler to improve the energy absorption efficiency of thin-walled structures under various loading conditions. Our next step is to test the dynamic compressive and bending behavior of LNFTs at higher strain rates by utilizing drop tower and split Hopkinson Pressure bar apparatus.

This work was supported in part by Weiyi Lu Michigan State University Start Up Grant

Keywords: thin-walled tubes, energy absorption efficiency, liquid nanofoam, quasi-static test, dynamic test

Poster Number: MS-19
Authors: Ali Imani Azad; Rigoberto Burgueño
Title: An Analytical Model to Predict the Postbuckling Response of Thin-Walled Cylindrical Shells with Non-Uniform Distributed Stiffness

Abstract: Thin-walled cylindrical shells show multi-stable behavior under compressive loads which recently receives more attention for smart applications. However the postbuckling response of such a cylinder is not predictable yet due to its high sensitivity to the initial imperfections. This study aims to develop an analytical model for the thin-walled cylinder with non-uniform distributed stiffness to control its postbuckling behavior. The distribution of non-uniform stiffness limits the buckling events to the specific panels surrounded by stiffer unbuckled areas with various levels of stiffness. In this model, equilibrium and compatibility equations are developed for an individual panel with flexible boundaries based on classical shell theories and Von Karman's kinematic nonlinearity. These equations are approximately solved by Galerkin method. The overall nonlinear response of the cylinder is produced from superposing the response of individual panels. The results from this analytical solution will be verified against the results from experiment and verified finite element model. Finally, the effect of number, stiffness, and size of the stiffened areas on the force-displacement relation of the cylinder will be studied.

This work was supported in part by NSF

Keywords: cylindrical shell,postbuckling response, nonuniform stiffness

Poster Number: MS-20
Authors: Vahid Morovati; Roozbeh Dargazany
Title: A Physically Motivated Model for Accumulated Damage of Double-Network Hydrogels

Abstract: Double network hydrogel (DN hydrogels) is a class of reinforced hydrogels that benefits from a significantly high stretchability and toughness. However, they lose their toughness due to the accumulation of damages in the cyclic loading during their lifetime. They have high water content and are extremely soft and mostly biocompatible. These excellent properties make them a great candidate for load bearing in biomedical applications. While recent advances in the process and characterization of the gels have led to significant improvements in their properties, our understandings of the accumulated damage mechanism within the material remain sparse and inconclusive. In this study, a physically motivated constitutive model is presented for DN gels subjected to a high number of cyclic deformations which will eventually approach to a steady-state after thousands of cycles. The model can be particularly used to elucidate the inelastic features such as permanent damage during deformation of each cycle. The observed damage may be induced from the chains scission, chain slippage or polymer relaxation. Therefore, irreversible chain detachment and decomposition of the first network due to its highly cross-linked structure are explored as the underlying reasons for the nonlinear stress softening phenomenon. The model is validated against the experimental tests. The model contains a few numbers of material constants and shows good agreement with cyclic uni-axial tensile test data.

Keywords: constitutive model, accumulated damage, hydrogels, double-network, inelastic

Poster Number: MS-21
Authors: Roya Solhmirzaei; Venkatesh Kodur
Title: Shear Behavior of Ultra High Performance Concrete Beams without Stirrups

Abstract: Ultra High Performance Concrete (UHPC) is finding increasing applications in infrastructures due to its superior mechanical and durability properties. One such benefit of using UHPC in beams is high shear resistance that can be achieved through adding steel fibers to concrete. There is still lack of research data and design guidelines on shear behavior of UHPC beams. To evaluate the behavior of UHPC beams, a finite element based numerical model is developed in ABAQUS. The developed model accounts for detailed stress strain response of UHPC in both compression and tension and strain hardening effect. Response parameters generated from the model namely deflections, crack propagation, and failure mode are validated against measured data from experiments on UHPC beams. The developed model is applied to study effect of removing stirrups in UHPC beams. Feasibility of removing stirrups in UHPC beams was also evaluated by experiments on beams with varying shear reinforcement ratio. Results indicate that unlike conventional concrete, UHPC beams perform well under dominant shear loading even when no stirrups are provided in beams.

Keywords: Ultra high performance concrete, Steel fibers, Shear response, Shear reinforcement, Finite element analysis

Poster Number: MS-22
Authors: Saleh Alogla; Venkatesh Kodur
Title: Temperature-Induced Transient Creep Strain in Fiber Reinforced Concrete

Abstract: This poster presents development of temperature-induced transient creep strain in different types of concrete. To measure creep strain, concrete specimens were subjected to combined effects of heating and mechanical loading in the temperature range between 20°C to 750°C. The test variables included temperature, load level, rate of heating, strength of concrete and presence of fibers in concrete. Data from these tests indicate that transient creep strain constitutes a significant portion of total strain. Data also affirm that temperature range and stress level have significant influence on the magnitude of transient creep strain, specially at temperatures above 500°C and stress levels of 40% or more. However, rate of heating and presence of fibers in concrete have only a moderate influence on the generated transient creep. Presence of steel fibers in normal strength concrete slightly reduce the extent of transient creep strain, while the addition of polypropylene fibers to high strength concrete leads to higher transient creep strain. Finally, data generated in tests on transient creep strain is utilized to propose temperature and stress dependent creep strain relations for different types of concrete.

Keywords: creep strain, high-temperature creep, transient heating, fire resistance, steel fibers, polypropylene fibers

Poster Number: MS-23
Authors: Srishti Banerji; Venkatesh Kodur
Title: Fire Response of Ultra High Performance Concrete Beams

Abstract: Fire represents one of the most severe environmental conditions to which structures may be subjected during their lifetime and hence provision of fire resistance to structural members is a key consideration in structural design. Generally, concrete structural members (made from Normal Strength Concrete (NSC)) exhibit excellent fire resistance properties. In recent years, Ultra High Performance Concrete (UHPC) is being promoted in infrastructure applications due to its exceptional mechanical and durability properties. However, preliminary research has clearly shown that UHPC exhibits poor fire resistance properties and is highly susceptible to explosive spalling under severe fire conditions. Currently, there are no comprehensive experimental and numerical studies on the fire response of UHPC beams. To overcome these knowledge gaps, a macroscopic finite element model is developed for assessing fire performance of UHPC beams. In the model, fire resistance analysis is carried out in incremental time steps under the combined effects of fire exposure and structural loading till failure of the beam. Spalling in each element is evaluated at each time increment by comparing the resulting stresses, generated from pore pressure and structural loading, against the reduced strength of concrete. The developed model is validated by comparing predicted response of UHPC beams with measured data from fire tests. Results from the analysis clearly indicate UHPC beams have significantly poor fire resistance and are highly susceptible to spalling under fire conditions.

Keywords: ultra high performance concrete, fire induced spalling, numerical model, pore pressure, fire resistance

Poster Number: MS-24
Authors: Yogesh Kumbargeri; Anne Heidelberg; M. Emin Kutay; Ilker Boz
Title: An Image Processing Based Method to Evaluate Chip Seal Pavement Performance

Abstract: The shrink in government budgets has resulted in road agencies to shift focus on pavement preservation strategies as an economically sustainable alternative. Chip seal is one of the most popularly adopted pavement preservation strategies which involves adding hot asphalt or emulsion on surface of existing pavement, spraying aggregates on the top, followed by roller compaction. This treatment generally yields a road life extension of around five years. But with strong evaluation and design methods, it can be further extended to a great extent, in order to save precious tax payers' money. The current practice adopted by road agencies is mostly empirical in nature, hence doesn’t deliver robust analysis and design based on robust mechanistic principles. In order to move towards mechanistic design procedure, there is a need to develop a mechanistic evaluation and analysis method to characterize chip seals.
The objective of this research study was to develop an image processing based method to characterize chip seal performance. This novel technique uses actual images of chip seal pavements (taken by document camera or cell phone camera) to convert into finite element meshes for mechanistic performance evaluation, through development of standalone software package. Furthermore, using this method, effect of aggregate type and percent embedment of aggregates on chip seal performance at multiple temperatures was also evaluated. Results revealed that internal structure and interlocking of aggregates play a major (than expected) role in performance. Thus, this image processing based method and software can be successfully applied to characterize chip seal pavements.

Keywords: pavement preservation, chip seals, image processing, finite element analysis, percent embedment

Poster Number: MS-25
Authors: Haoran Lyu; Haiyan Zhang; Venkatesh Kodur
Title: Experimental Validation of Similarity Theory on RC Beams Under Fire Conditions

Abstract: Fire tests on six rectangular reinforced concrete (RC) beams, with three different scales (1:0.7:0.5), were conducted in this paper, to validate the similarity theory of RC beams under fire conditions. The dimensions and reinforcement of these beams were designed in proportion. Two different loads, with load ratio of 0.35 and 0.5, were applied on each scale of the beam. ISO834 standard temperature-time curves were used for the beam with the smallest scale, and the temperature-time curves of the other beams were calculated through the similarity theory. Test results indicate that the thermal responses of all six beams exhibit good similarity, while the similarity in structural responses are not good as expected. The dissimilarity in structural responses of beams in fire is due to the size effect of mechanical behavior of concrete and reinforced bars at elevated temperatures.

Keywords: beam; fire; concrete; simalirty; model

Poster Number: MS-26
Authors: Augusto Gil; Camila Simonetti; Anderson Bauer; Fernanda Pacheco; Bernardo Tutikian; Venkatesh Kodur
Title: Residual Mechanical Properties of Concretes Made with Steel Fiber Taken From Waste Tires After Exposure to High Temperatures

Abstract: Nowadays, there are several ways to mitigate environmental impacts from incorrect disposal of waste tires, as well as research on methods of reuse for these materials. The construction industry offers an opportunity for reuse of these tires in various applications of concrete and improve some of concrete properties. However, there is still a concern and lack of information on the performance of concrete with waste incorporation when exposed to high temperatures. This paper presents test data and analysis on the loss of mechanical properties of concrete with recycled steel fiber from waste tires due to heat exposure. The experimental program is based on evaluation of the residual mechanical properties of the concrete subjected to elevated temperatures at different levels. After 28 days of curing and 7 days in a kiln to establish humidity, the specimens were heated to 300°C and 600°C in a muffle. The specimens were submitted to uniaxial compression, indirect tensile and permeability of concrete. The results indicate that the presence of steel fibers provide a certain residual mechanical strength to concrete, even when exposed to high temperatures. The material data collected can be useful to guide the development of more adequate design procedures for structures exposed to fire.

Keywords: rubber concrete, SFRC, waste tire, high temperatures, fire exposure

Poster Number: MS-27
Authors: Pratik Bhatt; Venkatesh Kodur
Title: Effect of Temperature Induced Bond Degradation on Response of FRP-Strengthened Concrete Beams Exposed to Fire

Abstract: Fiber-reinforced polymers (FRP) are used for strengthening and retrofitting of reinforced concrete (RC) structures. When used in buildings, appropriate fire resistance requirements for structural members must be met, as fire safety is a critical condition in building design. Limited experimental and numerical studies are available in the literature on the fire behavior of FRP-strengthened RC flexural members. However, there are no broad guidelines for fire resistant design of FRP-strengthened concrete structures. Moreover, the effect of bond degradation on fire resistance was not fully captured in most previous studies. To overcome some of the current knowledge gap a macroscopic finite element based numerical model is developed for tracing the response of FRP-strengthened RC beams, from preloading stage to failure under fire conditions. The model utilizes temperature dependent sectional moment curvature relations to trace the response of a FRP-strengthened RC beam as a function of fire exposure time. The model accounts for temperature induced degradation in properties of concrete, steel, FRP, and fire insulation as well as varying temperature induced bond degradation at FRP-concrete interface along the length of the beam. The model is validated by comparing predicted response of FRP-strengthened beams with response parameters, including bond degradation effects, measured in fire tests. The validated model is applied to quantify the critical factors governing fire resistance of FRP-strengthened beams, specifically varying bond degradation along the beam length.

Keywords: bond degradation, CFRP, fire resistance, numerical modeling

Poster Number: MS-28
Authors: Salina Ramli; Andrew Valentine; Mahmood Haq

Title: Experimental Characterization of Hybrid Bolted Joints: Effects of Bolt Diameter and Sleeve Material

Abstract: Multi-material joining is considered as one of the key challenges to overcome for use of composites in mass-produced automotive applications. Drilling holes in composite for fastening results in delamination, creates locations for onset of failure and can reduce load-carrying capacities. Hybrid fastening system with a structural adhesive insert has shown to eliminate bolt-adherend slip, reduce delamination and increase load bearing capacity. Prior work in our group has shown that for ½” bolts consisting of adhesive structural inserts reinforced with composite sleeves resulted in peak load enhancements of 200% to 500% relative to slip-loads in conventional fastening system.
In this work, experimental characterization of hybrid fastening systems comprised of glass fiber reinforced polymer (GFRP) composite substrates fastened using a fully threaded grade 5 steel bolts with varying bolt diameter was performed. The preload was maintained at 75% of the bolt yield strength for all joints. The effect of adhesive, sleeve material and bolt diameter on the efficiency of the hybrid fastening system were compared with conventional fastened joints. Preliminary results indicate that the failure mechanism changed with varying bolt diameter and the type of adhesive used. Hybrid joints were found to have 8 to 17 times higher load carrying capacities relative to slip-loads for conventional joints. Overall, hybrid fastening system used in this work shows promise in multi-material joining for lightweighting applications.

Keywords: hybrid fastening, hybrid bolted joint, composite, adhesive insert

Poster Number: MS-29
Authors: Aksel Seitllari; Mike Lanotte; M. Emin Kutay
Title: Challenges on Calibration of the MEPDG Rutting Model in Asphalt Pavements

Abstract: The repeated load permanent deformation (RLPD) test has been recognized as the most appropriate laboratory procedure to characterize asphalt mixtures, and it is currently used in support of the calibration of the rutting transfer function of the Mechanistic-Empirical Pavement Design Guide (MEPDG). However, many aspects of the RLPD testing conditions, as well as the analysis of the test results and the calibration process itself, seem to be not well defined or accepted and need to be addressed thoroughly for proper calibration.
The primary objective of this study is to provide an overview of the possible issues of the calibration process and quantify the errors in the prediction of HMA rutting using the AASHTOWare Pavement ME software when the calibration is not performed correctly. Four mixtures were characterized in the laboratory by performing confined and unconfined dynamic modulus tests and RLPD tests at a single temperature. RLPD data for two additional temperatures were obtained mathematically using the dynamic modulus shift factors (from both confined and unconfined conditions). The effect on the predicted rutting of (i) using confined and unconfined dynamic modulus testing results to calculate resilient strains and (ii) shift the RLPD data, as well as the (iii) use of a single or multiple RLPD temperatures and (iv) the use of confined and unconfined |E*| as input of the AASHTOWare PavementME, have been evaluated. Results obtained from the AASHTOWare PavementME software showed a significant variability of the predicted rut depths when the calibration process is not appropriately performed.

Keywords: pavement design, rutting calibration, mechanistic-empirical

Poster Number: MS-30
Authors: Aksel Seitllari; M. Emin Kutay
Title: 3-Point Bending Cylinder Test for Characterization of Fatigue Performance in Asphalt Pavements

Abstract: Fatigue cracking in bituminous mixes is one of the most common distresses that affect asphalt pavement roads. The improvement of the laboratory test methods used in their design is crucial to extend the service life of asphalt pavements. This article introduces new a test method that can be used to characterize fatigue cracking phenomena in asphalt pavements. This new approach includes cyclic tests run on cylindrical asphalt specimens in three-point beam mode referred to as three-point bending cylinder (3PBC) test. Timoshenko beam theory and viscoelastic continuum damage theory (VECD) are coupled together to analyze and simulate the fatigue performance of the mixture under different conditions. The 3PBC setup possesses the possibility of estimating Poisson's ratio from the tested data. The proposed 3PBC approach was evaluated through laboratory tests conducted on various asphalt mixtures with varying mix components and volumetric properties. Finite element analysis method was engaged to validate the proposed approach.

Keywords: fatigue characterization, 3PBC test, VECD, finite element method

Poster Number: MS-31
Authors: Syed Fahad Hassan; Suhail H Vattathurvalappil; Rajendra P Palanisamy; Mahmoodul Haq
Title: Evaluating Residual Stresses in Bonded Lap Joints Through Experiments and Numerical Modeling

Abstract: Structural adhesive joining is considered to be an excellent route to achieve both light weighting and dissimilar material joining for automotive structures. While adhesive joining eliminates the needs for drilling holes and distributes the load over larger areas; the processing/curing conditions, especially the thermal shock (rapid cooling) can create residual stresses that significantly reduce the strength of the resulting joints, in most cases prior to application of mechanical/service loads. These residual stresses can lead to dimensional instability, increased stress corrosion and reduced fatigue life. In this study, adhesively bonded single lap joints were manufactured using Acrylonitrile Butadiene Styrene (ABS) adhesive and glass fiber reinforced epoxy (Garolite, G-10) substrates. The joints were processed at a constant temperature of 240℃ maintained via oven-heating and subsequently allowed to cool under natural convection in ambient air. The residual strains generated in the adhesive layer were measured experimentally using an embedded high-resolution fiber-optic strain sensor. The results were compared against a coupled thermo-mechanical finite element (FE) model. Initial results show good agreement between the experiments and numerical models for the elastic behavior.

Keywords: residual stress, bonded lap joints, adhesive joining, finite element modelling, thermoplastic polymers

Poster Number: MS-32
Authors: Martino Taffetani; Giovanni Belingardi; Mahmoodul Haq
Title: Design, Manufacturing and Experimental Testing of a Composite Leaf-Spring Suspension Shackle using "Tailored Fiber Alignment (TFA)"

Abstract: Fiber reinforced polymer (FRP) composites provide high strength to weight ratio and hence attractive for lightweighting in mass-produced vehicles. FRPs allow for tailoring the resulting properties through arrangement of fibers in each layer and strategic lamina stack-up. Structural components having complicated geometries create complex non-linear load paths wherein 'cutting of flat-parts or stackup of lamina' to the desired shape does not work. Furthermore, the cutting of FRPs leads to delamination and additional damage.
Tailored Fiber Alignment (TFA), wherein a fiber bundle(tow) is placed along the load path has shown promise for structural components. In this work, the feasibility of TFA technique to manufacture a composite shackle plate for automotive application is explored. A holistic process that incorporates all the steps from initial design, numerical analysis to determine load paths, TFA of preform, manufacturing of the part and experimental testing was performed . Initially, a computational phase of FE analysis, with a focus on weight reduction and fiber orientation optimization was completed. The stress contours and load-paths were transferred to the fiber-alignment machine to create the desire preforms. Next, vacuum assisted resin transfer molding (VARTM) techniques was used to infuse the preform with SC-15 epoxy (Two-part toughened epoxy). Finally, a dedicated fixture was manufactured to test the part and validate the previous simulations. Similar shackle plates were made with metal and flat composite plates (cut to net part-shape) and the efficiency of TFA part was compared. Initial results show great promise in reducing the weight of the component without sacrificing performance.

This work was supported in part by Politecnico di Torino; FCA

Keywords: TFA; TFP; CFRP; composite; shackle

Poster Number: MS-33
Authors: Marissa Grobbel; Matthew Lewis; Anne Tonson; Robert Wiseman; Sara Roccabianca
Title: Remodeling in the Lean and Obese Type II Diabetic Urinary Bladder

Abstract: Diabetic patients experiencing symptoms of neuropathy can develop a neurogenic bladder, also known as diabetic cystopathy. Loss of connection between the urinary bladder (UB) and nervous system dulls the sensation of fullness in the UB, leading to chronic over-distension. This type of volume overload has been shown to cause an increase in compliance and elastin content, thinned walls, and inflammation. In order to characterize how this remodeling affects the mechanical behavior of UB tissue, uniaxial ring tests and histological analyses were performed on both lean and obese type II diabetic rat UB's. Specifically, we used Goto-Kakizaki (GK, lean diabetic, Wistar as control) and Zucker diabetic fatty (ZDF, obese diabetic, lean littermate as control) rat models. Stress-strain data from these tests were then fitted to an isotropic, exponential material model to compare parameters across the groups. Our results show that in both the lean and obese models, there is an increase in compliance. Namely, parameters specific to compliance at low stresses increased in the diabetic samples. Additionally, the ZDF bladders showed increased compliance compared to the GK's in both the control and diabetic cases. Ongoing histological analyses show a potential increase in elastin content, changes in collagen structure, and increase in mast cell activation in ZDF diabetic bladders compared to controls. Both lean and obese (GK and ZDF) type II diabetic models show signs of UB remodeling, but changes seem to be exacerbated in the obese.

Keywords: Diabetes, urology, remodeling, constitutive modeling

SUSTAINABILITY AND ENVIRONMENT

Poster Number: SE-01
Authors: Moh Alhaj, Ramani Narayan
Title: Analytical Characterization of PLA

Abstract: PLA has been a promising candidate in medical applications (i.e.: drug delivery) due to its biocompatibility and biodegradable behavior. As a chiral molecule, its cyclic monomer lactide possesses three different stereoisomers: L-lactide, D-lactide, and meso-lactide. As a result, the chain rotation varies for each stereoisomer through polarized light. While L-lactide and D-lactide are enantiomers of one another that possess similar material properties, the meso compound possesses considerably different properties (mechanical, thermal, etc.), producing a completely amorphous polymer structure if it is atactic. In addition, meso-lactide has been reported to be an optically inactive compound, as opposed to L- and D-lactide. This experiment is focused on verifying the purity of neat lactide's stereoisomers, comparing them with literature results and commercial standard grades. The polymers will be produced using Witzke's melt polymerization technique. Commercially available and experimentally produced monomer/polymer will be analyzed and compared using various characterization techniques. The chemical composition, molecular weight, optical rotation, and thermal properties will be analyzed and compared with literature results.

This work was supported in part by NSF-GRFP

Keywords: biobased, biodegradable, optical purity, enantiomer, meso

Poster Number: SE-02
Authors: Ehsan Ashoori; Heyu Yin; Sina Parsnejad; Andrew J. Mason
Title: Wearable Particulate Matter Sensor for Real Time Exposure Assessment

Abstract: Airborne particulate matter (PM) includes small particles with aerodynamic diameter of 10 µm or less floating in the air in solid or liquid droplets. When inhaled, these particles are very harmful for human health especially particles smaller than 2.5 µm (PM2.5), also called fine particles. Therefore, a low-cost, wearable PM sensor for individual PM exposure assessment is of high value. To this end, a monitoring platform for real-time PM level assessment is presented. This monitoring platform consists of a particle size separator and a capacitive particle detector. A microfluidic structure is designed for separating particles. It uses an I-shaped pillar based deterministic lateral displacement method to classify and separate particles based on their aerodynamic size. After separation, particle detection takes place where the presence of the particles with specific size causes change in capacitance of the sensing electrodes. By designing low noise read out circuit, extremely small capacitance change of aF range is detectable which in turn enables the monitoring platform to detect fine particles PM2.5.

This work was supported in part by NIH

Keywords: air quality assessment, particulate matter

Poster Number: SE-03
Authors: Sayli Bote; Ramani Narayan
Title: Design and Engineering of Polyols and Polyurethane Foams from Renewable Feedstocks

Abstract: In recent years, increasing concern about the environment and sustainability of petroleum products has led to the invention of various biobased materials. The limited use of biobased polyols in commercial PUFs is due to its inferior performance properties, high technology cost, and incompatibility with petroleum-based polyols. This work will introduce new scalable and economically viable biobased polyols derived from soybean and lactide for polyurethane foam applications. The first part emphasizes on utilizing simple reaction chemistries in a one-pot synthesis method to produce polyols from renewable resources. Polyols from soymeal were synthesized using transamidation followed by ring opening reaction. Different lactide-based diols were synthesized for their application in polyester polyols and polyurethane foams (PUFs). The high hydroxyl value 200~800 mg of KOH/gm of these polyols is suitable for its use in rigid PUFs. The polyols with 35~90 mg of KOH/gm of hydroxyl value and 80% of renewable carbon content were synthesized using polycondensation chemistry for the application in flexible PUFs. After obtaining a broad portfolio of biobased polyols, their performance in PUFs was tested. The latter part focuses on optimizing catalyst concentrations for foam formulations and its subsequent use in synthesizing rigid and flexible PUFs. The rigid PUFs from biobased polyols were characterized for its application in construction materials. The flexible PUFs were tested for mechanical and thermal properties for automotive applications. The properties of flexible PUFs improved with increasing biobased polyol content. These biobased polyols also showed good compatibility with commercial polyols that can potentially provide added advantages through blending. The use of renewable and inexpensive raw materials not only reduces the carbon footprint and cost but also creates value-addition to the bio-refinery products.

Keywords: polyurethane foams, renewable, soybean, automotive, insulation

Poster Number: SE-04
Authors: Erik Brown; Raul Quispe-Abad; Norbert Mueller
Title: Rethinking Hydropower: An Amazon With No New Reservoirs

Abstract: Contrary to popular opinion, traditional reservoir-based dam hydropower is not necessarily an environmentally friendly power generator. The dam can block sediment and marine life transport and migration, flood land that is otherwise available for other species and use, displace people disrupting communities and businesses, increase greenhouse gas emission, and increase the evaporation rate of water, contribute to climate change. It is suggested to replace plans for traditional dam-reservoir hydropower with plans for more ecologically and socially friendly renewable energy sources. It is suggested to replace traditional dam-reservoir hydropower plans with more ecologically and socially friendly renewable energy sources. It is hypothesized that the under produced and future planned dam power can be met with a combination of small and large-scale photovoltaic and in-stream turbine generation systems.

This work was supported in part by NSF

Keywords: dams, renewable energy, in-stream turbines, Amazon

Poster Number: SE-05
Authors: Mateo Burbano; Yadu Pokhrel
Title: Examining the Effects of Changing Hydrologic Regime on Fish Catch in the Mekong River Basin

Abstract: The construction of dam structures in the Lower Mekong River Basin (LMRB) is harming fish populations, and consequently undermining food security in the LMRB through severe impacts on fishery. The Lower Mekong countries of Laos, Vietnam, Thailand, and Cambodia count on fish as their primary protein sources. Due to the inevitably significant decrease in fish due to dam construction, we can expect a shift towards alternative sources of protein. As a result, the production of protein alternatives to fish such as beef, poultry, and pork becomes imperative. In this study we estimate the water footprints (WF) and virtual water flows (VWF) of protein alternatives in the LMB. We use Food and Agriculture Organization of the United Nations (FAO) data to estimate the WF for each food source in the LMB. Additionally, we use the hydrological model H08 in order to estimate the virtual water contents of each food group. Finally, we examine the connection between hydrological changes in the river and fish populations by developing a statistical model. These results will provide explanatory and predictive power of fish catch data for the future. Further, a quantification of the economic result has the potential to provide an improved projection on diet shift for the population at hand.

This work was supported in part by Partially funded by NASA under the award 80NSSC17K0259.

Keywords: hydrology, fish catch, water resources, virtual water trade, river basin

Poster Number: SE-06
Authors: Suyog Chaudhari; Yadu Pokhrel
Title: Characterization and Multi-decadal Evolution of Extreme Amazonian Droughts

Abstract: We investigate the interdecadal and interannual hydrological changes in the Amazon river basin and its sub-basins over a 36-year period (1980-2015) using GRACE data and a physically-based, 2-km grid continental scale hydrological model (Leaf-Hydro-Flood) that includes a prognostic groundwater scheme, surface water-groundwater interactions, and the effects of land use land cover change. The analyses focus on the dominant mechanisms that are in play during different drought years. Our results indicate that (1) the 2010s is the driest period since 1980, characterized by a major shift in decadal mean compared to the 2000s due to the increased frequency and severity of droughts in Amazon, (2) long-term trends in TWS suggests that the Amazon as a whole is getting wetter (1.13 mm/y), whereas its southern and southeastern sub-basins are facing significant negative trends in TWS, caused primarily by intensified LULC changes, (3) increasing divergence between dry season total water deficit (TWD), and corresponding TWS release (TWS-R) suggest strengthening of the dry season in the Amazon, indicated by higher TWD than TWS-R, especially for the southern and southeastern sub-basins, and (4) the sub-surface water store regulates the propagation of meteorological droughts into hydrological droughts by modulating TWS-R with respect to its storage preceding the drought. Our simulations provide crucial insight on the importance of sub-surface water store in alleviating surface water stress condition across the Amazon and open pathways for improving prediction and mitigation of extreme drought conditions under changing climate and increasing hydrologic alterations due to accelerating human activities across the basin.

This work was supported in part by National Science Foundation (Award#: 1639115)

Keywords: Amazon River Basin, GRACE, terrestrial water storage, droughts

Poster Number: SE-07
Authors: Douglas Clements; Megan Beaver; Henry Frost; Xiaojing Ma
Title: Innovative Engineering Solutions to Attempt Eradication of Red Swamp Crayfish

Abstract: Red Swamp Crayfish is an invasive species threatening ecosystems and infrastructure in Michigan. This study was conducted to design an improved trapping mechanism to increase catch rates and decrease labor associated with retrieving trapped crayfish in retention ponds in Michigan. The objectives of the study were: to discover the effect of sound on crayfish and to design a trap with higher catch-rates than the current trapping mechanisms. Experimental habitats were constructed out of 3 large cattle bunk feeders, river pebbles, and standard aquarium accessories to ensure healthy conditions for the crayfish during experiments. A sound system involving audio software, MP3 players, preamplifiers, amplifiers, and underwater speakers was used to expose the crayfish to a variety of pure tone frequencies between 500 and 15,000 Hz. The habitats were divided into 3 zones, and the number of crayfish in each zone was recorded after 24 hours of silence. Crayfish were then exposed to sound and the distribution of crayfish was recorded after 24 hours of sound. Statistical analysis of preliminary data was performed using one-way ANOVA's and the Tukey Multiple Comparisons Test in the coding language R. Preliminary results show that frequency had a significant effect on crayfish behavior in zone 3, which was closest to the speaker. For the frequencies above 1000 Hz, the number of crayfish closest to the speaker was greater than that of a silent control, revealing a pulling effect of crayfish toward the speaker. Based on this result, a trap was designed to capture crayfish.

This work was supported in part by Michigan Department of Natural Resources

Keywords: Invasive species crayfish trap eradication

Poster Number: SE-08
Authors: Korey Cook; Andre Benard
Title: Development of a Membraneless Organic Redox Flow Battery

Abstract: The development of a novel electrochemical energy storage system, specifically a redox flow batteries (RFB), is discussed in this work. It has the distinction of not requiring an ion-selective membrane due to novel chemical compounds. The techno-economic aspects of a low-cost 3D printed flow cell and system design tailored for a novel chemistry is discussed. The organic compounds employed are inexpensive, have a long lifespan, and as mentioned enable the system to be membraneless. All these substantially decrease the capital and maintenance costs. Suitable systems were developed and tested using chemically compatible 3D printed materials for the flow cells. The estimated cost per kWh is lower than the Department of Energy's target cost of $150/kWh for grid storage capacity. A commercial scale system, rated for a 1 MW, 5-hour discharge time, has an estimated cost of $65/kWh. The proposed technology could revolutionize the energy storage industry and help with the construction of a more stable and efficient energy grid.

Keywords: battery, flow, redox, membraneless

Poster Number: SE-09
Authors: Ashley Cutshaw; Henry Frost; Sibel Uludag-Demirer; Yan (Susie) Liu; Wei Liao
Title: Mechano-Chemical Hydrolysis of Algal Biomass to Develop an Amino Acid Salt Absorbent for CO2 Capture

Abstract: Increasing levels of atmospheric greenhouse gases and carbon dioxide (CO2) have been of concern in the scientific community for decades. A large portion of CO2 emissions are a result of power generation from fossil fuels. With this much direct contribution to the issue of carbon dioxide emissions, power plants have become a place of focus for resolving the issue of air pollution. The goal of recent research in carbon capture has been to sequester CO2 emissions before they leave the power plant, providing a post-combustion solution. Amino acid salt solutions gain increasing attraction due to their relatively high capture efficiency and environmentally friendly nature. The goal of this research was to develop an efficient protein extraction and hydrolysis technique for algal biomass to optimize amino acid yield for use in an amino acid salt absorbent. Algal biomass of the species Chlorella sorokiniana underwent mechano-chemical treatment using a ball mill and potassium hydroxide (KOH). Experimental parameters included material, rotational speed, milling time, ball:biomass mass ratio and biomass:KOH mass ratio. Following the optimization of the initial stage of extraction, amino acid release was carried out using a thermo-chemical hydrolysis process. The hydrolysis parameters of temperature and time were optimized. Results of these preliminary experiments indicate the potential for algal biomass as a source for mixed amino acid salt solutions for CO2 sequestration.

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

Keywords: algal biomass, CO2, amino acids

Poster Number: SE-10
Authors: Carly Daiek; Yan (Susie) Liu; Wei Liao
Title: Feasibility of Nutrient and Water Recycling for Microalgae Cultivation in Photobioreactors

Abstract: Several major technical challenges on large-scale algal cultivation hinder commercial algal fuel and chemical production, including low algal biomass yield in outdoor conditions, lack of long-term stability, and high water and nutrient requirements. Achieving economic efficiency requires additional technological advances in photobioreactor (PBR) design and operational optimization. The goal of this research is to develop methods that will minimize operational expenses through the reuse of growth media. This project represents the preliminary findings of nutrient and water reuse in small-scale PBRs for microalgae cultivation of species Chlorella sorokiniana.

This work was supported in part by Department of Energy (DOE)

Keywords: algae, CO2 sequestration, sustainability, resource management

Poster Number: SE-11
Authors: Hongyu Dang; Yogendra H. Kanitkar; Robert D. Stedtfeld; Paul B. Hatzinger; Syed A. Hashsham; Alison M. Cupples
Title: An Investigation into the Presence of Genes Associated with Contaminant Biodegradation Across Multiple Sites

Abstract: Shotgun sequencing was used for the quantification of key taxonomic and functional biomarkers associated with chlorinated solvent bioremediation in groundwater samples from five contaminated sites, following bioaugmentation with SDC-9 between ~ 0.5 and 6.3 years prior to evaluation. The analysis determined the relative abundance of 1) genera previously associated with chlorinated solvent degradation, 2) reductive dehalogenase (RDases) genes, 3) genes associated with 1,4-dioxane removal and 4) genes associated with aerobic chlorinated solvent degradation. The taxonomic analysis revealed numerous genera previously linked to chlorinated solvent degradation, including, for example, Dehalococcoides, Desulfitobacterium and Dehalogenimonas. The functional gene analysis indicated vcrA and tceA from D. mccartyi were the RDases with the highest relative abundance. Lower abundance levels of genes associated with reductive dehalogenation were found from Dehalobacter and Desulfitobacterium. Reads aligning with both aerobic and anaerobic biomarkers were observed across the five sites. Two aerobic solvent degradation genes, etnC or etnE, were detected in at least one groundwater sample from each site, as were pmoA and mmoX. For 1,4-dioxane biomarkers, the most abundant number of reads aligned to Methylosinus trichosporium OB3b mmoX, followed by Burkholderia cepacia G4 tomA3 and Pseudomonas pickettii PKO1 tbuA1. Three others were detected at lower levels. The work illustrates the importance of shotgun sequencing to provide a more complete picture of the functional abilities of in situ microbial communities. The approach is advantageous over current methods, such as traditional qPCR, because an unlimited number of functional genes can be quantified.

This work was supported in part by SERDP

Keywords: chlorinated ethene; 1,4-dioxane; biodegradation; shotgun sequencing; functional gene

Poster Number: SE-12
Authors: Mary Ensch; Michael F. Becker; Thomas Schuelke; Cory A. Rusinek
Title: A Pilot Scale Flow-Through System Utilizing Boron-Doped Diamond Perforated Plates for the Destruction of PFOA

Abstract: Perfluorooctanoic acid (PFOA) is a man-made surfactant that is persistent in the environment. Although its manufacturing has been phased out of industry, it has been detected around the world at concentrations well above the miniscule levels that have shown toxic health effects in humans and animals. Electrochemical oxidation has shown promise in degrading this compound in wastewater sources using various electrode materials including boron-doped diamond (BDD) at the bench-scale. This study takes this investigation a step further and explores the possibility of advancing the degradation process to large-scale. A 2 ppm solution of PFOA in 50 mM sodium sulfate with a total volume of 10 L was used. The combined active anode surface area was 33.6 square centimeters with an applied current density of 200 milliamps per centimeter squared. Temperature, pH, and voltage were recorded throughout the duration of the 8 hour test. Samples were removed from the systems tank at set time intervals and analyzed using a fluoride ion selective electrode (ISE) and liquid chromatography mass spectroscopy (LC-MS). At the end of the test, only 0.25% of the original PFOA concentration remained. Examination into the fluoride mass balance and generation of shorter chains gave further insight into this methods ability to be successful.

This work was supported in part by Fraunhofer Center for Coatings and Diamond Technologies

Keywords: PFOA, BDD, electrochemical oxidation

Poster Number: SE-13
Authors: Angela Farina; Annick Anctil; M. Emin Kutay
Title: Environmental Assessment of Hot Mix Asphalt Pavements Modified with Polymer Coated Scrap Tire Rubber

Abstract: Polymer coated rubber (PCR) is an innovative material in the field of asphalt pavement applications. It is a chemically enhanced rubber particle made from scrap tires partially covered by a polymer emulsion. Its use in hot mix asphalt (HMA) as a modifier to improve the mechanical performance of road pavements in lieu of the styrene-butadiene-styrene (SBS) is still being evaluated. In this specific stage of evaluation, performing an environmental assessment is essential to have a comprehensive analysis of this material, and to understand whether the tradeoff between SBS and PCR in HMAs is environmentally viable.
A life cycle assessment (LCA) approach was used to assess the environmental impacts in terms of global warming potential (GWP) and fossil material depletion. These impacts were associated with the production of 1 ton of HMAs containing 0.5% and 1% of PCR in comparison to an HMA modified with SBS.
The GWP for the mixes with 0.5% and 1% of PCR was respectively 7.3% and 5.7% lower than the SBS modified HMA. Similarly, the fossil depletion, calculated as MJ surplus as kg of oil equivalent, was respectively 8.7% and 7% lower than the results obtained for the SBS modified mixture. The use of the chemically enhanced rubber from end-of-life tires increases the electricity consumption during the manufacturing process, but overall, it has environmental benefits due to the lower asphalt binder content in the mixture.

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

Keywords: life cycle assessment, scrap tires, polymer coated rubber, hot mix asphalt pavements.

Poster Number: SE-14
Authors: Farshid Felfelani; Yadu Pokhrel
Title: Implementing an Advanced Groundwater Pumping Scheme in the Community Land Model (CLM)

Abstract: Groundwater plays a crucial role in the water cycle acting as a water buffer in agro-ecosystems that modulates both soil moisture and river flows through two-way interactions. Further, groundwater withdrawals account for 42%, 36%, and 27% of global irrigation, household, and industrial water use, respectively. Despite the key role of the groundwater in water cycle and as a major freshwater resource for food production, groundwater dynamics in large-scale hydrological models is rather poorly parameterized or even grossly ignored in many hydrological models. In this study, we implement an advanced groundwater model in the latest version of the Community Land Model (i.e., CLM5.0). The new groundwater model accounts for lateral groundwater flow and explicitly simulates the groundwater pumping based on two approaches: (1) the conventional water balance approach and (2) based on solving the 2-D groundwater equation in the radial coordinate system (i.e., by considering the groundwater pumping in the boundary conditions as well as considering the impact of wells on each other). We then conduct continental-scale simulations at fine resolution of 3 arc-minute (~5km) over the entire contiguous United States (CONUS) and evaluate the model estimation of water table depth with available data from the observational wells. The simulation of terrestrial water storage (TWS) from the new groundwater scheme is also assessed using the data from the Gravity Recovery and Climate Experiment (GRACE) satellite mission. The results from the new groundwater scheme show that significant improvements in the simulation of groundwater table and TWS are expected.

This work was supported in part by This study was partly supported by the National Science Foundation (award 1752729)

Keywords: grounwater modeling; community land model; groundwater pumping; lateral flow

Poster Number: SE-15
Authors: Henry Frost; Yuan Zhong; Susie Liu; Wei Liao
Title: An Environmentally Friendly One-Pot Approach to Release Mono-Sugars from Lignocellulosic Materials

Abstract: A novel, mechano-biocatalytic one-pot process was developed by this study to efficiently release mono-sugars from lignocellulosic materials in an environmentally-friendly manner. The process synergistically integrates agate ball milling and enzymatic hydrolysis into a reactor to carry out simultaneous pretreatment and hydrolysis of lignocellulosic materials. Solid digestate from anaerobic digestion, corn stover, switchgrass, and miscanthus were used to evaluate the performance of the mechano-biocatalytic one-pot process. High titer and good conversion yield were achieved. Among four studied feedstocks, solid digestate and corn stover demonstrated much better sugar concentrations and conversion yields. The XRD analysis further confirmed the hydrolysis results. Consequently, the energy balance analysis indicated that the studied process had a comparable energy profile with conventional co-hydrolysis technology. These results show that the mechano-biocatalytic one-pot process could have potential to significantly enhance the pretreatment and hydrolysis efficiencies for advanced fuels and chemicals production.

Keywords: ball mill, enzymatic hydrolysis, lignocellulosic materials, X-ray diffraction

Poster Number: SE-16
Authors: Shardula Gawankar; Rebecca H. Lahr
Title: Effect of UV/H2O2 Advanced Oxidation Process on Degradation of Saxitoxin in Drinking Water Treatment Plants

Abstract: Lake Erie has been affected by harmful algal blooms for decades, causing tap water shutoffs in Toledo in 2014 when toxic cyanotoxins were found in treated drinking water. Such occurrences are becoming more common across the globe and are triggering a need for research in toxin removal from drinking water. Water treatment plants on Lake Erie are currently focused on microcystins, the most common form of cyanotoxin, but climate change is predicted to increase the occurrence of other types of cyanotoxins, like saxitoxin. Saxitoxin, the paralytic shellfish toxin (PST), is a neurotoxin that is produced by marine dinoflagellates and freshwater cyanobacteria, typically in tropical regions. Climate change coupled with agricultural runoff makes Lake Erie a potential hub for saxitoxin production in the future. There is currently no oxidation process that a water treatment plant can implement to simultaneously remove all the cyanotoxins (microcystin, saxitoxin, cylindrospermopsin, and anatoxin) from drinking water. Conventional oxidation treatments like chlorination, use of ozone and potassium permanganate are not effective in removal of all cyanotoxins. Hydroxyl ion oxidation using the UV/H2O2 process breaks down microcystin, anatoxin, and cylindrospermopsin, but there is no research conducted to study its effect on saxitoxins. Therefore, we proposed to determine if UV/H2O2 can indeed be installed as defense against all the cyanotoxins.

Keywords: saxitoxin, UV/H2O2, disinfection by-products, degradation

Poster Number: SE-17
Authors: Jessica Hauda; Thiramet (Dream) Sotthiyapai; Kiran Lantrip; Megan Curtin

Title: Soluble Phosphorus Sorption from Tile Drainage with Natural, Waste, and Nano-engineered Medias

Abstract: Soluble phosphorus is a catalyst for eutrophication and cyanobacteria damage in freshwater environments, which impacts tourism, human health, environmental safety, and property value. Phosphorus is valuable to agriculture because it is a necessary nutrient promoting crop growth. One recent management practice for those who discharge phosphorus is utilizing medias that absorb phosphorus. Phosphorus has a strong binding affinity to these medias and additional methods can reclaim the phosphorus off its surface for reuse. The goal of this project is to select the best media for phosphorus adsorption in tile drain water to Michigan corn growers. Five reputable media options (2 natural-based, 2 engineered nanomaterials, and 1 biochar) were selected from literature. Isotherm testing on the media and column studies measured the effectiveness of the medias under real and synthetic tile drain water feed. Next steps are to conduct a techno-economic analysis (TEA) of each media (cost per unit), select the most suitable media, and perform a field demonstration on the selected media for Michigan corn growers.

This work was supported in part by Michigan Corn Grower's Association

Keywords: phosphorus, sorption media, tile drainage, agriculture, nutrient

Poster Number: SE-18
Authors: Seyed Mohammadreza Heidari; Lucas Hardy; Annick Anctil
Title: Ecotoxicity Assessment of Fullerene Purification Process

Abstract: Fullerenes (C60, C70, and higher fullerenes) are allotropes of carbon that are used in cancer therapy, MRI, drug delivery, Nano-sensors, and organic photovoltaic (OPV) devices. Fullerenes are not inherently toxic, but their synthesis and purification produce a large amount of toxic waste and by-products which may threaten the ecosystem when they are released to the environment. Using less toxic solvents and limiting the amount of toxic wastes are two principles of green chemistry metrics that are employed to improve the purification process. The current large-scale purification processes use conventional solvents, such as 1,2,4-Trimethylbenzene which produce toxic wastes and byproducts during the experiment. In this study, acute toxicity tests were designed to compare the impact of exposing fullerenes, wastes, and by-products from the purification process to Daphnia Magna. Based on the results from the ecotoxicity assessment, an alternative purification method with lower toxic impacts on the freshwater ecosystem is proposed.
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Keywords: ecotoxicity, fullerene, Daphnia magna, waste management

Poster Number: SE-19
Authors: C.A. Hejase; S. Kucuk; I. Kolesnik; J.W. Chew; V.V. Tarabara
Title: Cleaning Up Emulsified Oil Spills in Sea Water: Assessing Microfiltration as a Remediation Strategy

Abstract: During the 2010 Deepwater Horizon oil spill, nearly 800 million liters of oil were released into the Gulf of Mexico polluting the deep ocean and more than 1600 km of the Gulf's shoreline [1]. A large amount (1.84 million US gallons) of dispersant, Corexit 9500A, was applied to the spill; as a result, the oil was emulsified into microdroplets that remained suspended in the water column. Even though small droplets facilitate biodegradation, they can pose significant environmental risks. Available clean-up strategies (e.g. skimming, in-situ burning) are effective for collecting "free oil", which is the fraction of oil that quickly rises to the sea surface. Options for removing oil droplets suspended in the water columns are limited. Membrane filtration is one of the most cost-effective remediation technologies that can remove emulsified oil. Despite extensive studies, however, mechanisms of membrane separation of emulsified oil remain poorly understood. Previous work in our research team demonstrated the feasibility of a direct real-time visualization of membrane surfaces being coated by emulsified oil in the presence of hydrodynamic shear [2]. In the present study, we investigated the impact of salinity on the properties and filterability of oil-in-water emulsions. Direct Observation Through the Membrane technique was employed to visualize the droplets in real time on the surface of a microfiltration membrane. Visualization was complemented by crossflow filtration tests to gain quantitative understanding of oil droplets deposition onto the filter. Emulsions were characterized in terms of droplet size distribution, interfacial tension, and charge. Corexit altered both emulsion stability and the wetting properties of the membranes. Emulsion characterization and constant pressure crossflow filtration tests indicate that salinity affects the stability of emulsions and can cause precipitous flux decline. The low values of the steady state permeate flux indicate that microfiltration is suitable as a polishing step that follows an extensive pretreatment by large throughput deoiling unit processes such as hydrocyclonic separation or flotation.
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Keywords: emulsified oil; fouling; direct observation through the membrane (DOTM)

Poster Number: SE-20
Authors: J. Sebastian Hernandez-Suarez; A. Pouyan Nejadhashemi; Ian M. Kropp, Mohammad Abouali; Zhen Zhang; Kalyanmoy Deb
Title: Evaluation of the impacts of hydrologic model calibration methods on predictability of ecologically-relevant hydrologic indices

Abstract: Hydrological modeling for the prediction of ecologically-relevant hydrologic indices is a common step for estimating the spatial distribution of stream health at large scales. However, the ability of hydrologic models for replicating these indices is limited. Two strategies based on three forms of Nash-Sutcliffe Efficiency (NSE) and root-mean-squared error (RMSE) were implemented. The hydrological model used in this study is the Soil and Water Assessment Tool (SWAT) for the Honeyoey Creek-Pine Creek Watershed, located in Michigan, USA, and is calibrated using a single streamflow gauging station and the Non-dominated Sorting Genetic Algorithm III (NSGA-III). The results demonstrated that using different sets of solutions, instead of a single best trade-off, introduces more flexibility in the predictability of different hydrologic indices of ecological interest.

This work was supported in part by Fulbright-COLCIENCIAS

Keywords: multiobjective optimization, watershed modeling, hydrologic indicators, environmental flows

Poster Number: SE-21
Authors: Ryan Julien; Jade Mitchell
Title: Evaluating Impacts of Water Age on Water Quality in a Full-Scale Green Home

Abstract: Water use in the built environment has significantly changed in recent decades. Focus on water efficiency has increased the prevalence of low-flow appliances and fixtures and significantly reduced the quantity of water conveyed through Water Distribution Systems (WDSs). In fact, residential water use has declined 22% from 1999 to 2016. However, plumbing design has not been adapted to these changes. As a result, water remains stagnant in WDS and in-building plumbing for a longer period of time, adversely affecting water quality through degradation of residual disinfectant, increased pipe material leaching, and additional growth of Opportunistic Premise Plumbing Pathogens (OPPPs) such as Legionella spp. and Mycobacterium spp. Additionally, the human population in the United States is growing older and chronic illness is becoming more common; both of which are primary risk factors for OPPP susceptibility. Perhaps as a result, the incidence of these infections has risen dramatically in recent years. However, these risks are not yet well understood. This study uses data collected from flowmeters installed throughout a full-scale home to determine the duration of time water spends within the home's plumbing. Additionally, water quality samples have been collected from several fixtures and analyzed for parameters such as disinfectant residual, dissolved carbon, and the presence of several OPPPs. Estimated water age will be compared with selected water quality parameters to evaluate correlations between water usage patterns and water quality at the tap.

This work was supported in part by EPA National Priorities Grant

Keywords: green building design, opportunistic pathogens, low flow fixtures, water age, water demand

Poster Number: SE-22
Authors: Dipti Kamath; Taylor Stephen; Annick Anctil
Title: Modeling availability and cost of repurposed electric vehicle batteries for residential energy storage using a system dynamics approach

Abstract: The number of plug-in Electric Vehicles or EVs (plug-in hybrid and all-electric) in the US has increased from 345 in 2010 to 627,734 in 2016. EVs have rechargeable Lithium-ion battery (LIB) systems, which are typically unable to perform effectively when they have lost more than 20% of their original capacity. An end-of-life (EOL) strategy to utilize the remaining 80% capacity is to repurpose the batteries for stationary applications, such as residential energy storage with photovoltaic applications. The common assumption of all repurposed batteries studies that estimate their economic and environmental benefits is the existence of an established repurposed battery market. However, the availability and demand of EOL LIBs are unknown, weakening the established market assumption. A system dynamics model was developed using Stella Architect software to address the temporal aspect of the repurposed battery market. It included different market outlook forecasts of EV sales, residential energy storage sales, raw materials for LIBs, recycling and repurposing rates, as well as expected lifetimes of EVs, LIBs during their in-vehicle use, and LIBs after their repurposing. As a result, the change in EOL LIB volume, lithium availability, and repurposed battery cost was calculated from 2010 to 2060 for the US. Preliminary results using the business-as-usual scenario estimates that by 2060, a cumulative availability of 2,970 GWh of the original batteries could be repurposed for residential storage applications. Future work will estimate the current and future life cycle environmental impact of repurposed batteries which will include the repurposing and recycling processes.

This work was supported in part by Ford

Keywords: repurposed battery, residential energy storage

Poster Number: SE-23
Authors: Ian Kropp; A. Pouyan Nejadhashemi; Kalyanmoy Deb; Mohammad Abouali; Proteek C. Roy; Gerrit Hoogenboom
Title: A Multi-Objective Approach to Sustainable Agricultural Intensification

Abstract: One of the main problems that society is facing in the 21st century is that agricultural production must keep pace with a rapidly increasing global population in an environmentally sustainable manner. One of the solutions to this global problem is a system approach through the application of optimization techniques to manage farm operations. However, unlike existing agricultural optimization research, this work seeks to optimize multiple agricultural objectives at once via multi-objective optimization techniques. Specifically, the algorithm Unified Non-dominated Sorting Genetic Algorithm-III (U-NSGA-III) searched for irrigation and nutrient management practices that minimized combinations of environmental objectives (e.g., total irrigation applied, total nitrogen leached) while maximizing crop yield for maize. During optimization, the crop model named the Decision Support System for Agrotechnology Transfer (DSSAT) calculated the yield and nitrogen leaching for each given management practices. This study also developed a novel bi-level optimization framework to improve the performance of the optimization algorithm, employing U-NSGA-III on the upper level and Monte Carlo optimization on the lower level. The multi-objective optimization framework resulted in groups of equally optimal solutions that each offered a unique trade-off among the objectives. As a result, producers can choose the one that best addresses their needs among these groups of solutions, known as Pareto fronts. In addition, the bi-level optimization framework further improved the number, performance, and diversity of solutions within the Pareto fronts.

Keywords: optimization agriculture multi-objective maize sustainable

Poster Number: SE-24
Authors: Apoorva Kulkarni; Ramani Narayan
Title: Synthesis and Characterization of Maleated Thermoplastic Starch (MTPS) Blends with Copolyetser (PETG)

Abstract: Maleated thermoplastic starch/Polyethylene terephthalate glycol (MTPS/PETG) blends were prepared via melt blending reactive extrusion method. First, MTPS was prepared via reactive extrusion of starch using glycerol as plasticizer and malic anhydride as esterification agent. The MTPS was then melt blended with PETG in 30:70 (w/w) ratio. The extent of transesterification reaction between the two polymers was determined via soxhlet extraction to find % grafting. The extracts and residues obtained were analyzed by TGA. Mechanical properties of were investigated and compared with the tensile properties of neat PETG. The results indicated that even after incorporation of 30% starch, the strength and elongation at break does not reduce significantly. Further, the blend morphology was studied by Scanning Electron Microscopy (SEM) to get better understanding about dispersion of two phases. Presence of PETG gives this blend a potential for better hydrophobicity and superior mechanical properties. Whereas, presence of starch can increase the biodegradability of the blend.

Keywords: starch, PETG, blends, transesterification, extrusion

Poster Number: SE-25
Authors: Xiaoyan Li; Selett Allen; Alyssa R. Sanderson; Rebecca H. Lahr
Title: Water Chemistry Evaluation by Image Analysis on Coffee Ring Effect Residue Pattern

Abstract: As water infrastructure ages and public funds to monitor tap water decrease, new methods for household testing that are fast, cost-efficient, user-friendly, low tech, and reliable will become increasingly valuable. A new low cost water analysis method is currently under development to harness the separation of solutes from aqueous solutions via the coffee ring effect. The coffee ring effect is the phenomenon by which water droplets leave distinguishable fingerprint residue patterns after water evaporates, where residues display ring-like deposits of solute particles separated by size and solubility along the perimeter of the residue. Synthetic water samples were prepared, water droplets dried, and photographs collected of the residues after harnessing the coffee ring effect. Principal component analysis (PCA) was conducted on (a) images of the water residue patterns and (b) measurements of the particles observed in photographs (feature extraction). Both analyses demonstrate that the coffee ring pattern is sensitive to the water chemistry in the sample. The number of particles and the average area of particles were also used in an analysis of variance (ANOVA); these features of the residue patterns also differ significantly with water chemistry. Few water testing methods can be conducted cheaply and without specialized equipment to ”fingerprint” a water sample in a single snapshot; thus, with further development this method may be valuable for low cost tap water analysis.

Keywords: coffee ring effect, machine learning, water chemistry, principal component analysis, pattern feature

Poster Number: SE-26
Authors: Camille McCall; Huiyun Wu; Irene Xagoraraki
Title: Early Detection of Potential Hepatitis A and Norovirus Outbreaks in Detroit, Michigan

Abstract: Diseases associated with food- and water-related viruses, such as hepatitis A virus and norovirus, often result in large-scale epidemics. Viruses pose a major threat to human health because of their high mutation rates, low infectious dose, and lack of medications to treat viral infections. These agents can be especially difficult to manage in urban settings since high population density promotes the rapid spread of communicable diseases. Therefore, methods for early detection and surveillance of disease outbreaks are needed to protect public health. Water-related viruses excreted in human feces can remain stable and persist in wastewater systems. Thus, we propose a wastewater-based approach for early detection and surveillance of water-related viral disease outbreaks in urban communities. Untreated sewage samples (n=54) were collected from the wastewater treatment facility in Detroit, MI, from November 2017 to February 2018. Viruses were concentrated from large volumes of wastewater using a virus adsorption-elution method. Viral concentrations for hepatitis A virus and norovirus genogroup II in sewage samples were determined using real-time polymerase chain reaction assays. Next, we assessed correlations between these viral concentrations and clinical cases for their respective diseases in communities serviced by the Detroit WWTP. Virus concentrations for hepatitis A virus and norovirus were highest during November and December, respectively. Significant findings show temporal correlations between viral concentrations in sewage samples and the number of reported disease cases in service counties.

This work was supported in part by National Science Foundation

Keywords: Hepatitis A, Norovirus, Waterborne Pathogens, Wastewater

Poster Number: SE-27
Authors: Camille McCall; Huiyun Wu; Irene Xagoraraki
Title: Diversity of Single-Stranded RNA Viruses Excreted in Wastewater of a Large Urban Center

Abstract: Clinically relevant viruses like hepatitis virus, poliovirus, Ebola virus, West Nile virus, and others have single-stranded (ss) RNA genomes. Likewise, the most significant cause of gastroenteritis worldwide is contributed to ssRNA viruses (i.e. sapoviruses and noroviruses) and are excreted in domestic wastewater by infected individuals. Single-stranded RNA viruses are known for their high mutation rates and small genomes, which makes detecting them in environmental reservoirs difficult. Here, we determine the diversity of ssRNA viral pathogens in sewage samples collected from the wastewater treatment facility in Detroit, Michigan. Untreated sewage samples were collected from November 2017 to February 2018, viruses were concentrated from large volumes of wastewater using a virus adsorption-elution method. We used whole-genome shotgun sequencing and an optimized metagenomics approach to assess the diversity of ssRNA viral pathogens in collected samples. Results suggests the presence of ssRNA viral pathogens in all samples belonging to several families, including Caliciviridae, Picornaviridae, and Hepeviridae.

This work was supported in part by National Science Foundation

Keywords: ssRNA viruses, diversity, WGS, wastewater

Poster Number: SE-28
Authors: Brijen Miyani; Irene Xagoraraki
Title: Prevalence and Diversity of Human Herpesviruses in Wastewater from a Large Urban Area

Abstract: Human Herpesviruses (HHV) are double stranded DNA viruses that belong to the family of Herpesviridae. All nine types of HHV are prevalent among the USA population. Most of them affect at least 70% of adults. HHV 5, 6 and 7 have been found in at least 30% of children by the time they reach age 5. All HHV establish lifelong latency and can reactivate, especially in immuno-compromised individuals. Due to their abundance, lifelong latency and lack of vaccines these viruses are ineradicable. HHV are shed in genital and ocular secretions, saliva, urine and stool, depending upon their mode of transmission, and ultimately end up in wastewater plants. To evaluate prevalence and diversity of HHV in a large urban center, samples were collected from the Detroit wastewater treatment plant between November 2017 and February 2018. Samples were collected in electropositive cartridge filters, eluted with beef extract solution, concentrated, and ultimately DNA was extracted. The nucleic acid was analyzed with multiplex PCR for the presence of HHV. Furthermore samples were sequenced by Illumina shotgun next generation sequencing and blasted against viral databases. The results from both methods indicate high prevalence of multiple HHV species in the Detroit area population.

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

Keywords: human herpesvirus, wastewater, next generation sequencing, PCR reaction

Poster Number: SE-29
Authors: Akshay Murali; Daniel J. Thomas; Rémi Gonety; Brendan S. Wrobel; Volodymyr V. Tarabara
Title: Natural Coagulants as Low-Cost Alternatives for Water Treatment in Resource-Constrained Settings: The Case for Moringa Oleifera

Abstract: Coagulation is a crucial unit process in most water treatment operations. Even relatively inexpensive coagulants like alum and ferric chloride may be unavailable in some settings. Coagulants derived from locally available plants may provide cost-effective, safe alternatives to chemical coagulants. The drumstick tree, Moringa oleifera (M. oleifera), is an example of a plant that can be used to obtain natural coagulants. The coagulant material can be extracted by mixing shelled, powdered seeds with low salinity water and filtering out seed fragments. However, the application of this new coagulant is hampered by insufficient knowledge of its chemical makeup and coagulation mechanisms. Other constraints are practical concerns such as increased organic content of the treated water. The present project focuses on elucidating mechanisms of coagulation by M. oleifera derived materials. Experimental data shows a turbidity removal of up to 92.7 +/- 0.6 %, obtained with a coagulant dosage of 20.3 +/- 0.6 mg(TOC)/l and a residual organic content of 16.6 +/- 1.0 mg(TOC)/l. A contingent goal is to design a method for cost-effective application of M. oleifera derived coagulants and test it against model suspensions and real surface water over a range of operational parameters. We envision an outreach component to this work and are looking for opportunities to organize such efforts.

Keywords: water, coagulation, water-treatment, cost-effective, Moringa oleifera

Poster Number: SE-30
Authors: Vidhya Ramalingam; Alison M. Cupples
Title: A Study of Aerobic and Anaerobic Biodegradation of 1,4-Dioxane Using Inocula from Agricultural Soils and Contaminated Sediments

Abstract: It is now well recognized that there is a need to develop management strategies for 1,4-dioxane due to its widespread occurrence. A major challenge in addressing 1,4-dioxane contamination concerns chemical characteristics that result in migration and persistence. This study aims to examine the biodegradation potential of 1,4-dioxane in aerobic and anaerobic microcosms by developing enrichment cultures. To date, experiments have involved the establishment of microcosms using agricultural soils, river sediments and sediments from 1,4-dioxane contaminated sites (California and Maine) under a range of redox conditions (aerobic, nitrate amended, iron amended, sulfate amended and methanogenic). Significant differences ($p<0.05$) in 1,4-dioxane between the abiotic controls and the live microcosms were noted under methanogenic conditions for two of the three agricultural soils, one contaminated site sediment and one river sediment after approximately 300 days, suggesting biological degradation of 1,4-dioxane. Compound specific isotope analysis involving 13C/12C measurements confirmed 1,4-dioxane degradation in one set of microcosms. This work is important because limited previous research has documented 1,4-dioxane biodegradation under anaerobic conditions. Under aerobic conditions, five of the six inocula tested illustrated significant reductions in 1,4-dioxane compared to the abiotic controls. Additional plans include the use of high throughput sequencing to identify the dominant microorganisms in the 1,4-dioxane degrading enrichments. Also, these enrichments will be combined with the bioaugmentation culture SDC-9 to determine if the chlorinated solvents can be reduced during 1,4-dioxane biodegradation.

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

Keywords: 1,4-Dioxane, biodegradation, Compound Specific Isotope Analysis(CSIA), enrichment culture , anaerobic

Poster Number: SE-31
Authors: Clement Roy, James Klausner
Title: CFD Modelling of a Humidifier for a Diffusion Driven Desalination Unit

Abstract: The process of Diffusion Driven Desalination utilizes direct contact evaporation and condensation for the distillation of seawater. A classical setup for direct contact evaporation and condensation involves liquid supplied to the top of a packed bed and a non-condensable gas is blown at the bottom. Therefore, the gas and liquid circulate counter currently through the packed bed wetting its surface. Heat and mass transfer occurs at the interface between liquid and gas. The prediction of the behavior and performance of such system is developed in the literature but a deep understanding of the physics taking place in packed beds is very limited. Currently, system scale models are able to predict quite accurately the overall performance of a facility relying on empirical closure correlations. Therefore, the lack of knowledge on the heat and mass transfer occurring in packed beds makes the enhancement of their performance challenging. The increase in computing power over the last decade now allows computational fluid dynamic to be able to model accurately the fluid dynamic as well as the heat and mass transfers occurring within the packed bed.
The modeling of a counter-current packed bed has been done in a commercial computational fluid dynamic software package (FLUENT) using a Volume of Fluid method (VOF) coupled with a PLIC (Piecewise Linear Interpolation Correlation) method to model the interfacial mass transfer between the liquid and gas phases. At the microscopic scale, the validation of CFD results relies on test cases available in the literature such as co-current falling film in a pipe or on an inclined plate. The macroscopic validation is done against system scale level modeling code that are compared with experimental results. The validation allows the study of packed bed using complex structured geometry to identify the parameters influencing the packing performance and develop new correlations for design tools.

Keywords: CFD, mass transfer, multiphase flows, desalination

Poster Number: SE-32

Authors: Sanghoon Shin; Yadu Pokhrel

Title: Technical Challenges in Developing Reservoir Operation Schemes in Hyper-resolution Global Hydrological Models

Abstract: Moving towards hyper-resolution global hydrological models requires relaxation of assumptions made in coarse-resolution models as the scales of interest become finer. Considering the importance of man-made reservoirs in mediating processes in both local and global scales, improving reservoir operation schemes is indispensable; however, reservoirs have been poorly modeled by treating them as separated entities from natural river-floodplain system not only in course-resolution models but also in recently developed high-resolution models. In this study, we demonstrate that simply increasing model grid resolution can cause critical issues, specifically when natural and dam-induced floods are modeled in an integrated manner, and accordingly, measures to prevent such problems are suggested. In addition, we present an improved reservoir operation scheme with providing analytic analysis and numerical experiments on existing generic reservoir operation schemes. The new modeling framework for integrated simulation of river, reservoirs, and floodplain is first tested for contiguous US having abundant data. The simulated river-reservoir-floodplain storage shows a good agreement with satellite-driven datasets. The results of reservoir releases and storages are also found to be improved. Further, the new model is applied to the Mekong river basin where unprecedented hydropower dam construction boom occurs. We investigate potential cumulative effect of flow regulations to the inundation dynamics over the entire Lower Mekong. We also identify and address the issues in high-resolution modeling of natural and dam-induced floods in Mekong river basin in an integrated manner, which arise as less data are available in the Mekong river basin compared to in the US.

This work was supported in part by WaterCUBE project from Michigan State University (Award#: GR100096); National Science Foundation (Award#: 1752729); NASA (Award#: 80NSSC17K0259)

Keywords: global hydrological model; reservoir operation; dam construction; flood dynamics; water-food-energy nexus (WFE nexus)

Poster Number: SE-33

Authors: Siddharth Shukla; Eunsang Lee; Richard R. Lunt; Annick Anctil

Title: Energy Saving in Residential Buildings Associated with the Use of Transparent Organic Photovoltaics in the United States

Abstract: Residential consumption accounts for approximately 20 % of the total energy consumption in the United States. Cooling energy represents 15 % of the total residential energy demand and costs $35 billion annually. New solutions such as transparent organic photovoltaics (TPVs) have been developed in recent years and their energy saving potential for commercial buildings has been previously established by our group. For commercial buildings, the energy saving using chloroaluminium phthalocyanine (ClAlPc) based TPVs was estimated to be 10-25 % depending on the location. Some remaining questions that are addressed in this work are whether TPV will also provide energy reduction in residential buildings and if other materials than ClAlPc can increase the energy saving by absorbing a different region of the solar spectrum. In this work, we evaluated the energy saving for residential houses in Detroit, Los Angeles, Phoenix and Honolulu with two types of TPVs and compared it with the baseline scenario of using clear glass windows. The absorbance and transmittance of TPVs using ClAlPc and heptamethine (815-TPFB) as donor materials were used in combination with weather files to model monthly natural gas and electricity consumption for cooling using EnergyPlus 9.0. The heating appliances and thermal properties of the buildings were used as other model inputs. Preliminary results indicate a cooling energy demand of 0.98-1.93 MWh/year for single-family residential dwellings. Final results will provide monthly energy saving associated with the use of TPVs.

This work was supported in part by Ford Motor Company

Keywords: photovoltaics, sustainable energy , residential electricity savings

Poster Number: SE-34
Authors: Katelyn Skornia; Steven Safferman; Umesh Adhikari; Corrine Zeeff
Title: Treatment of Michigan Winery Wastewater using Adsorption Media in Gravel Vertical Flow Contactors

Abstract: Winery wastewater is characteristically high in phosphorus, ammonia, and biochemical oxygen demand (BOD). If not properly treated before discharge to groundwater, these pollutants can cause human health and environmental issues. Michigan wineries are typically rural, and as a result, many treat their high strength wastewater onsite. This often requires a relatively large portion of land that otherwise could be used for valuable vineyard space. Alternate treatment options have been challenging due to the intermittent nature of winery wastewater production and high phosphorus levels that make it difficult to treat biologically. This research addresses these challenges and investigates the potential of a gravel vertical flow contactor, a type of constructed wetland, and adsorption media to effectively and efficiently treat Michigan winery wastewater year round. Previous studies proved that gravel vertical flow contactors are effective in removing BOD and nitrogen from high strength wastewater, and adsorption media can be used to remove phosphorus and alleviate the effects of low microbial activity after periods without wastewater flow. Bench-scale testing with local winery wastewater is used to determine the effectiveness of adsorption media for removing pollutants from winery wastewater. A series of four column studies is used to verify the amount of nitrogen adsorption media needed for treatment and an additional column study will determine the amount of phosphorus adsorption media required. Effects of intermittent operation and multiple temperatures will be examined to determine optimal loading conditions.

This work was supported in part by Michigan Craft Beverage Council

Keywords: winery wastewater, wastewater treatment, constructed vertical flow wetland, phosphorus sorption, ammonia sorption

Poster Number: SE-35
Authors: Adam Smerigan; Sibel Uludag-Demirer; Wei Liao
Title: Treatment of Swine Manure by Anaerobic Digestion: Impacts of Using Activated Carbon on Digestability of Swine Manure and Biogas Quality

Abstract: With the cost of organic waste treatment becoming more expensive, there has been an increased interest in alternative waste treatment technologies. Considering this, anaerobic digestion has become a progressively more popular technology for the treatment of agricultural and industrial wastes. Anaerobic digestion reduces odors, reduces the organic strength of a waste stream, and produces energy rich biogas. The capture of this biogas can reduce greenhouse gas emissions and in some cases be used to accumulate carbon credits.
The management of swine manure using anaerobic technologies has been a long-standing challenge, since it is composed of high nitrogen (N) and phosphorus (P) causing inhibition of anaerobic bacteria and archae activities. This research aims to extend the anaerobic biodegradability of swine manure using activated carbon (AC). A biochemical methane potential (BMP) test of swine manure was set up to measure the ultimate biodegradation of swine manure using acid and based washed AC to understand the effects of surface charge of AC particles on volume of biogas produced and biogas quality. The results obtained from BMP test of swine manure will be used to improve swine manure treatment by anaerobic digestion technologies.

This work was supported in part by Department of Defense

Keywords: anaerobic digestion, activated carbon, biochemical methane potential

Poster Number: SE-37
Authors: Ziwei Wang; R. Mark. Worden
Title: Industrial-Scale Bioreactor Utilizing Tight-Pack Ejector Nozzle Formation

Abstract: Microbubble sparging has demonstrated great potential in gas-intense operations where gas mass transfer is usually the rate limiting step. Introducing bubbles into gas-liquid reaction system can drastically improve the overall reaction rate via increasing kLa. Smaller bubbles have higher kLa and slower rising speed, which further enhances the overall gas transfer rate.
Microbubble sparging has been proven beneficial to various kind of fermentation processes inside bioreactors of different configurations. Microbubble generations methods have been extensively covered by previous reviews。 The cost-efficiency of the microbubble is also previously covered by estimating the kLa and power consumption of the bubble generating methods. Ejector style microbubble generation method was found to be a cost-efficient method to generate large number of microbubbles while maintaining relatively low operating cost.The gas input from one single ejector nozzle is not enough to fully aerate an industrial-scale bioreactor. This can be solved by tightly packing numerous nozzles on a level and stack multiple levels of nozzle formations inside the said reactor, as shown in the following figure.
Reactor system as sophisticated as such demands simulation models with substantial level of details that represents fluid dynamics inside the reactor. For this article, numerous aspects of the performance of such bioreactors with nozzle formation were examined and compiled into intuitive results that demonstrates what researchers and engineers would expect from an industrial-scale nozzle-formation reactor.

Keywords: microbubble, fermentation, bioreactor, scale-up, simulation

Poster Number: SE-38
Authors: Chelsea Weiskerger; Jade Mitchell
Title: Digging for Disease: Quantifying Microbial Risks to Children's Health in Beach Sands

Abstract: For millions worldwide, a day at the beach is a welcome respite from the heat of summer, and beach tourism is a major economic sector in shoreline communities. Beachgoers are often aware of risks associated with swimming in the water but are frequently less cognizant of those risks related to playing in the sand. A risk assessment was undertaken in the context of sand microbial contamination at Jeorse Park beach, Indiana and found substantial risks to children playing in beach sand, in the form of contamination by Campylobacter jejuni, Shigella spp., and Cryptosporidium spp. (probability of infection = 1.15*10-2, 3.22*10-4, and 1.73*10-4, respectively) that exceed safe waterborne pathogen levels. This previously overlooked risk can contribute substantially to beachgoer health problems after a day at the beach. It is important to not only manage beach sand for microbial contamination and human, but to also better communicate the risks that sand and water pose to beach visitors and why the risks are different from those associated with the water. Communication strategies may include lifeguard and beach manager education, signage at the beach, and development of digital information in the form of apps and websites devoted to sand contamination and its effect on beach safety.

Keywords: quantitative microbial risk assessment, beach, sand, pathogen, Great Lakes

Poster Number: SE-39
Authors: Huiyun Wu; Ruth Kline-Robach; Irene Xagoraraki
Title: Watershed Bio-Surveillance for Identification of Pollution Sources and Potential Disease Signals

Abstract: Early detection and prevention of livestock disease outbreaks is paramount to the animal agriculture industry. In agriculture-dominated watersheds it is impractical to test every animal for potential disease. Sampling runoff-impacted surface water from agricultural areas represents a community fecal and urine sample of the livestock population in the sub-watershed; therefore, it can serve as a screening tool for the presence of potential disease outbreaks in the corresponding livestock population. Whole genome shotgun sequencing analysis of the collected samples will provide a wide range of potential pathogens present in the sample. In this paper we characterized bacterial contamination in Sloan Creek subwatershed, located in the Great Lakes basin. In addition to E. coli, we quantified bovine-associated bacteroides indicating that pollution is partly originating from livestock sources. We conducted whole genome shotgun sequencing analysis of water samples collected in the mouth of the sub-watershed. The analysis of the genomic sequences was focused on the identification of potential cattle pathogens. We observed genomic sequences related to Mycobacterium, Brucella, and other species. The information serves as a screening tool for the identification and early detection of signals of potential livestock disease, including bovine tuberculosis. This proposed approach may only serve as a screening tool for the presence for potential disease. When signals of disease of interest are observed, further testing of manure and individual animals is required.

This work was supported in part by DEQ

Keywords: bio-surveillance, One Health approach, whole genome shotgun sequencing, pathogens

Poster Number: SE-40
Authors: Stephen Zajac; Timothy A. Grotjohn
Title: Fabrication and Testing of High Power Diamond Schottky Diodes up to 1800V

Abstract: Diamond as a semiconductor material offers the promise of electronic devices with higher reverse breakdown voltages, higher operating powers, and higher operating temperatures when compared to silicon based electronics. These improved metrics are possible because of the unique characteristics of diamond such as a high breakdown electric field strength, high hole and electron mobility, and high thermal conductivity. Potential applications of these diamond electronics devices include electric car motor inverters, renewable energy power conversion systems, and any application that requires high power density and low loss. A challenge has been growing epitaxial diamond material in the quantities and qualities needed for high power devices. Much of the past research has focused on understanding the material properties of diamond, and has succeeded in fabricating devices with high reverse voltages and high current densities, but the large area, practical devices have been elusive. This research is focused on looking at what is necessary to create these practical devices. Vertical Schottky diodes are fabricated with p+ doped substrates to measure the properties of the grown diamond. One end result on a 4 mm by 4 mm substrate with 200 µm diameter contacts and a boron doping level of 1 x 1016 cm-3 in the drift layer as measured by CV had a measured breakdown voltage of 1.8 kV, and a forward current density of 300 A/cm-2.

This work was supported in part by DOE ARPA-E

Keywords: Solar Power, Wind Power, Renewable Energy, Electric Cars, Diamond

Poster Number: SE-41
Authors: Yurui Zheng; Douglas Clements; Shiwang Cheng; Yan(Susie) Liu; Wei Liao
Title: Synergistic Integration of Gas Separation and Algal Cultivation to Capture CO2 in Air

Abstract: Rapid growth of the world's population, along with accelerating industrialization and expanding urbanization, has led to a dramatic increase of carbon emissions that have exceeded the amount that can be taken up by natural sinks. Reducing CO2 emission is urgently needed to stabilize Earth's surface temperature and avoid catastrophic consequences in the future. The objective of this study is to develop a direct CO2 capture process by integrating membrane separation and algal cultivation technologies. The process includes two interconnected unit operations: gas membrane for CO2 enrichment from air and algal cultivation of CO2 utilization. The integrated process can concentrate CO2 from 400 ppm to 2% (v/v) to support algal growth, and accumulate a protein-rich algal biomass with a CO2 utilization efficiency of more than 50%.

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

Keywords: CO2 capture

ARTIFICIAL INTELLIGENCE, MACHINE LEARNING AND DATA SCIENCE

Poster Number: AIMLDS-01
Authors: Haochen Liu; Hongshen Chen; Yihong Zhao; Jiliang Tang; Dawei Yin
Title: Enriching Context Understanding and Response Paraphrasing for Neural Dialogue Generation

Abstract: Neural dialogue generation has achieved noticeable progress in recent years. It regards dialogue as a sequence of context-response pairs. At each turn, given previous dialogue context, a neural dialogue generation model understands the context and then generates a response word-by-word. The model benefits from the unified end-to-end fashion with much simplicity. However, the context and the response have numerous variations in different sentence architectures and ever-changing conversation scenarios, which pose tremendous challenges to sufficiently understand the context and appropriately generate responses. As a result, most of the existing neural dialogue generation models suffer from generating raw, meaningless or even irrelevant responses. In this paper, we aim to enrich context understanding and response paraphrasing for dialogue generation by taking advantage of pervasive free-text corpora. To achieve this goal, we propose a novel neural dialogue deliberation model. When encoding, it analyzes the context by comparing it with the retrieved similar contexts, which mimics the situation when we are confronting with an unintelligible context, we may look back upon the similar ones and compare them with the current context to handle the real meaning through comparison. For decoding, it first generates a raw response and then refines it by its similar texts, which is quite similar to the imitation sentence making process. Extensive experiments have been conducted on various real-world datasets to verify a significant improvement of our proposed model against competitive baseline models in response generation.

Keywords: dialogue System, neural dialogue generation, context understanding, response paraphrasing

Poster Number: AIMLDS-02
Authors: Wenqi Fan; Yao Ma; Qing Li; Yuan He; Eric Zhao; Jiliang Tang; Dawei Yin
Title: GraphRec_Graph Neural Networks for Social Recommendation

Abstract: In recent years, Graph Neural Networks (GNNs), which can naturally integrate node information and topological structure, have been demonstrated to be powerful in learning on graph data. These advantages of GNNs provide great potential to advance social recommendation since data in social recommender systems can be represented as user-user social graph and user-item graph; and learning latent factors of users and items is the key. However, building social recommender systems based on GNNs faces challenges. For example, the user-item graph encodes both interactions and their associated opinions; social relations have heterogeneous strengths; users involve in two graphs (e.g., the user-user social graph and the user-item graph). To address the three aforementioned challenges simultaneously, in this paper, we present a novel graph neural network framework (GraphRec) for social recommendations. In particular, we provide a principled approach to jointly capture interactions and opinions in the user-item graph and propose the framework GraphRec, which coherently models two graphs and heterogeneous strengths. Extensive experiments on two real-world datasets demonstrate the effectiveness of the proposed framework GraphRec.

Keywords: social recommendation, recommender systems, social network, graph neural networks, neural networks

Poster Number: AIMLDS-03
Authors: Xiangyu Zhao; Long Xia; Liang Zhang; Zhuoye Ding; Dawei Yin; Jiliang Tang
Title: Deep Reinforcement Learning for Page-wise Recommendations

Abstract: Recommender systems can mitigate the information overload problem by suggesting users' personalized items. In real-world recommendations such as e-commerce, a typical interaction between the system and its users is -- users are recommended a page of items and provide feedback; and then the system recommends a new page of items. To effectively capture such interaction for recommendations, we need to solve two key problems -- (1) how to update recommending strategy according to user's real-time feedback, and 2) how to generate a page of items with proper display, which pose tremendous challenges to traditional recommender systems. In this paper, we study the problem of page-wise recommendations aiming to address aforementioned two challenges simultaneously. In particular, we propose a principled approach to jointly generate a set of complementary items and the corresponding strategy to display them in a 2-D page; and propose a novel page-wise recommendation framework based on deep reinforcement learning, DeepPage, which can optimize a page of items with proper display based on real-time feedback from users. The experimental results based on a real-world e-commerce dataset demonstrate the effectiveness of the proposed framework.

This work was supported in part by National Science Foundation (NSF) under grant number IIS-1714741 and IIS-1715940, and a grant from Criteo Faculty Research Award

Keywords: recommender systems; deep reinforcement learning; actor-critic; item display strategy; sequential preference

Poster Number: AIMLDS-04
Authors: Shengjie Zhu; Garrick Brazil
Title: 3D Driving Scene Understanding

Abstract: Thorough 3D scene understanding in urban scenes is of the utmost importance for autonomous driving. While there is extensive prior work studying individual components related to scene understanding (segmentation, 2D/3D detection, depth), we aim to unify the tasks into a single comprehensive 3D scene understanding problem using only monocular images. We propose to classify every distinct object, both foreground and background, into a shared collective 3D world in the form of 3D cuboids. To overcome intensive labeling efforts, we propose a sequential optimization technique to generate reliable 3D cuboid ground truths for all classes of a scene utilizing estimated segmentation, depth, and detection, alongside ground truths when available. Collectively, we produce 3D cuboid for 7 classes within the KITTI autonomous driving dataset and aim to generalize to further urban driving datasets in the future.

Keywords: 3d model, scene understanding, bounding box label

Poster Number: AIMLDS-05
Authors: Kamran Ali, Alex X. Liu, Kazuhito Koishida
Title: AirSense: Bringing Wi-Fi Based Activity Recognition to Smart-Home Assistants

Abstract: WiFi signals are the most ubiquitous form of sensing around us. In this work, we propose to leverage WiFi signals to recognize different activities inside homes. Our system is privacy non-intrusive and can recognize multiple human activities in an environment and individual independent manner. We collect data from more than 90 users, and show that our system achieve activity recognition accuracy of more than 86%.

Keywords: sensing, radio frequency, WiFi, smart-homes, alexa, microsoft research

Poster Number: AIMLDS-06
Authors: Danielle Barnes; Jose Perea
Title: A Predictive Extension to the Mapper Algorithm

Abstract: This poster presents a predictive extension of Mapper and shows increased accuracy in prediction on the iris dataset. The predictive extension uses existing features in the original data to create a partition of unity on the mapper object, and provides an alternative adjacency matrix for the mapper object based on the desired outcome variable. For the iris dataset, this provides increased predictive accuracy over a K-nearest-neighbors model. Further research into additional datasets and definitions is needed.

Keywords: topology, data science, machine learning, statistics

Poster Number: AIMLDS-07
Authors: Garrick Brazil; Xiaoming Liu
Title: 3D Object Detection Optimised by 2D Perspective Geometry Constraints

Abstract: Understanding the world in 3D is a critical component of urban autonomous driving. Generally, the combination of expensive LiDAR sensors and stereo RGB imaging has been paramount for successful 3D object detection algorithms, whereas monocular image-only methods on 3D detection experience drastically reduced performance. We propose to bridge the gap by reformulating the monocular 3D detection problem using the geometric relationship of 3D and 2D perspectives as a strong heuristic, essentially allowing 3D boxes to leverage the well-known and powerful 2D detection characteristics. We both design a novel 3D detection framework using these constraints to train a high-performing model, and propose a fast and simple post-optimisation algorithm using geometric heuristics which force Intersection over Union (IoU) consistency of 3D projected boxes with its 2D counterparts. In doing so, we are able to drastically improve the performance of monocular 3D object detection using the challenging KITTI urban autonomous driving dataset while maintaining an efficient runtime.

Keywords: computer vision; object detection; recognition

Poster Number: AIMLDS-08
Authors: Xavier Brumwell; Paul Sinz; Kwang Jin Kim; Michael Swift; Jialin Liu; Yue Qi; Matthew Hirn
Title: Wavelet Scattering for Predictions in Lithium-Silicon Systems

Abstract: We improve upon a machine learning architecture using wavelet scattering coefficients of three dimensional images in application to quantum chemistry. Wavelets are oscillatory filters with localized support that decompose a signal into different frequency components. Solid harmonic wavelet scattering transforms of three dimensional signals were previously introduced for regression over properties of small organic molecules. Here, we train an improved model on a database of amorphous lithium-silicon states, generated using plane-wave Density Functional Theory methods, to predict various properties.

This work was supported in part by DARPA YFA #D16AP00117

Keywords: machine learning, quantum chemistry, wavelets

Poster Number: AIMLDS-09
Authors: Norman Chamusah; Michael Murillo
Title: Modeling Gene Drive Strategies for Eradicating Malaria

Abstract: Malaria is a mosquito-borne infectious disease that is endemic in tropical and subtropical countries. Globally, malaria infects more than 200 million people and kills 500 thousand people every year. Most of malaria control measures are directed at reducing anopheles mosquito bites. Although these measures have been successful at reducing malaria transmissions, they have been insufficient in eradicating this deadly disease. Health organizations are looking at new methods of effectively eliminating malaria. Gene drive strategies offer a powerful opportunity to reduce new transmissions and suppress anopheles mosquitoes. Gene drive is a technique that introduces genetic elements at a faster rate than the mendelian inheritances, self replicating and driving themselves into population. Successful laboratory tests have been carried out that aim at driving y chromosomes and disrupting fertility gene to collapse a mosquito population. A second method adds a gene that makes anopheles mosquitoes resistant to the malaria parasite. There are many ecological disruptions and ethical factors that need to be considered before releasing gene drives into a society. In this study, we develop an Agent-based model (ABM) that account for mosquito-parasite-human cycle, social environment, mosquito and human mobility factors. ABMs are computational models in which individual agents with specified set of characteristics interact with each other and with environment according to predefined rules. We leverage laboratory test results, compartmental models and realistic environmental settings and climate parameters to predict outcomes of introducing gene drive mosquitoes. The model enable us to optimize gene drive mosquitoes and pre-existing malaria control measures

Keywords: gene drive Malaria control model

Poster Number: AIMLDS-10
Authors: Tarang Chugh; Anil K. Jain
Title: Fingerprint Presentation Attack Detection: Generalization and Efficiency

Abstract: We study the problem of fingerprint presentation attack detection (PAD) under unknown PA materials not seen during PAD training. A dataset of 5,743 bonafide and 4,912 PA images of 12 different materials is used to evaluate a state-of-the-art PAD, namely Fingerprint Spoof Buster. We utilize 3D t-SNE visualization and clustering of material characteristics to identify a representative set of PA materials that cover most of PA feature space. We observe that a set of six PA materials, namely Silicone, 2D Paper, Play Doh, Gelatin, Latex Body Paint and Monster Liquid Latex provide a good representative set that should be included in training to achieve generalization of PAD. We also propose an optimized Android app of Fingerprint Spoof Buster that can run on a commodity smartphone (Xiaomi Redmi Note 4) without a significant drop in PAD performance (from TDR = 95.7% to 95.3% @ FDR = 0.2%) which can make a PA prediction in less than 300ms.

This work was supported in part by IARPA R&D Contract No. 2017 - 17020200004

Keywords: fingerprint spoof detection, presentation attacks, biometrics

Poster Number: AIMLDS-11
Authors: Yuning Hao; Ming Yan; Blake R. Heath; Yu L. Lei; Yuying Xie
Title: Fast and Robust Deconvolution of Tumor Infiltrating Lymphocyte from Expression Profiles using Least Trimmed Squares

Abstract: Gene-expression deconvolution is used to quantify different types of cells in a mixed population. It provides a highly promising solution to rapidly characterize the tumor-infiltrating immune landscape and identify cold cancers. However, a major challenge is that gene-expression data are frequently contaminated by many outliers that decrease the estimation accuracy. Thus, it is imperative to develop a robust deconvolution method that automatically decontaminates data by reliably detecting and removing outliers. We developed a new machine learning tool, Fast And Robust Deconvolution of Expression Profiles (FARDEEP), to enumerate immune cell subsets from whole tumor tissue samples. To reduce noise in the tumor gene expression datasets, FARDEEP utilizes an adaptive least trimmed square to automatically detect and remove outliers before estimating the cell compositions. We show that FARDEEP is less susceptible to outliers and returns a better estimation of coefficients than the existing methods with both numerical simulations and real datasets. FARDEEP provides the absolute quantitation of each immune cell subset in addition to relative percentages. Hence, FARDEEP represents a novel robust algorithm to complement the
existing toolkit for the characterization of tissue-infiltrating immune cell landscape.

This work was supported in part by NIH grants R03 DE027399, R01 DE026728 and R00 DE024173, NSF grant DMS-1621798, the Michigan State University STEM Gateway Fellowship, and University of Michigan Rogel Cancer Center Research Grant.

Keywords: robust regression, outlier detection, least trimmed square, deconvolution, machine learning

Poster Number: AIMLDS-12
Authors: Jieqian He; Matthew Hirn; Michael Perlmutter
Title: Multi-layer Scattering for Poisson Processes

Abstract: Scattering transforms are a mathematical model for convolutional neural networks that combine wavelet transforms with non-linear modulus operators. The scattering representation of a signal is translation invariant, stable to diffeomorphisms and captures high frequency information of the signal. In this project, we discuss the statistical properties of scattering coefficients of Poisson point processes, which can be used to model a variety of real-world phenomena. We show that multi-layer small scale asymptotics of scattering coefficients capture arbitrary moments of the signal heights, in addition to information related to the distribution of the points. We also show that scattering representations distinguish Poisson processes from alpha-stable processes and fractional Brownian Motion. A deep convolutional GAN is constructed to generate new realizations of Poisson processes by matching the distribution of scattering coefficients.

This work was supported in part by NSF grant #1620216

Keywords: scattering transforms, Poisson processes

Poster Number: AIMLDS-13
Authors: Feng Liu; Tran Luan; Xiaoming Liu
Title: 3D Face Modeling from Diverse Raw Scan Data

Abstract: Traditional 3D models always learn a latent representation of faces using linear subspaces from no more than 300 training scans of single database. The main roadblock of building a large-scale face model from diverse set of 3D databases lies in dense correspondence for raw scans. To address these problems, this paper proposes an innovative framework to jointly learn a nonlinear face model from a diverse set of raw 3D scan databases and establish dense point-to-point correspondence among them. Specifically, by treating input raw scans as unorganized point clouds, we explore the use of PointNet architectures for converting point clouds to identity and expression feature representations, from which the decoder networks recover their 3D face shapes. Further, a weakly supervised learning approach is proposed which do not require label correspondence for the scans. We demonstrate the superior dense correspondence and representation power of our proposed method in shape and expression, and its contribution to single image 3D face reconstruction.

Keywords: 3D face modeling; auto-encoder; diverse raw scan data

Poster Number: AIMLDS-14
Authors: Hamid Karimi; Jiliang Tang
Title: Learning Hierarchical Discourse-level Structure for Fake News Detection

Abstract: On the one hand, nowadays, fake news articles are easily propagated through various online media platforms and have become a grand threat to the trustworthiness of information. On the other hand, our understanding of the language of fake news is still minimal. Incorporating hierarchical discourse-level structure of fake and real news articles is one crucial step toward better understanding of how these articles are structured. Nevertheless, this has rarely been investigated in the fake news detection domain and faces tremendous challenges – existing methods for capturing discourse-level structure rely on annotated corpora which are not available for fake news datasets. To address these challenges, we propose Discourse-level Hierarchical Structure for Fake news detection. DHSF constructs discourse-level structures of fake/real news articles in an automated manner. Moreover, we identify insightful structure-related properties, which can explain the discovered structures and boost our understating of fake news. Extensive experiments show the effectiveness of the proposed approach. The further structural analysis suggests that real and fake news present substantial differences in the hierarchical discourse-level structure.

Keywords: fake news, hierarchical structure, discourse,

Poster Number: AIMLDS-15
Authors: Mehmet Kaymak; Metin Aktulga; Ron Fox; Sean Liddick
Title: Data Analysis for Atomic Shapes in Nuclear Science

Abstract: One of the overarching questions in the field of nuclear science is how simple phenomena emerges from complex systems. A nucleus is composed of both protons and neutrons and while many assume the atomic nucleus adopts a spherical shape, the nuclear shape is, in fact, quite variable. Nuclear physicists seek to understand the shape of the atomic nucleus by probing specific transitions between nuclear energy states which occur at high energy with short timescales. This is achieved through detecting a unique experimental signature in the recorded time-series data in experiments conducted at the National Superconducting Cyclotron Laboratory. The current method involves fitting each sample in the dataset to a given parameterized model function. However, this procedure is computationally expensive due to the nature of the nonlinear curve fitting problem. Since data is skewed towards non-unique signatures, we offer a way to filter out the majority of the uninteresting samples from the dataset by using machine learning methods. By doing so, we decrease the computational costs for detection of the unique experimental signatures in the time-series data. Also, we present a way to generate synthetic training data by estimating the distribution of the underlying parameters of the model function with Kernel Density Estimation. The new workflow that leverages machine learned classifiers trained on the synthetic data are shown to significantly outperform the current procedures used by our nuclear physics collaborators in actual datasets.

Keywords: data analytics, machine learning, nuclear science

Poster Number: AIMLDS-16
Authors: Michael Langford; Betty H.C. Cheng
Title: Enhancing Learning-Enabled Software Systems with Novelty Search to Address Environmental Uncertainty

Abstract: Due to the complexity of the natural environment and the increasing number and complexity of onboard features that may cause unwanted interactions in learning-enabled high assurance systems, such as autonomous vehicles, it is challenging to collect the data needed to train such systems to be resilient against environmental uncertainty. Automated methods can ease the burden for developers by augmenting real-world data with synthetically generated data. We propose a method to assist developers with the problem of assessing learning-enabled systems in environments not covered by available datasets. We have developed Enki, a tool that can simulate various conditions of the environment and discover properties that lead to diverse and unique system behaviors. These environmental properties are then used to construct synthetic data for two purposes: (1) to assess a system's performance in an uncertain environment and (2) to improve system resilience in the presence of uncertainty. We show that our technique outperforms a random selection method by demonstrating the effect of multiple adverse environmental conditions on a Deep Neural Network (DNN) trained for the CIFAR-10 benchmark.

This work was supported in part by NSF (CNS-1305358 and DBI-0939454), Ford Motor Company, General Motors Research, and Air Force Research Laboratory (AFRL) under agreement number FA8750-16-2-02

Keywords: evolutionary computation, search-based software engineering, novelty search, machine learning, deep neural networks

Poster Number: AIMLDS-17
Authors: Boyang Liu; Pang-Ning Tan; Jiayu Zhou
Title: Augmented Multi-Task Learning by Optimal Transport

Abstract: Augmented Multi-Task Learning by Optimal TransportBoyang Liu∗Pang-Ning TanJiayu ZhouAbstractMulti-task learning (MTL) provides an effective ap-proach to improve generalization error for multiple re-lated prediction tasks by learning the tasks jointly, as-suming there is a common structure shared by theirmodel parameters. Despite its successes, the shared pa-rameter assumption is ineffective when the sample sizesfor some tasks are too small to infer the task relation-ships correctly from data. To overcome this limitation,we propose a novel framework for increasing the effectivesample size of each task by augmenting it with pseudo-labeled instances generated from the training data ofother related tasks. Incorporating training data fromother tasks is a challenge for regression problems as theirdata distributions may not be consistent due to the co-variate shift and response drift problems. Our proposedframework addresses this challenge by coupling multi-task regression with a series of optimal transport stepsto iteratively learn the pseudo-labeled instances by iden-tifying relevant training instances from other source do-mains and refining the pseudo-labels until they are con-sistent with the training instances of the target domain.Experimental results on both synthetic and real-worlddata showed that our framework consistently outper-formed other state-of-the-art MTL methods

This work was supported in part by NSF and ONR

Keywords: multi-task learning, optimal transport

Poster Number: AIMLDS-18
Authors: Yaojie Liu; Joel Stehouwer; Amin Jourabloo; Xiaoming Liu
Title: Deep Tree Learning for Zero-shot Face Anti-Spoofing

Abstract: Face anti-spoofing is designed to keep face recognition systems from recognizing fake faces as the genuine users. While advanced face anti-spoofing methods are developed, new types of spoof attacks are also being created and becoming a threat to all existing systems. We define the detection of unknown spoof attacks as Zero-Shot Face Anti-spoofing (ZSFA). Previous works of ZSFA only study 1-2 types of spoof attacks, such as print/replay attacks, which limits the insight of this problem. In this work, we expand the ZSFA problem to a wide range of 13 types of spoof attacks, including print attack, replay attack, 3D mask attacks, and so on. A novel Deep Tree Network (DTN) is proposed to tackle the ZSFA. The tree is learned to partition the spoof samples into semantic sub-groups in an unsupervised fashion. When a data sample arrives, being know or unknown attacks, DTN routes it to the most similar spoof cluster, and make the binary decision. In addition, to enable the study of ZSFA, we introduce the first face anti-spoofing database that contains diverse types of spoof attacks. Experiments show that our proposed method achieves the state of the art on multiple testing protocols of ZSFA.

This work was supported in part by IARPA

Keywords: computer vision, biometrics, face anti-spoofing, unknown attack, deep learning

Poster Number: AIMLDS-19
Authors: Yao Ma; Suhang Wang; Charu C. Aggarwal; Dawei Yin; Jiliang Tang
Title: Multi-dimensional Graph Convolutional Networks

Abstract: Convolutional neural networks (CNNs) leverage the great power in representation learning on regular grid data such as image and video. Recently, increasing attention has been paid on generalizing CNNs to graph or network data which is highly irregular. Some focus on graph-level representation learning while others aim to learn node-level representations. These methods have been shown to boost the performance of many graph-level tasks such as graph classification and node-level tasks such as node classification. Most of these methods have been designed for single-dimensional graphs where a pair of nodes can only be connected by one type of relation. However, many real-world graphs have multiple types of relations and they can be naturally modeled as multi-dimensional graphs with each type of relation as a dimension. Multi-dimensional graphs bring about richer interactions between dimensions, which poses tremendous challenges to the graph convolutional neural networks designed for single-dimensional graphs. In this paper, we study the problem of graph convolutional networks for multi-dimensional graphs and propose a multi-dimensional convolutional neural network model mGCN aiming to capture rich information in learning node-level representations for multi-dimensional graphs. Comprehensive experiments on real-world multi-dimensional graphs demonstrate the effectiveness of the proposed framework.

This work was supported in part by IIS-171474; IIS-1715940

Keywords: graph neural networks; multi-dimensional graph

Poster Number: AIMLDS-20
Authors: Farzan Masrour; Pang-Ning Tan; Abdol-Hossein Esfahanian
Title: OPTANE: An OPtimal Transport Algorithm for NEtwork Alignment

Abstract: Networks are powerful representational tools for modeling dyadic
interactions among interconnected entities in a complex system.
Examples include the Internet as a physical network of interconnected computing devices, social media platforms such as Facebook
for human communications, and genetic regulatory networks in
biochemical systems. With the proliferation of data collected in many of these application domains, it is becoming increasingly common for the entities to appear in more than one network. Network Alignment(NA) is an important problem that tries to find the best overall alignment between the input networks. However, learning the proper alignment matrix is a challenge because this a computationally expensive problem. In this project we proposed OPTANE a novel framework for unsupervised network alignment, which consists of learning an optimal transportation from one network to the other based on node
attributes and topological features of the networks.

Keywords: data mining, network alignment, optimal transport

Poster Number: AIMLDS-21
Authors: Mitchell Eithun; Daniel H. Chitwood; James Larson; Gregory Lang; Elizabeth Munch
Title: Algorithmic Isolation of Phyllotactic Growth Patterns

Abstract: We apply techniques from image processing to determine the locations of epicormic vascular traces embedded within secondary growth of sweet cherry (Prunus avium L.), revealing the juvenile phyllotactic pattern in the trunk of an adult tree. Techniques include breadth-first search to find the pith of the tree, edge detection to approximate the radius, and a conversion to polar coordinates to threshold and segment phyllotactic features. Intensity values from Magnetic Resonance Imaging (MRI) of the trunk are projected onto the surface of a perfect cylinder to find the locations of traces in the ``boundary image''. Mathematical phyllotaxy provides a means to capture the patterns in the boundary image by modeling phyllotactic parameters. Our cherry tree specimen has the conspicuous parastichy pair (2,3) phyllotactic fraction 2/5, and divergence angle of approximately 143 degrees.
The methods described not only provide a framework to study phyllotaxy, but for image processing of volumetric image data in plants. Our results have practical implications for orchard rejuvenation and directed approaches to influence tree architecture. The study of epicormic structures, which are hidden within secondary growth, using tomographic methods also opens the possibility of studying the genetic and environmental basis of such structures.

This project was supported by the USDA National Institute of Food and Agriculture, and by Michigan State University AgBioResearch. The work of EM was supported in part by NSF grants DMS-1800446 and CMMI-1800466.

Keywords: phyllotaxy, plant growth, image processing, magnetic resonance imaging, sweet cherry

Poster Number: AIMLDS-22
Authors: Dinh-Luan Nguyen; Anil K. Jain
Title: Fingerprint Inpainting: End-to-End Evaluation

Abstract: Image inpainting and reconstruction is the problem of filling noisy areas in a given image and reconstructing the filled in areas to maintain the context based on neighboring spatial information. We pose the fingerprint inpainting and reconstruction problem by splitting it into two stages: (i) foreground separation, and (ii) inpainting of friction ridges. Specifically, we propose an end-to-end deep generative framework that exploits the spatial contextual information, but still preserves identity information within the reconstructed fingerprint images. Experimental results show that the proposed method outperforms the state-of-the-art in terms of qualitative, quantitative, and recognition metrics. We also demonstrate the applicability of our method to other image domains, including faces and arbitrary images.

Keywords: inpainting, fingerprint enhancement, quality assessment

Poster Number: AIMLDS-23
Authors: Ningyu Sha; Youzuo Lin; Ting Chen; Ming Yan
Title: Efficient Seismic Event Detection using Robust Principal Component Analysis

Abstract: Modeling seismic events relies on accurate assumptions on the property of different signals. Normal signals received at different receivers are correlated, and they lie in a low dimensional subspace of a high dimensional space. Therefore, dimension reduction techniques are utilized to model those signals, and robust principle component analysis (RPCA) is one of them. It is able to separate sparse events from a low-rank low dimensional signal. However, existing algorithms for RPCA are slow. We developed an algorithm that is 3-20x faster than existing ones for RPCA. The speedup is verified on synthetic data and real data.

This work was supported in part by NSF grant DMS-1621798

Keywords: Seismic data, RPCA, infimal convolution, nonconvex

Poster Number: AIMLDS-24
Authors: Seyyid Emre Sofuoglu; Selin Aviyente
Title: Tensor-Train Discriminant Analysis

Abstract: The rapid development of information technology is making it possible to collect massive amounts of multidimensional, multimodal data with high dimensionality in a diverse set of science and engineering disciplines. Although there has been a lot of recent work in the area of unsupervised tensor learning, extensions to supervised learning, feature extraction and classification are still limited. Moreover, most of the existing supervised tensor learning approaches are based on the Tucker model. However, this model has some limitations for large tensors including high memory and execution time costs. In this paper, we introduce a supervised learning approach for tensor classification based on the tensor-train model. In particular, we introduce two computationally efficient implementations of tensor-train discriminant analysis (TT-DA). The proposed approaches are evaluated on image classification tasks with respect to computation time, storage cost and classification accuracy.

This work was supported in part by NSF

Keywords: tensor networks, multidimensional discriminant analysis

Poster Number: AIMLDS-25
Authors: Joel Stehouwer; Yaojie Liu; Amin Jourabloo; Xiaoming Liu
Title: Noise Modeling, Synthesis and Classification for Generic Object Anti-Spoofing

Abstract: With the popularity of online person-to-person shopping, e.g., Ebay, there is a need to have a general anti-spoofing system, which determines if an image is captured from the real object, or through another medium, such as digital screen. Considerable research has been done for biometric anti-spoofing in three independent modalities; iris, fingerprint, and face. However, the vast majority of these research are modality-specific. In this paper, we propose the first set of methods and dataset (GOSet) for generic object anti-spoofing. We design GOLab algorithm to identify the types of sensors and spoof mediums. Given the impact of sensor and medium type to anti-spoofing, and the challenge of collecting data with all sensor/medium combinations, we develop GOGen algorithm to synthesize spoof images at any sensor/medium combination from live images. We show that the generated spoof images improve the performance and generalization of anti-spoofing methods. Finally, we demonstrate that anti-spoofing models learned from only generic objects are able to contribute to face anti-spoofing.

This work was supported in part by IARPA

Keywords: anti-spoofing, noise modeling, noise synthesis

Poster Number: AIMLDS-26
Authors: Sarah Tymochko; Elizabeth Munch; Jason Dunion; Kristen Corbosiero; Ryan Torn
Title: Using Persistent Homology to Quantify a Diurnal Cycle in Hurricane Felix

Abstract: The tropical cyclone (TC) diurnal cycle is a regular, daily cycle in hurricanes that may have implications for the structure and intensity of hurricanes. This pattern can be seen in a cooling ring forming in the inner core of the storm near sunset and propagating away from the storm center overnight, followed by warmer clouds on its inside edge. The current state of the art for diurnal cycle measurement has a limited ability to analyze the behavior beyond qualitative observations. Our method creates a more advanced mathematical method for quantifying the TC diurnal cycle using tools from Topological Data Analysis, specifically one dimensional persistent homology. Using geostationary operational environmental satellite (GOES) IR imagery data from Hurricane Felix in 2007, our method is able to detect an approximately daily cycle in the hurricane.

This work was supported in part by The work of ST and EM was supported in part by NSF grant DMS-1800446; EM was also supported in part by NSF CMMI-1800466. The work of JD was supported in part by the Office of Naval Research Program Element (PE) 0601153N Grant N000141410132 and by NOAA Grant NA14OAR4830172 from the Unmanned Aircraft Systems (UAS) Program. KC was supported by NSF Grant AGS-1636799.

Keywords: topological data analysis, atmospheric science

Poster Number: AIMLDS-27
Authors: Ding Wang; Boyang Liu; Pang-Ning Tan; Lifeng Luo
Title: Online Multi-Lead Time Location Predictionfor Hurricane Trajectory Forecasting

Abstract: Hurricanes are powerful tropical cyclones with sustained wind speeds ranging from at least 74 mph (for category 1 storms) to more than 157 mph (for category 5 storms). Accurate prediction of hurricane tracks is essential to help minimize property damages and prevent the devastating loss of human lives. In this paper, we cast the hurricane trajectory forecasting task as an online multi-lead time location prediction problem and present a framework to improve path prediction by combining the 6-hourly and 12-hourly forecasts generated from an ensemble of dynamical (physical) models. Our framework employs an online learning with restart strategy to incrementally update the weights of the ensemble model combination as new observation data becomes available. A novel aspect of the framework is that it can handle the varying dynamical models available for predicting different hurricanes. Experimental results using the Atlantic and Eastern North Pacific hurricane data showed that the proposed framework significantly outperformed various competing methods, including the official forecasts produced by the National Hurricane Center (NHC).

Keywords: online, hurricane, trajectory, forecasting

Poster Number: AIMLDS-28
Authors: Zhiwei Wang; Yao Ma; Dawei Yin; Jiliang Tang
Title: Recurrent Neural Network

Abstract: Recurrent Neural Networks (RNNs) have been proven to be effective in modeling sequential data and they have been applied to boost a variety of tasks such as document classification, speech recognition and machine translation. Most of existing RNN models have been designed for sequences assumed to be identically and independently distributed (i.i.d). However,in many real-world applications, sequences are naturally linked.For example, web documents are connected by hyperlinks; and genes interact with each other. On the one hand, linked sequences are inherently not i.i.d., which poses tremendous challenges to existing RNN models. On the other hand, linked sequences offer link information in addition to the sequential information, which enables unprecedented opportunities to build advanced RNN models. In this paper, we study the problem of RNN for linked sequences. In particular, we introduce a principled approach to capture link information and propose a linked Recurrent Neural Network (LinkedRNN), which models sequential and link information coherently. We conduct experiments on real-world datasets from multiple domains and the experimental results validate the effectiveness of the proposed framework.

This work was supported in part by NSF

Keywords: recurrent neural network, link information, sequence modeling

Poster Number: AIMLDS-29
Authors: Anna Yannakopoulos; Alison Bernstein; Irving Vega; Arjun Krishnan
Title: Predicting ALZ-associated Protein Biomarkers From Multiple Evidence Sources

Abstract: Complex diseases such as Alzheimer’s disease (ALZ) are caused by several perturbed cellular mechanisms associated with hundreds of interacting genes. To identify novel disease-gene linkages, we use machine learning (ML) to build upon known disease-associated genes to identify others based on hundreds of thousands of human genetic and molecular data that is publicly available. We specifically focus on the fact that known disease-gene associations are often sourced from a variety of studies and study types of varying quality. To that end, we examine methods to generate predictions that take into account both the data itself as well the reliability of its source in the context of predicting ALZ-associated protein biomarkers. In addition to proteins quantified directly using mass spectroscopy, we evaluate multiple study types including microarray and genome-/epigenome-wide association studies on their ability to recapitulate ALZ biomarkers. We then incorporate these concordance measures within weighted ML methods to produce an integrated genome-wide ranking of ALZ-associated protein biomarkers. Our results show that, compared to only including known ALZ protein biomarkers, naively including all available data without regard to quality lessens predictive performance while incorporating data weighted with respect to its quality improves predictive performance. Experimental evaluation of our top predictions implicates several novel candidates as bona-fide ALZ-associated biomarkers.

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Keywords: Alzheimer's disease; disease-gene associations; machine learning; weighted learning; multiple evidence sources

Poster Number: AIMLDS-30
Authors: Ali Zare; Selin Aviyente; Mark A. Iwen; Tapabrata Maiti; Rongrong Wang
Title: Tensor Based Feature Extraction for MRI Data Classification

Abstract: The performance of tensor-based dimensionality reduction methods, Multilinear Principal Component Analysis (MPCA) and Matrix Product State (MPS) is investigated in comparison with regular PCA using MRI data from Alzheimer’s disease Neuroimaging Initiative (ADNI). Comparisons are made in terms of Classification Success Rate (CSR) and training time vs model size. Classification is performed using Nearest Neighbor and Linear Discriminant Analysis (LDA) after dimensionality reduction. Results are reported for various levels of dimension reduction, and show improved classification performance and storage cost of MPCA and MPS compared to PCA for an increase in training time.

Keywords: classification, tensor, dimensionality reduction, MPCA, MPS

Poster Number: AIMLDS-31
Authors: Ziyuan Zhang; Luan Tran; Xi Yin; Yousef Atoum; Xiaoming Liu; Jian Wan; Nanxin Wang
Title: Gait Recognition via Disentangled Representation Learning

Abstract: Gait, the walking pattern of individuals, is one of the most important biometrics modalities. Most of the existing gait recognition methods take silhouettes or articulated body models as the gait features. These methods suffer from degraded recognition performance when handling confounding variables, such as clothing, carrying and view angle. To remedy this issue, we propose a novel AutoEncoder framework to explicitly disentangle pose and appearance features from RGB imagery and the LSTM-based integration of pose features over time produces the gait feature. In addition, we collect a Frontal-View Gait (FVG) dataset to focus on gait recognition from frontal-view walking, which is a challenging problem since frontal view contains minimal gait cues compared to other views. FVG also includes other important variations, e.g., walking speed, carrying, and clothing. Extensive experiments are conducted on CASIA-B, USF and FVG datasets. Our method demonstrates superior performance than the state of the arts quantitatively, the ability of feature disentanglement qualitatively, and promising computational efficiency.

This work was supported in part by Ford

Keywords: gait recognition, pattern recognition, deep learning

Poster Number: AIMLDS-32
Authors: Tyler Derr; Yao Ma; Jiliang Tang
Title: Signed Graph Convolutional Networks

Abstract: Due to the fact much of today's data can be represented as graphs, there has been a demand for generalizing neural network models for graph data. One recent direction that has shown fruitful results, and therefore growing interest, is the usage of graph convolutional neural networks (GCNs). They have been shown to provide a significant improvement on many tasks in network analysis, one of which being node representation learning that in turn can provide increased performance on a plethora of other tasks from link prediction and node classification, to community detection and visualization. Simultaneously, signed networks (or graphs having both positive and negative links) have become ubiquitous with the growing popularity of social media. However, since previous GCN models have focused on graphs consisting of only positive links, it is unclear how they could be applied to signed networks due to the fact that negative links forming complex relations with positive links while also having inherently different principles and semantic meaning. Therefore we propose a dedicated and principled effort that utilizes balance theory to correctly aggregate and propagate the information across layers of a signed GCN model. We perform empirical experiments comparing our proposed signed GCN against state-of-the-art baselines for learning node representations in signed networks. More specifically, our experiments are performed on four real-world datasets for the classical link sign prediction problem that is commonly used as the benchmark for signed network embeddings algorithms.

This work was supported in part by National Science Foundation (NSF) under grant numbers IIS-1714741, IIS-1715940 and CNS-1815636, and a grant from Criteo Faculty Research Award.

Keywords: social networks, neural networks, network embedding

Poster Number: AIMLDS-33
Authors: Rayan Hussein; Proteek Chandan Roy; Kalyanmoy Deb
Title: Adaptive Switching Among Frameworks for Metamodeling Based Multi-Objective Optimization

Abstract: Evaluating computationally expensive objective and constraint functions is one of the main challenges faced when solving real-world optimization problems. For handling such problems, it is common to use a metamodeling approach. Metamodels for objectives and constraints are initially formed using a few high-fidelity solution evaluations. Then, the metamodels are optimized to find a set of in-fill solutions. New metamodels are then formed by including high-fidelity evaluations of in-fill solutions to the initial set. This procedure is continued in a progressive manner until a predetermined budget of solutions are evaluated. A recent study has provided a taxonomy of 10 different frameworks for forming metamodels of objective and constraint combinations.

Keywords: surrogate model, metamodel, evolutionary multi-objective optimization, kriging

Poster Number: AIMLDS-34
Authors: Muhammad Munum Masud, Syed Waqar Haider
Title: Identifying Potential Factors Affecting Weigh-in-Motion (WIM) System Accuracy

Abstract: Weigh-in-Motion (WIM) is a primary technology used for monitoring and collecting vehicle weights and axle loads on roadways. Highway agencies collect WIM data for many reasons, including highway planning, pavement and bridge design, freight movement studies, motor vehicle enforcement, and regulatory studies. The new mechanistic-empirical pavement design guide also requires WIM data for predicting pavement distresses. Inappropriate WIM data may result in significant over- or underestimation of the pavement performance period and hence, lead to premature failure. Therefore, it is crucial that the data collected at WIM systems are accurate and consistent.
There are several concerns regarding the accuracy since WIM systems infer static weights from dynamic measurements. The actual difference between the static and instantaneous dynamic load is often treated as an integral part of the WIM error. Generally, WIM errors contain three components: (a) actual static and dynamic force differences; (b) dynamic force measurement errors; and (c) static load measurement errors. Three significant factors affecting WIM errors include (a) roadway factors—smoothness and longitudinal/transverse profile; (b) vehicular factors—speed, acceleration, tire conditions, load, and suspension type; and (c) environmental factors—wind, water, and temperature. All of these factors can cause a random error even if the WIM sensor is calibrated. A drift in calibration factors is likely to take place between periods of routine or recurring calibrations resulting in biased axle load measurements.
In order to improve the desired accuracy of WIM systems, the factors highlighted above need to be evaluated further using quality WIM data. Therefore, the primary objective of the research is to quantify the influence of factors related to the pavement, vehicle, environmental, sensor type, WIM data acquisition system, and traffic on the performance of the WIM sites. The WIM data from the Long-term Pavement Performance (LTPP) and other comparable high-quality data sets are used to assess the data accuracy. The results of the statistical analysis will be used to develop mathematical and logical models for assessing and quantifying the influence of different factors on bias and accuracy in WIM data. The model inputs will be site-specific values for the factors identified in WIM data, and the model output will be the likely range of WIM measurement error.

Keywords: Weigh-in-Motion (WIM), Long-term Pavement Performance (LTPP), static weights, dynamic measurements

Poster Number: AIMLDS-35
Authors: AKM Khaled Talukder; Kalyanmoy Deb
Title: PaletteViz: A Novel Exploratory Data Analysis Framework for High-dimensional Pareto-optimal Dataset

Abstract: In this paper we present an alternative way to visualize a high-dimensional data-set in a two/three-dimensional space. The pro-posed method is more suitable if the trade-off (Pareto-dominance relationship) among the features are important. Although there have been a number of visualization methods for multivariate data analysis are proposed in the recent years, however, none of them does not consider the visualization in terms of the structure (either topological or geometrical) of the data point in the high dimension (i.e. dimensions more than three). Our proposed method is based on the statistical point depth of the data points in the high-dimension. PaletteViz works by first computing the point depth contour of the data points using a non-convex hull peeling algorithm, then it projects a set of points from the same depth-equivalence class onto a two-dimensional RadViz plot. As the non-convex hull peeling will produce a set of depth-equivalence classes, the final plot is a set of RadViz plots stacked on top of each other. Where each RadViz plot represents the “layers” of the data point cloud in the high-dimensional space. PaletteViz can maintain a faithful representation of neighborhood and center-outward relationships among data points, therefore it can retain the structural information of the dataset in high-dimension. We compare our method with different existing techniques and show that PaletteViz can offer new insights into the high-dimensional data that other existing methods can not. Although we developed this method for the visualization of high-dimensional Pareto-optimal front (for multi-criteria exploratory data analysis), however the proposed method can be useful in other scenarios as well.

Keywords: high-dimensional dataset, point depth, point depth contour, depth equivalence class, radial visualization, Pareto-optimal front

COMPUTING

Poster Number: COMP-01
Authors: Ali Akhavan-Safaei; John Foss; Mohsen Zayernouri
Title: Spectral Element Method for Stochastic CFD and Uncertainty Quantification

Abstract: Employing high-order, efficient, and scalable computational schemes is an essential matter in long-time integration of fluid problems and direct numerical simulation (DNS) of turbulent flows in complex geometries. In particular, spectral element method (SEM) has been shown to be a powerful and cost-efficient numerical approach to achieve high (i.e., spectral-to-exponential) accuracy in DNS of turbulent and chaotic flows in simple-to-complex domains. To better understand the random and nonlinear nature of turbulent flow sensitivities to "perturbations" in the initial/boundary/topological conditions, we formulate a proper stochastic modeling and uncertainty quantification (UQ) framework for studying a two-dimensional (2-D) rotating cylinder, where the sources of uncertainties are considered to be imperfect rotational break system, off-centered rotation, and imperfect geometries of cylinder. We study the internal flow and the vorticity dynamics after the break (i.e., arriving at rest starting from a constant rotational speed within a short time-period) in a high-speed rotational cylinder, which is fully-filled with the working fluid. Here, our deterministic solver is NEKTAR++, which is a spectral/hp element parallel scientific computing platform. Employing NEKTAR++ alongside the designed stochastic processes, we perform the corresponding stochastic simulations (i.e., realizations of perturbations) utilizing Monte Carlo (MC) sampling and probabilistic collocation method (PCM). This study will pave the ground for future calibrating and validating the simulation results with a set of experimental tests obtained using PIV method in 2-D and higher-dimensional domains.

This work was supported in part by AFOSR Young Investigator Program (YIP) award (FA9550-17-1-0150) and the MURI/ARO (W911NF- 15-1-0562).

Keywords: spectral element methods, CFD, stochastic modeling, UQ

Poster Number: COMP-02
Authors: Abdullah Alperen; Kurt A. O'Hearn; Hasan Metin Aktulga
Title: Performance Optimization of Reactive Molecular Dynamics Simulations on Distributed Memory Platforms

Abstract: Reactive molecular dynamics (MD) simulations are crucial for simulations of large systems that involve chemical reactions. The performance and scalability of reactive force fields are limited by (i) iterative solvers that are used to determine atom polarization and (ii) redundant bond order calculations. The main objective of this work is to address these limitations. To accomplish this goal, several optimizations are implemented such as initialization and data structure changes, and acceleration of the charge model solver through more effective preconditioning techniques and numerical methods with reduced communication overheads. Detailed scalability analysis of these optimizations and their overall impact is presented. A single all-reduce pipelined non-blocking conjugate gradient (CG) solver with sparse approximate inverse preconditioner that is based on a Frobenius norm minimization has been observed to yield promising speedups over a baseline standard CG solver with Jacobi preconditioner. These results are important as they can facilitate scalable simulations of large reactive systems, and presented techniques can be used in several other MD models.

Keywords: reactive molecular dynamics, iterative sparse solvers, distributed preconditioners, communication hiding techniques

Poster Number: COMP-03
Authors: Tom Dixon; Alex Dickson
Title: History Based Resampling Algorithm for Weighted Ensemble

Abstract: Molecular dynamics (MD) can be used to study real world phenomena such as protein folding, protein-ligand interactions, and molecular diffusion. However, many events of interest, such as ligand unbinding, occur at the millisecond to minute timescale; outside of the time range MD can typically simulate for complex systems. To sample these rare events without adding additional bias, weighted ensemble algorithms (WE) were developed. These algorithms work by looping between two major phases: 1) running several independent MD trajectories, known as walkers, for time tau and 2) resampling. Resampling is where two or more walkers that are similar to each other in some regard are combined into a single trajectory (merging), and/or a single walker that is unique in some regard is replicated (cloning). Using many iterative cycles of dynamics and resampling, WE simulations have successfully observed the unbinding of several protein-ligand complexes such as trypsin–benzamidine, with a simulation time on the order of microseconds. However, there are systems where ligand unbinding is difficult to observe for WE simulations due to high energy barriers and stable transitional states. Using WE we have performed simulations on the Translocator protein (TSPO)-PK11195 (PK) complex for over 10 microseconds and have not seen unbinding. Therefore, we propose a resampling algorithm that incorporates history as a way to improve sampling. We present a comparison between history and non-history based WE algorithms (a variant we call “Reweighting of Ensembles by Variance Optimization” or “REVO”), using an N-dimensional random walk model system and TSPO-PK unbinding simulations.

This work was supported in part by NIH

Keywords: molecular dynamics, weighted ensemble, REVO

Poster Number: COMP-04
Authors: Kayla Johnson; Arjun Krishnan
Title: Building Robust Gene Co-expression Networks from RNA-seq Data

Abstract: As the cost of RNA sequencing has continued to fall, the amount of publicly available RNA-seq data has continued to grow; currently, there are over 80,000 publicly-available human RNA-seq samples. A predominant method for studying gene function in specific biological contexts is to construct a gene co-expression networks using transcriptomes from those contexts. Although many studies have focussed on best preprocessing procedures for use of RNA-seq data for analysis of differential expression, not enough attention has been given to best practices for processing RNA-seq data for calculating gene co-expression. Constructing an accurate co-expression network depends on several factors including expression quantification from read count and presence of experimental and technical artifacts, which introduce non-biological variation into the data. In this research, we leverage thousands of uniformly aligned RNA-seq samples from various experiments that span diverse tissues, diseases, and conditions to investigate these factors. We construct gene co-expression networks using different within-sample and between-sample normalizations and network transformation methods, and then evaluate the resulting networks based on their ability to recover documented tissue-naive and tissue-specific gene functional relationships. This comprehensive benchmarking provides insight to the best procedures for deriving a robust gene co-expression network from an RNA-seq dataset.

This work was supported in part by US National Institutes of Health (NIH) grants R35 RC108840 to A.K.

Keywords: gene co-expression networks

Poster Number: COMP-05
Authors: Ryan LaRose; Arkin Tikku; Étude O'Neel-Judy; Lukasz Cincio; Patrick J. Coles
Title: Variational Quantum State Diagonalization

Abstract: Variational hybrid quantum-classical algorithms are promising candidates for near-term implementation on quantum computers. In these algorithms, a quantum computer evaluates the cost of a gate sequence (with exponential speedup over classical cost evaluation), and a classical computer uses this information to adjust the parameters of the gate sequence. Here we present such an algorithm for quantum state diagonalization. State diagonalization has applications in condensed matter physics (e.g., entanglement spectroscopy) as well as in machine learning (e.g., principal component analysis). For a quantum state rho and gate sequence U, our cost function quantifies how far UrhoU† is from being diagonal. We introduce novel short-depth quantum circuits to quantify our cost. Minimizing this cost returns a gate sequence that approximately diagonalizes rho. One can then read out approximations of the largest eigenvalues, and the associated eigenvectors, of rho. As a proof-of-principle, we implement our algorithm on Rigetti's quantum computer to diagonalize one-qubit states and on a simulator to find the entanglement spectrum of the Heisenberg model ground state.

Keywords: quantum computing, quantum algorithms, high performance computing, quantum physics

Poster Number: COMP-06
Authors: Alexander McKim, Arjun Krishnan
Title: A Genome-wide Landscape of the Functional Basis of Complex Traits and Diseases

Abstract: Complex traits like ‘blood pressure’ and ‘language development’ are polygenic, meaning that tens to hundreds of genes play a role in their expression. Genome-wide association study (GWAS) is a powerful approach to find single-nucleotide polymorphisms (SNPs), or genetic variants, across the genome that are associated with a given trait/disease. The pressing challenge over the past decade has been to relate the SNPs that are revealed by GWAS to genes and cellular processes so that we can understand their role mechanistically. The goal of this project is to develop a scalable computational approach to analyze millions of GWAS variants from publicly available databanks, score their impact on genes. The result of this analysis is a genome-wide landscape of biological processes that are associated with thousands of complex human traits. This landscape has many uses including the identification of cellular processes are common to multiple traits/diseases, which can point to similar ways in which the traits/diseases can be measured/diagnosed and treated at a molecular level. Together, our approach will help chart mechanism-guided paths from genetic variants to diagnostic and treatment options.

Keywords: complex traits, GWAS, disease relationships, gene ontology

Poster Number: COMP-07
Authors: Nazanin Donyapour; Alex Dickson
Title: Resampling of Ensembles by Variance Optimization

Abstract: Despite dramatic advancements in the power and speed of computational systems - as well as emerging high-performance systems and GPUs - sampling rare events of biomolecular systems is often limited by large energetic barriers that separate stable molecular states. Hence, we need to devise advanced sampling algorithms that increase the chance of visiting new and rare regions of a phase space during molecular simulation. Such sampling algorithms play an important role in protein folding, binding, and unbinding processes. An example of this is the WExplore algorithm, where computational effort is balanced across a set of sampling regions that are defined dynamically over the course of a simulation. Further, to improve the performance of WExplore, (i.e., addressing regioning issues in WExplore), We propose a new region-free enhanced sampling algorithm called REVO. Here we first describe the theoretical basis of REVO, and compare the sampling efficiency of REVO, WExplore using the N-dimensional random walk system, as well as the sampling of trypsin-benzamidine ligand release pathways. We find that that REVO clearly outperforms WExplore for high-dimensional order parameter spaces, and we examine performance of the algorithm for different definitions of the spread function.

This work was supported in part by National Institute of General Medical Sciences of the National Institutes of Health

Keywords: rare events, enhanced sampling, molecular dynamics

Poster Number: COMP-08
Authors: Fazlay Rabbi; Md. Afibuzzaman; Hasan Metin Aktulga
Title: DeepSparse: Towards Reducing Data Movement On Deep Memory Hierarchy by Exploiting Computational Dependencies

Abstract: We propose a novel sparse linear algebra framework, called DeepSparse, which focuses on optimizing data movement for sparse linear algebra computations on deep memory hierarchies of massively parallel computers. The main idea in DeepSparse is to represent the solver computations as a directed acyclic graph (where nodes correspond to computational tasks, and edges correspond to data flow between tasks); DeepSparse then uses effective directed acyclic graph partitioning algorithms to determine a scheduling of tasks that minimizes the data movement. Our proposed framework differs from the existing work in the sense that we propose a holistic approach that targets all computational steps in a sparse solver rather than narrowing the problem into a single kernel (e.g., SpMV, SpMM, etc). Our initial results using an iterative block eigensolver (i.e., LOBPCG) have been very promising, as we observe significant reductions of data movement (from DRAM to cache or between different layers in the cache) compared to a reference implementation.

Keywords: Parallel algorithms, sparse matrix computations, non-volatile random access memory storages, middleware systems, data-intensive computing

Poster Number: COMP-09
Authors: Omkar Ramachandran; Alejandro Diaz; Shanker Balasubramaniam
Title: LEAP Preconditioning for Acoustic Finite Element Solvers

Abstract: Finite Element solutions to differential equations invariably require solving a linear system of equations, often through the use of an iterative solver. The efficiency of such a method is largely determined by the number of iterations required for the solution to converge. As a result, an obvious way to optimize an iterative solver is to condition the system matrix so that it converges faster. Domain Decomposition Methods (DDMs) are one such optimization technique that work by splitting the computational domain of a solve boundary value problem into smaller subdomains. Each subdomain can then be solved directly and made to influence it's neighbours through appropriately imposed boundary conditions. DDMs are becoming increasingly popular primarily due to (1) their ability to improve the efficiency of an iterative solver (such as GMRES) when used with an appropriate preconditioner and (2) their potential for efficient parallelization. A popular example of this is the Finite Element Tearing and Interconnect (FETI) family of DDMs, which work well for a variety of problems. Recent work in computational electromagnetics has demonstrated that the use of the Locally Exact Algebraic Preconditioner (LEAP) in conjunction with FETI produce solutions that converge exponentially in a few iterations. In this work, we present an implementation of the FETI-LEAP solver for acoustic finite element problems.

Keywords: acoustics, finite elements, domain decomposition

Poster Number: COMP-10
Authors: William Sands; Andrew Christlieb; Pierson Guthrey; Mathialakan Thavappiragasm
Title: A Two-Level Domain Decomposition Approach for Solving Time Dependent Hamilton-Jacobi Equations Based on the Method of Lines Transpose

Abstract: In this work, we develop parallel extensions of the implicit methods for time-dependent Hamilton-Jacobi equations presented in [1], targeted at distributed computing platforms. These schemes, which are formally matrix-free, represent the differential operators using convolution integrals that can be evaluated in O(N) operations, using a novel fast convolution algorithm. Moreover, these methods facilitate dimensional-splitting using a line-by-line approach, which allows for a simple extension to multi-dimensional problems. The primary difficulty encountered in achieving scaling with our domain decomposition technique is the treatment of the convolution integrals. To this end, propose an iterative method for localizing the calculations so that the accuracy of the method is not compromised. A detailed discussion of our domain decomposition technique is presented, as well as some preliminary scaling results on multi-node systems.
[1] A. Christlieb, W. Guo, and Y. Jiang. A Kernel Based High Order "Explicit" Unconditionally Stable Scheme for Time Dependent Hamilton-Jacobi Equations. arXiv preprint arXiv:1802.00536, 2018.

Keywords: high-performance computing, algorithms, implicit methods, numerical analysis

Poster Number: COMP-11
Authors: Jorge Suzuki; Mohsen Zayernouri
Title: Fractional Modeling of Visco-Elasto-Plastic Materials

Abstract:
We present multiple time-fractional (constitutive) models for visco-elastic and visco-elasto-plastic materials. We make use of fractional Scott-Blair elements instead of standard Hookean springs and Newtonian dashpots, which introduces power-law stress-strain behaviors in both visco-elasticity and visco-plasticity. The thermodynamic consistency of the models is verified using fractional free-energy potentials with the classical Clausius-Duhem inequality. We develop proper numerical methods for long and accurate time-integration through the efficient computation of the history load and the use of fractional return-mapping algorithms. Finally, we analyze these models in the context of structural analysis by incorporating the resulting constitutive laws in a finite element framework.

This work was supported in part by AFOSR Young Investigator Program (YIP) award (FA9550-17-1-0150) and the MURI/ARO (W911NF- 15-1-0562)

Keywords: visco-elasticity, fractional differential equations

Poster Number: COMP-12
Authors: Wei Wang; Kevin J. Liu
Title: Support Estimation of Phylogenetic Tree Using SERES Resampling Approach

Abstract: The phylogenetic tree describes the evolutionary history of a group of species, which is widely used in many biological studies. The nonparametric bootstrap method has long been used as a standard technique to determine the confidence of the inferred phylogenetic tree. One problem of the bootstrap method is its assumption that sites in biomolecular sequences are independent and identically distributed (i.i.d) since the intra-sequence dependence is very common in biomolecular sequences.
In this study, we applied a new resampling technique, SERES (SEquential RESampling), which account for the intra-sequences dependence, on the problem of support estimation of the phylogenetic tree. Computational experiments to assess the performance and accuracy of SERES and bootstrap resampling approaches were conducted on both simulated datasets and empirical datasets. From the preliminary results, we found that the SERES-based approach greatly improved the accuracy of phylogenetic tree support estimation compared with the bootstrap-based approach on most simulated datasets and intronic empirical datasets. On the non-intronic empirical datasets, the performance of the SERES-based approach is comparable to the bootstrap-based approach.

This work was supported in part by National Science Foundation (grant nos. CCF-1565719, CCF-1714417, and DEB-1737898). Computational experiments were performed using the High Performance Computing Center (HPCC) at Michigan State University (MSU).

Keywords: support estimation, phylogenetic tree, resampling, bootstrap

Poster Number: COMP-13
Authors: Yongtao Zhou, Mohsen Zayernouri
Title: Convergence of the Fractional Adams-Bashforth/Moulton Methods for Nonlinear Fractional Differential Equations

Abstract: This paper deals with the numerical solutions of the nonlinear fractional differential equations (FDEs). The fractional Adams-Bashforth/Moulton methods, proposed by Zayernouri and Matzavinos (J. Comput. Phys. 317, 1--14, 2016), are used to solve the nonlinear FDEs. The convergence of the methods with smooth and non-smooth solutions are carefully investigated under some suitable conditions. At last, several numerical examples are provided to illustrate the obtained theoretical results and the computational effectiveness of the methods.

This work was supported in part by This work was supported by the AFOSR Young Investigator Program (YIP) award (FA9550-17-1-0150) and the MURI/ARO (W911NF- 15-1-0562).

Keywords: Adams-Bashforth/Moulton methods, fractional differential equations, Caputo derivative, convergence

Poster Number: COMP-14
Authors: Pranshu Bajpai; Richard Enbody
Title: Key Generation in Ransomware

Abstract: Ransomware are malicious software that encrypt user files and demand a ransom payment in exchange for a decryption key. Symmetric encryption is commonly used to encrypt user data and is achieved with a symmetric key algorithm such as AES. In symmetric encryption, the same secret key is used for encryption and decryption of data. This symmetric key must be unique for each victim lest victims share decryption keys among each other. There are multiple ways in which ransomware developers can acquire this unique encryption key post infection. Primarily, this key can either be generated on the system or acquired over the network via communication with the ransomware's command-and-control server. In this research, we present various key generation techniques that are used by ransomware developers to acquire the unique encryption key that will be used to encrypt user files and hold them for ransom.

Keywords: computer security, malware, key management, ransomware

Poster Number: COMP-15
Authors: Xinyu Lei; Tian Xie; Alex X. Liu; Guan-Hua Tu
Title: An Empirical Study of Cryptographic/Security Protocol Support in Wi-Fi Smart Home IoT Devices

Abstract: Wi-Fi connected IoT devices are getting popular for smart home (e.g., smart sockets) in recent years. Most device vendors (e.g., Honeywell) enable users to control their IoT devices remotely. It indeed brings users great convenience but may create new attack vectors for adversaries. The reason is that the IoT devices have limited resources and may not afford to support well-examined cryptographic/security protocols (e.g., IPSec/TLS), which are widely used for device communication. In this work, we conduct an empirical study on how the cryptographic/security protocols are supported on 40 popular Wi-Fi smart home IoT devices. Surprisingly, we discover two security vulnerabilities and show that adversaries can exploit them to hijack the control of victims' IoT devices or peek at victims' activities. However, limited functions and resources on the IoT devices can thwart remote after-the-market remedies. We thus leverage home Wi-Fi routers, with which they have to cooperate, to secure them by proposing a thorough solution framework, Secure Wi-Fi IoT Router (SecWIR). SecWIR does not require any modifications on the Wi-Fi IoT devices and IoT service applications or need an additional IoT security gateway. Our results show that SecWIR can work well on a variety of low-cost Wi-Fi routers (below $50) with very small overhead on the bandwidth (i.e., less than 4.2% downgrade).

Keywords: IoT, smart home, security

Poster Number: COMP-16
Authors: Tam Le; Matt Mutka
Title: Access Control with Delegation for Smart Home Applications

Abstract: With the emergence of smart home applications, it is important to have flexible access control so that users can create/transfer their permissions in a convenient way. We propose a lightweight authorization protocol with support of a delegation chain in which a user can easily transfer (part of) his/her access rights to smart appliances in the form of a Bloom filter. The security of our protocol is based on the false positive rate of a Bloom filter. A prototype has been built for evaluation.

Keywords: IoT, smart home, access control, delegation

Poster Number: COMP-17
Authors: Masoud Zarifneshat; Proteek Roy; Li Xiao
Title: Multi-Objective Approach to Improve Load Balance and Blockage in mm-Wave Cellular Networks

Abstract: One of the main enabling technologies of 5G wireless networks is to use mm-Wave spectrum band. Despite its large and wide frequency bandwidth, the obtained data rate can be diminished due to link blockage in this frequency band. In this paper, we formulate a bi-objective optimization problem to optimize user association in cellular networks with mm-Wave enabled base stations. The two objectives to minimize are maximum base station utility and blockage score (to indicate the chance of a link getting blocked). We simulate three different scalarization methods to turn a bi-objective vector into a scalar. Since the combinatorial bi-objective problem is NP-Hard, we conduct Lagrangian dual analysis on all of the scalarization methods. Solving the dual problem decreases the time complexity of the solver algorithm, but the solution has a distance from optimal point created by solving the primal. We also solve the primal optimization problem with a single objective optimization tool. Compared to the time complexity of the primal problem of scalarization methods, the time complexities of solutions to the dual problems are lower. The results show that our solution to bi-objective optimization problem has a better outcome in terms of the number of link blockage and the maximum base station utility compared to optimizing each objective alone.

Keywords: mm-Wave, cellular networks, link blockage, load balancing, bi-objective combinatorial optimization

Poster Number: COMP-18
Authors: Duong Nguyen; Aleksey Charapko; Sandeep Kulkarni; Murat Demirbas
Title: Optimistic Execution in Key-Value Stores

Abstract: Limitations of CAP theorem imply that if avail ability is desired in the presence of network partitions, one must sacrifice sequential consistency, a consistency model that is more natural for system design. We focus on the problem of what a designer should do if she has an algorithm that works correctly with sequential consistency but is faced with an underlying key-value store that provides a weaker (e.g., eventual or causal) consistency. We propose a detect-rollback based approach: The designer identifies a correctness predicate, say P , and continue to run the protocol, as our system monitors P. If P is violated (because the underlying key-value store provides a weaker consistency), the system rolls back and resumes the computation at a state where P holds.

We evaluate this approach in the Voldemort key-value store. Our experiments with deployment of Voldemort on Amazon AWS shows that using eventual consistency with monitoring can provide 20 − 40% increase in throughput when compared with sequential consistency. We also show that the overhead of the monitor itself is small (typically less than 8%) and the latency of detecting violations is very low. For example, more than 99.9% violations are detected in less than 1 second.

Keywords: distributed systems, key-value stores

Poster Number: COMP-19
Authors: Matthew W. Pasco; Sharmin Jahan; Rose F. Gamble; Philip K. McKinley; Betty H.C. Cheng;
Title: MAPE-SAC: A Framework to Dynamically Manage Security Assurance Cases

Abstract: Assuring security compliance in adaptive systems is challenging, notably as both functional and security conditions may change at run time. For example in the US, to certify the security of an information system, security assurance cases (SACs) can be designed based on security controls defined by NIST (National Institute of Standards and Technology). In traditional systems, certification of security controls is manually performed with some movement towards formal verification. SAC specification using certification results and their adaptation has been examined from a security perspective. However, environmental and functional uncertainties may require more complex adaptations beyond the SAC, possibly in response to security-based adaptations. This paper introduces the MAPE-SAC framework and synergistically uses it in conjunction with a MAPE-K control loop to manage run-time adaptation in response to changes in functional, performance, and security conditions. We illustrate the use of the MAPE-SAC loop and its interaction with the MAPE-K loop on an autonomous rover responding to a potential security incident.

This work was supported in part by Air Force Research Laboratory

Keywords: security assurance cases, self-adaptation, security certifica- tion, MAPE loop

Poster Number: COMP-20
Authors: Vidhya Tekken Valapil; Sandeep Kulkarni
Title: Biased Clocks: A Novel Approach to Improve the Ability To Perform Predicate Detection with O(1) Clocks

Abstract: In this paper, we present the notion of biased hybrid logical clocks. These clocks are intended to improve the ability of a distributed system to perform predicate detection with just O(1) sized clocks. In traditional logical clocks (or hybrid logical clocks, their extension), the only way to guarantee that two events are concurrent is by checking if their clock values are equal. By contrast, biased clocks provide a window where this guarantee is provided. We validate our intuition that these biased clocks substantially improve the ability to successfully detect a given predicate with just O(1) sized clock. In particular, for many scenarios, we show that biased clocks improve the ability to detect predicates by 100–200 times when compared to standard hybrid logical clocks.

This work was supported in part by NSF XPS 1533802

Keywords: distributed systems, concurrency, hybrid logical clocks, predicate detection

Poster Number: COMP-21
Authors: Abdel Alsnayyan; Alex Diaz; Shanker Balasumbramaniam
Title: Isogeometric Boundary Element Method for Analysis of Acoustic Scattering using Subdivision and Wideband MLFMA

Abstract: The analysis of acoustic scattering through the Boundary Element Method (BEM) on realistic structures gives rise to a class of problems that are multiple length/frequency scales. Here dense discretion is necessary to accurately capture geometric features. Futher, null spaces of the resulting operator results spurious modes. These spurious modes are handled by applying the Burton-Miller formulation which demands evaluating highly singular integrals of 1/R^5 order over the geometry. In our analysis, we explore the use of subdivision basis set in order to represent both the geometry and the physics; this results in a 4th order surface description that is at most c^2 continuous everywhere. One of the many advantages is that it enables us to more accurately capture complex features with fewer degrees of freedom. With these challenges in mind, solutions to the BEM is challenging, due to their high computational cost. We aim to reduce the computational cost by using wideband Multi-Level Fast Multipole Acceleration (MLFMA) that eloquently combines the Accelerated Cartesian Expansion (ACE) with the Fast Multipole Method (FMM) that allows for stability and efficiency at low frequencies. Numerical examples provided show the computational complexity of our of fast method, the convergence of integrals and the subdivision basis set, as well as the handling of spurious modes on acoustically large objects.

Keywords: acoustics, BEM, fast methods, subdivision

Poster Number: COMP-22
Authors: Matthew Link; Frank Graziani; Mark Sherlock; Andrew Christlieb; Michael S. Murillo

Title: Towards Kinetic Theory Molecular Dynamics: Wigner-Poisson System

Abstract: In DT fusion, a neutron and an alpha particle are produced. Capturing the energy of the alpha is important for recycling it into the fuel to compensate for losses and to be able to extract power for a fusion reactor. Accurate predictions for the alpha stopping power are needed to design experiments. Over the decades, many theoretical approaches have been applied to the stopping power problem. Modern methods that promise higher fidelity and self-consistency, such as time-dependent density functional theory (TDDFT), have been recently explored; here, we are examining Kinetic Theory Molecular Dynamics (KTMD) in an attempt to better capture kinetic effects that cannot obviously be treated in a TDDFT approach. KTMD models the ions with molecular dynamics and uses quantum kinetic theory to model the electrons. Our first step toward these goals is to write a solver for the Wigner-Poisson system, which is our current model for the electron dynamics. Because Wigner is the quantum analog to Vlasov, we began with a 1D-1V Vlasov solver and more recently examined the Wigner acceleration term that incorporates Heisenberg uncertainty. The poster will present our current numerical approach, which includes Strang splitting in time, finite volume and Fourier transforms to handle the convolution. We verify our code by testing it in a harmonic potential, measuring the Landau damping rate and examining the classical limit.

This work was supported in part by LLNL

Keywords: Wigner-Poisson, plasma, quantum kinetic theory

Poster Number: COMP-23
Authors: Ali Munir; Alex X. Liu
Title: Are We Safe Online?

Abstract: In this poster, we report vulnerabilities in Multipath TCP (MPTCP) that can compromise our security when using internet. MPTCP is widely used by run various apps and programs in iPhone and Android devices to access internet. We present two attacks to exploit these vulnerabilities. In the connection hijack attack, an attacker takes full control of the MPTCP connection by suspending the connections he has no access to. In the traffic diversion attack, an attacker diverts traffic from one path to other paths. These vulnerabilites are very fundamental and affect everyone on the internet as MPTCP is being used by both the iOS and android. Proposed vulnerabilities fixes, changes to MPTCP specification, provide the guarantees that MPTCP users are safe online. Our proposed solution has been made part of the MPTCP standard.

Keywords: online security, hijack attacks

Poster Number: COMP-24
Authors: Wenjie Qi; Sudin Bhattacharya
Title: Modeling Aryl Hydrocarbon Receptor-mediated Gene Regulatory Networks in the Human Liver

Abstract: The Aryl Hydrocarbon Receptor (AHR) is a ligand-inducible transcription factor that regulates genes involved in a variety of physiological functions in response to the potent and persistent environmental contaminant 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Assembly of AHR regulatory networks is critical for the understanding of the intracellular events that lead to tissue-specific adverse health effects upon chemical exposure. However, the precise sequence of DNA binding sites for AHR, as well as its extended regulatory network in the human liver, remain unknown. In this study, we applied a supervised machine learning model, Xgboost, to predict direct AHR binding sites ("dioxin response elements", or DREs). We used DNA sequence and histone modification features to train the model from ChIP-Seq data in MCF-7 cells, and then used the trained model to predict AHR binding sites in accessible DNA regions in the HepG2 cell line. By combining our predictive model with RNA-seq analysis of TCDD-treated HepG2 cells, we identified TCDD-responsive genes that have the predicted AHR binding sites in their proximal promoter. On the other hand, we also identified genes that have AHR binding sites only in their distal enhancer region, suggesting widespread long- range gene regulation mediated by the AHR. Our work provides an approach for reconstruction as well as analysis of AHR regulatory cascades in multiple tissues by combining accurate prediction of AHR binding sites and mapping both proximal and distal AHR binding sites to target genes.

This work was supported in part by NIEHS Superfund grant (P42ES04911)

Keywords: Transcription factor binding sites prediction

Poster Number: COMP-25
Authors: Mehdi Samiee; Mohsen Zayernouri
Title: A Fractional Subgrid-Scale Model for Turbulent Flows

Abstract: Starting from the framework of kinetic theory, we propose a new approach to the functional modeling of subgrid-scale (SGS) stresses in the simulation of isotropic homogeneous turbulent flows. This approach is motivated by the non-local behavior of the filtered equilibrium distribution function in the filtered Boltzmann transport equation. By modeling the multi-exponential behavior of the filtered equilibrium distribution function in the Boltzmann transport equation with a power-law distribution, the divergence of the SGS stresses can be approximated by a fractional Laplacian, in which the fractional exponent is a function of the filter size and Reynolds number. We also evaluate a priori analysis of the model using direct numerical simulation (DNS) of 3D forced isotropic homogeneous turbulent flows.

This work was supported in part by This work was supported by the AFOSR Young Investigator Program (YIP) award (FA9550-17-1-0150) and the MURI/ARO (W911NF- 15-1-0562).

Keywords: Fractional Laplacian, large eddy simulation, Boltzmann transport equation, a priori analysis

Poster Number: COMP-26
Authors: Mathialakan Thavappiragasam; John Luginsland; Pierson Guthrey; Andrew Christlieb
Title: A Fast and Versatile Scheme For a Decoupled Electromagnetic Potential With Perfectly Conducting Boundaries

Abstract: We present a fast and geometrically flexible approach to calculate the solution to Maxwell's equations in vector potential form under the Lorenz gauge. The scheme is an implicit, linear-time, high-order, A-stable method which is based on the method of lines transpose (MOLT). As presented, the method is 4th order in time and second order in space, but the A-stable formulation could be extended to both high order in time and space. An $O(n)$ fast convolution is employed for space-integration. The main focus of this work is to develop an approach to impose perfectly electrically conducting (PEC) boundary conditions in MOLT by extending our past work on embedded boundary methods. As the method is A-stable, it does not suffer from small time step limitations that are found in explicit finite difference time domain methods when using either embedded boundary or cut cell methods to capture geometry. While there is no conceptual limitation to develop this in 3D, our initial work has centered on 2D. The eventual goal is to combine this method with particle methods for the simulations of plasma. In the current work, the scheme is evaluated for EM wave propagation within an object which is bounded by PEC. The consistency and performance of the scheme are confirmed using the ping test and frequency mode analysis for rotated square cavities. We then demonstrate the diffraction Q value test and the use of this method for simulating an A6 magnetron.

Keywords: electromagnetic potential, perfectly conducting boundary condition, embedded boundary method, implicit scheme, method of lines transpose

Poster Number: COMP-27
Authors: Danupon Nanongkai; Thatchaphol Saranurak; Sorrachai Yingchareonthawornchai
Title: Breaking Quadratic Time for Small Vertex Connectivity

Abstract: Vertex connectivity is a classic extensively-studied problem. Given an integer k, its goal is to decide if an n-node m-edge graph can be disconnected by removing k vertices. Although a linear-time algorithm was postulated in 1974 [Aho, Hopcroft and Ullman], and despite its sibling problem of edge connectivity being resolved over two decades ago [Karger STOC'96], so far no vertex connectivity algorithms are faster than $O(n^2)$ time even for $k = 4$ and $m = O(n)$. In the simplest case, the $O(n^2)$ bound dates 49 years back to [Kleitman IEEE Trans. Circuit Theory'69]. For higher m, $O(m)$ time is known for $k \le 3$ [Tarjan FOCS'71; Hopcroft, Tarjan SICOMP'73], the first $O(n^2)$ time is from [Kanevsky, Ramachandran, FOCS'87] for $k = 4$ and from [Nagamochi, Ibaraki, Algorithmica'92] for $k = O(1)$. For general k and m, the best bound is essentially $O(mn)$ [Henzinger, Rao, Gabow FOCS'96].
We present a randomized algorithm with $O(m + k^{7/3}n^{4/3})$ time. This gives the first subquadratic time bound for any $4 \le k \le o(n^{2/7})$ and improves all above classic bounds for all $k \le n^{0.44}$. The full version of our work will appear in [STOC'19].

Keywords: graph algorithms; vertex connectivity; randomized algorithm.

Poster Number: COMP-28
Authors: Qiqige Wuyun; Kevin Liu
Title: Fast and Accurate Introgression Detection

Abstract: Introgression is the movement of genes from one species to the gene pool of another by recurrent backcrossing of hybrid. Introgression is thought to play an important role in genome evolution throughout the Tree of Life, the evolutionary history of all life on Earth. To quantitatively investigate this hypothesis, a variety of state-of-the-art techniques have been developed for detecting introgression from genomic sequence data. However, no existing method is capable of fast and accurate introgression detection on datasets with many dozens of genomic sequences. In this work, we develop an improved introgression detection approach which enables scalable analysis of large-scale datasets. Our approach combines the multi-species network coalescent model with hidden Markov models (HMMs) to tease apart the effects of incomplete lineage sorting (ILS) from those of introgression. Moreover, we use a resampling method to improve the accuracy of our method.

Keywords: introgression, sampling, HMM, statistical inference

HEALTH, FOOD SAFETY AND BIOMECHANICS

Poster Number: HFSB-01
Authors: Chelsie Boodoo; Marissa Grobbel; Sara Roccabianca; Christina Chan
Title: Remodeling the Bladder through Static Pre-Stretch

Abstract: If there is too little folic acid or too much homocysteine, then the neural tube will develop malformations. Neural tube defects still occur despite attempts to supplement mothers with folic acid, due to late supplementation or deficiencies in folic acid uptake. As a result, children are born with deformed spines, or pieces of their skull are missing. Due to this disruption of innervation, when children are born, they do not have proper control of their lower bodies, especially their bladders.
One of the most severe neural tube defects is spina bifida (SB). As soon as children affected by SB are born, their bladders are catheterized. The children cannot sense when they need to void their bladder and do not have proper control of it. The children do not have proper urological control because the extracellular matrix of the neurogenic bladder contains excess elastin and insufficient collagen. It has been shown that homocysteine can upregulate collagen production and degrade elastin networks.
In this study, the effect of homocysteine and folic acid on the extracellular matrix of bladder smooth muscle cells is assessed. This is done by culturing rat bladder smooth muscle cells on a pre-stretched polydimethylsiloxane surface to model a SB neurogenic bladder. In addition, the growth rate of the smooth muscle cells and their alignment are evaluated on the pre-stretched surface. We hypothesize that this model would allow us to investigate the effect of homocysteine and mechanical cue on the extracellular matrix of the bladder smooth muscle cells.

This work was supported in part by NIH T32HD087166

Keywords: bladder, stretch, biomechanics

Poster Number: HFSB-02
Authors: Hamidreza Gharahi; Seungik Baek; Vasilina Filonova; C. Alberto Figueroa
Title: Fluid-Solid Growth Modeling of Pulmonary Vascular Tree: Establishing a Homeostatic Baseline State

Abstract: The onset and early progression of many vascular diseases can be traced to permanent changes in the thickness, size, or stiffness of the distal arterial tree. Although pressure measurements and high resolution medical images are available, the present medical imaging modalities are unable to provide accurate information about the downstream blood vessels. Therefore, it is critical to use models to determine the geometry and the homeostatic baseline state of the blood vessels in the distal arterial tree. The objective of the present work is to determine the homeostatic state in the distal arterial tree based on an extension of Murray’s law and steady state hemodynamics.
The minimum work principle is used to determine a target state defined by a homeostatic radius and a homeostatic material composition. This minimization problem involves the metabolic cost of maintaining the blood volume, the power needed to overcome viscous drag on the blood flow, and the metabolic cost of the materials that constitute the vessel wall under the constraint based on the mechanical equilibrium. The minimization is coupled with the steady state hemodynamics of the arterial tree by prescribing the flow at the inlet and pressure at the terminal vessels, namely terminal pressure, and using Poiseuille’s equation in each segment. The results of the coupled problem determine the composition of the arteries in the arterial tree as well as their geometry. When the homeostatic state is defined, arterial growth and remodeling can be used to test different hypotheses on pulmonary arterial hypertension.

This work was supported in part by NIH

Keywords: homeostasis, fluid solid growth, arterial tree

Poster Number: HFSB-03
Authors: Zhenxiang Jiang; Jongeun Choi; Seungik Baek
Title: Uncertainty Analysis of Vascular Surrogate Models

Abstract: Patient-specific computational modeling of vascular mechanics is an emerging area which has developed various computational tools on individual treatment. It aids in the clinical treatment by optimizing the diagnosis and prognosis prediction, and classifying staging. In vascular modeling, however, multiscale models have become more complicated and they require long computation time, which is often not acceptable in clinical practice. Therefore, there remains a pressing need for a powerful tool to reduce the computational cost while maintaining adequate accuracy. Surrogate models (SM) are methods where computational expensive physical models are approximated by faster metamodels. Although SM is promising, it reduces the complexity of the physical system, which increases modeling uncertainty. Motivated by this challenge, we present a novel framework to minimize the uncertainty caused by SM, using multi-fidelity surrogate model (MFSM) and Gaussian process upper confidence bound (GP-UCB) regression. Furthermore, a comprehensive uncertainty analysis algorithm is designed to quantify the uncertainties associated with SM and physical model respectively. For purpose of demonstration, this framework is applied to estimate patient-specific evolution prediction of abdominal aortic aneurysms (AAA) using follow-up CT images from 26 patients.

This work was supported in part by NIH U01 1HL135842 and R01 HL115185

Keywords: uncertainty analysis, surrogate model, abdominal aortic aneurysms, multi-fidelity model, Gaussian process

Poster Number: HFSB-04
Authors: Joseph Kerwin; Suhas Vidhate; Adam M. Willis; Ricardo Mejia-Alvarez
Title: Biofidelic Human Head Phantoms for Studies of Blast-TBI

Abstract: Blast-induced traumatic brain injury (bTBI) has become a ``signature wound'' of modern combat due to the expansive use of improvised explosive devices (IED). Over 60% of combat casualties haven been caused by explosive blasts from the operations in Iraq and Afghanistan. In-vivo blast studies cannot be conducted on human subjects. Cadaver models bring their own set of challenges due to ethical and safety concerns. On the other hand, due to significant differences between animals and humans in size, geometry, and tissue mechanical properties, animal models do not scale appropriately to blast exposure in humans. With this in mind, artificial head phantoms could contribute to study the mechanics of blast-induced Traumatic Brain Injury (bTBI) by introducing anatomy and material properties closer to those of a human. Now, in order to extract information about the dynamic response to shock loading, phantoms could be instrumented in ways that in-vivo models or cadavers cannot be instrumented.
Our group has designed and fabricated simplified phantoms of intracranial contents using different grades of polyacrylamide (PAA). Numerous anatomical features are incorporated within our phantoms: material interfaces between white and gray matter, dominant length scales of gyri and sulci folds, ventricular space, density, volume, and more general geometric aspects such as the calvarium the upper curved region of the neurocranium. A unique aspect of our phantom design is the inclusion of motion tracers within the brain phantom. These tracers enable measurements of strain and strain-rate with high-resolution optical methods such as Particle Image Velocimetry (PIV) in real time.

This work was supported in part by AFRL, Award No. FA8650-18-2-6880

Keywords: traumatic nrain Injury, shock-waves, modelling

Poster Number: HFSB-05
Authors: Archana Lamsal; Tamara Reid Bush
Title: Understanding Pelvic Tilt in Different Postures with a Height Adjustable Chair

Abstract: Understanding Pelvic Tilt in different Postures with a Height Adjustable Chair
In the US, average working individuals sit at a workstation for more than 4 hours a day [1]. This seated position leads to a significant amount of physical inactivity. To address this issue, an adjustable office chair which supports sitting, as well as a partial standing posture (called perching), is introduced along with a height adjustable desk. The purpose of this study is to identify the pelvic tilt angle, lumbar curvature and blood perfusion while an individual is working in three different positions; sitting, perching and standing. Our hypothesis is that the perching position will allow for considerable movement of hips without having to give up the comfort of sitting completely.
References:
[1] Harrington,M.D., et al.,"The descriptive epidemiology of sitting among US adults, NHANES 2009/2010", Journal of Science and Medicine in Sport (pg. 371-375), 2013.

This work was supported in part by Haworth Inc.

Keywords: Pelvic tilt, perching

Poster Number: HFSB-06
Authors: Adam C. Marsh; Natalia Pajares Chamorro; Xanthippi Chatzistavrou
Title: Polymer Foam Replication of 3D Scaffolds Using Silver-Containing Bioactive Glass

Abstract: A vast potential of mimicry exists between naturally occurring bone and 3D bioactive glass scaffolds aimed at regeneration of damaged or diseased bone. The aim of this work was to utilize a polymer foam replication technique to develop 3D scaffolds from a silver-doped bioactive glass (Ag-BG) system that maintained bioactive and antibacterial properties as well as a compressive strength comparative with cancellous bone. The thermal and sintering behavior of Ag-BG particles, characterized by Thermogravimetric Analysis (DTA/TGA) and Hot Stage Microscopy (HSM) methods, allowed for the design of an appropriate heat treatment for 3D scaffold fabrication. Evaluation of macro-structural features was done using micro-computing tomography (micro-CT); Scanned Electron Microscopy (SEM-EDS), X-ray diffraction (XRD), and Fourier Transmittance Infrared spectroscopy (FTIR-ATR) characterized the microstructural, morphological, and homogeneity of Ag-BG scaffolds. A high degree of crystallinity was seen in all scaffolds. The average compressive strength of Ag-BG scaffolds measure within the range for spongy bone (0.121 MPa). The capability of Ag-BG scaffolds to form an apatite phase when immersed into simulated body fluid (SBF) was studied. Structural and morphological changes occurred over time with amorphous calcium phosphate depositions seen after 24 hours of exposure. Ag-BG scaffolds were exposed to methicillin-resistant staphylococcus aureus (MRSA) and showed limited inhibition that was synergistically improved when combined with an antibiotic that MRSA resists such as Fosfomycin. 3D scaffolds derived from Ag-BG having promising mechanical, biological, and antibacterial properties have been realized.

Keywords: 3D scaffold, bioactive glass, silver

Poster Number: HFSB-07
Authors: Justin Scott; Brian Sheridan; Rick Andrus; Amy Selby; Nick Monday; Tamara Reid Bush
Title: Experimental Methods for Obtaining Mechanical Properties of the Thighs for Wheelchair Users

Abstract: Pressure ulcers are a significant complication for those who use wheelchairs. They are wounds that form when soft tissue experiences unrelieved external pressure. Such pressures are exerted on the thigh and buttock tissue while seated. This places wheelchair users at a heightened risk for pressure ulcers because they spend a majority of their day in a seated position. Finite element models are used to assess to risk of developing pressure ulcers. And these models rely on experimentally obtained in vivo tissue properties of the human thigh/buttocks. However, there is a need for collecting data on complete force-deflection curves of thigh tissues of wheelchair users, as they are not currently available. This work has established a method by which these data can be collected and has implemented it to collect preliminary force-deflection data from one participant.

This work was supported in part by NSF CBET Grant Number 1603646

Keywords: tissue properties, wheelchair

Poster Number: HFSB-08
Authors: Tyler Tuttle; Heidi Lujan; Stephen DiCarlo; Sara Roccabianca
Title: Changes in Mechanical Response of the Urinary Bladder Extracellular Matrix Due to Long Term Spinal Cord Injury

Abstract: The main function of the urinary bladder (UB) is to store and void urine through mechanical relaxation and contraction. Neurogenic bladder is the term used to characterize loss of control of the UB due to brain, spinal cord, or nerve problems (e.g., parkinsonism, spina bifida, spinal cord injury (SCI), and diabetes mellitus). The remodeling of the neurogenic bladder wall results in hypertrophy of the smooth muscle cells and deposition / removal of extracellular matrix (ECM), i.e., fibrosis. Wall remodeling, particularly changes in the ECM composition, can alter the compliance, thickness, and capacity of the UB, thus changing the underlying mechanical properties. This, in turn, can significantly affect the capability of the organ to perform its physiological function.

SCI surgery was conducted on Sprague-Dawley rats to induce paraplegia. Control animals underwent the same surgical procedure, but the spinal cord was not transected. Rats were sacrificed after 14 weeks. The UBs where excised, cut into rings, placed into embedding medium for frozen tissue specimens, and frozen at -80°C. Prior to mechanical testing, rings were thawed and decellularized to isolate the ECM. Uniaxial ring tests were performed on the decellularized UB rings.

Results show that the ECM of the UBs of animals 14 weeks after SCI seem to be more compliant when compared to urinary bladders of control animals.

More SCI and control UBs will be tested to help validate this observation. Histological analysis will be done on control and paraplegic rat UB samples to quantify changes in tissue morphology and ECM composition.

Keywords: urinary bladder, spinal cord injury

Poster Number: HFSB-09
Authors: Patrick Vaughan; Feng Wei; Roger Haut

Title: Influences of Age and Rate of Loading on Material Property and Fracture Morphology in the Porcine Femur

Abstract: A recent study by this laboratory using infant porcine femora has demonstrated that the behavior of a long bone under torsion is both age and rate sensitive, with spiral fractures possessing increasingly greater longitudinal components at either older ages or higher rates of twist. As torsion is a pure shear test that generates both transverse and longitudinal shear stresses, different modes of spiral fracture may occur from early development to skeletally mature bones due to the changes in the overall material property and the corresponding microstructural characteristics. The objective of the current study was to determine how the tensile and shear properties of porcine femora alter with specimen age and rate of loading. The results showed that initial longitudinal shear strength was greater than the transverse shear strength, and that the longitudinal shear strength decreased with specimen age while the transverse shear strength increased with specimen age, intersecting at approximately 7 days of age at a low rate. Interestingly, as the loading rate increased the longitudinal shear strength increased with specimen age, while the transverse shear strength remained unchanged, intersecting at approximately 4.5 days of age. Additionally, the tensile strength in the longitudinal and transverse directions remained relatively constant throughout the range of the developmental age (1-24 days) investigated in the study. These results may suggest that alterations in the previously observed gross morphology of spiral fracture may primarily be due to changes in the shear property, as opposed to changes in the tensile property of the infant porcine femora.

Keywords: biomechanics, shear strength, long bone, fracture pattern, animal model, biomechanical test

Poster Number: HFSB-10
Authors: Seungik Baek; Yuheng Wang; Laura Nye; Marissa Grobbel; Akshay Rao; Sara Roccabianca
Title: Pressure-induced Damage of Pulmonary Artery

Abstract: Pulmonary hypertension (PH) is associated with elevated pulmonary arterial pressure. PH prognosis remains poor with 15% mortality rate within 1 year even with modern clinical managements. Previous clinical studies proposed the wall shear stress (WSS) to be an important hemodynamic factor for affecting cell mechanotransduction and growth and remodeling in the disease progress. However, a typical range of WSS in vivo is at most 2.5 Pa and a doubt has been casted whether WSS alone can influence the disease progress. In the other hand, the blood pressure has been significantly elevated in PH and a pressure-induced damage may be occurred. Furthermore, our current understanding of PH pathology has largely been obtained through small animals and there has been seldom reports of caliber enlargement in the PH animal models. Therefore, a large-animal experiment on pulmonary arteries (PAs) is needed for validating whether an increased pressure can induce an enlargement of pulmonary caliber. In this study, we use an inflation testing device to characterize both nonlinear elastic behavior and irreversible damage of porcine arteries. Specifically, we use an elastic constitutive model of arterial wall that consists of two-fiber family and isotropic elastin. The parameters are estimated from the inflation test at a low pressure range first and then are compared with those from a high pressure range, which tests if those behavior are significantly different. Additionally, histological images are qualitatively examined for medial and adventitial layers. This study, therefore, sheds light on the relevance of pressure-induced damage mechanism in human PH.

Keywords: biomechanics, cardiovascular mechanics, mechanical engineering, tissue mehchanics

Poster Number: HFSB-11
Authors: Carly Gomez; Bradley P. Marks; Sanja Ilic; Holly Paden; Elliot T. Ryser; Jade Mitchell

Title: Creating a Risk Model for Nosocomial Listeriosis in Cancer Patients Who Consume Ready-to-Eat Salad

Abstract: Listeriosis is a foodborne illness with relatively low incidence, but substantial mortality rates. Risk of listeriosis is greater in immunocompromised populations, particularly cancer patients, because their treatments compromise several of the barriers against infection. Therefore, nosocomial foodborne listeriosis remains problematic for these patients, with consumption of ready-to-eat (RTE) fresh salads raising particular concern. Risk of listeriosis from salad consumption was assessed using an exponential dose-response model with rate constant r of 1.79E-10, adopted from a 1997 model that conservatively estimated risk of listeriosis for immunocompromised individuals. Food consumption data were collected from 100 patient surveys, with salad being defined as green lettuce, raw spinach, and/or raw tomatoes. Risk was calculated using Monte Carlo simulation in @Risk software. The hypothetical efficacies of two risk management strategies, washing treatments (stirring in water for two minutes, and immersion in sodium hypochlorite for 15 minutes followed by a tap water rinse) and storage (at 5 and 15°C), were also assessed. The risk of listeriosis due to fresh salad consumption during one cycle of chemotherapy was 0.000329 (0.033%). This is the mean value for risk in an average risk scenario; 90% of risk values were between 0.000009 and 0.001172. Neither washing treatment nor storage condition affected the dose of L. monocytogenes per serving of salad. Few consumption data-based risk models exist for this sub-population. Data-driven risk models for listeriosis in cancer patients could provide a justification for existing dietary restrictions.

Keywords: Listeriosis, cancer patients, risk model

Poster Number: HFSB-12
Authors: Ian Hildebrandt; Nicole Hall; Michael James; Elliot Ryser; Bradley Marks
Title: Humidity Affects Salmonella Lethality and USDA FSIS Appendix A Compliance for Impingement-Cooked Meat and Poultry Products

Abstract: A recent revision of USDA FSIS Appendix A articulates humidity requirements for meat/poultry cooking processes. However, information/data documenting the impact of humidity on the microbial safety of cooked meat/poultry is limited.
This study aimed to quantify the impact of humidity on Salmonella lethality in impingement cooked meat and poultry products, particularly as related to Appendix A compliance.
Beef strips, ground beef patties, chicken breast filets, and breaded chicken patties were inoculated with Salmonella. Each product was cooked in a pilot-scale, moist-air impingement oven at a specific temperature (218 or 232°C), absolute humidity (0.7, 30, or 70% v/v), and fan speed (20 or 80% power), to a center temperature of 70 or 73°C for beef and poultry products, respectively, then immediately cooled, dissected to remove surface and core samples, and to enumerate Salmonella survivors.
The addition of humidity significantly ($P < 0.05$) affected Salmonella lethality. For example, when processed with dry heat, the required 6.5 log reduction was not achieved for beef products at any condition. However, increasing the humidity to 30% resulted in >7.00 log reduction for all beef strips. Additionally, greater Salmonella survival in samples from the surface was observed ($P < 0.05$) for multiple products cooked with dry air at the high fan speed.
Compliance with Appendix A is critical for the meat and poultry industry to provide a safe product; however, the relationship between humidity and Salmonella survival includes complicated interactions. More research is necessary to confirm levels of humidity needed to achieve the required Salmonella lethality.

This work was supported in part by Foundation for Meat and Poultry Research and Education

Keywords: food safety, validation, Salmonella, meat

Poster Number: HFSB-13
Authors: Alice Kilvington; Mara Leimanis; Surender Rajasekaran; Ilce Medina-Meza
Title: Assessment of Bioactive Lipids in Powder Infant Formulations

Abstract: Infant formulations (IF) are critical to the health and growth of infants since it is an alternative to human breast milk. The different types of IF (i.e., premature babies, protein hydrolysate, soy protein allergies, etc.), raise questions about their antioxidant/oxidative status. The goal of this project is to profile the bioactive lipids in common IF using a lipidomic approach. 15 different powered IF were broken into 3 different groups based on their composition; i.e., high fat (HF), high sugar (HS), and high vitamin (HV). Cholesterol and phytosterols were quantified from IF extracted fat using a lipidomic analysis by GC-MS. The oxidative stability of IF is critical because the infant immune system is fully developed through exposure to the diet. The HF group had the highest cholesterol (0.53 mg/g of fat) and phytosterol (4.23 mg/g of fat) content, almost four times the phytosterol content in the HS group (1.35 mg/g of fat). Four different phytosterols were found in IF: stigmasterol, b-sitosterol, campesterol, and α-tocopherol. b-sitosterol had the highest amount in all the samples. The IF were also tested for cholesterol oxidative products (COPs). Six different COPs were found: 7beta-hydroxycholesterol, 7-ketocholestanol, 6-ketocholestanol, 25-hydroxycholesterol, 20alpha-hydroxycholesterol, and 7alpha-hydroxycholesterol. HS samples had higher amounts of COPs (2.5 microgram/g of fat). HF samples had an average COP amount of 2.0 microgram/g of fat. 7beta-hydroxycholesterol and 6-ketocholestanol had the highest amounts in the samples. These results show there is a variability of bioactive lipid content in IF and there are significant differences between types of formulation.

This work was supported in part by SHORA Spectrum Health

Keywords: Infant formulations, bioactive lipids, phytosterols, lipidomics, cholesterol

Poster Number: HFSB-14
Authors: Alexander Bricco; Iliya Miralavy; Micheal McMahon; Wolfgang Banzhaf; Assaf Gilad
Title: Breaking the MRI Sensitivity Barrier; Applying an Innovative Protein Design Approach Based on Genetic Programming

Abstract: Protein engineering has been able to improve human quality of life from the production of therapeutic proteins, to the improvement of industrial processes. The use computational tools shows promise in developing better proteins in shorter amounts of time. Presented here is a method which involves using genetic programing --a domain-independent method that genetically breeds a population of computer programs to solve a complex problem -- to identify motifs within a protein which may contribute to the function it is being optimized for. Based on these predictions, the program is then able to suggest new proteins that should be better than the current ones. After these new proteins are tested, the data from them can be fed back into the program, improving the accuracy for the next generation.
This method was then used to develop novel magnetic resonance imaging (MRI) contrast agents. Preliminary results of his work already help to identify unique peptides that generate significant MRI contrast. Remarkably, the algorithm identified functional peptides that defy the established understanding in the field. Some of those peptides have a neutral charge and reduced immunogenicity, which offer an advantage over the agents currently used in research. These proteins improve the sensitivity of future MRI agents for non-invasive cell tracking.

This work was supported in part by This project is supposed in part by the NIH grants: R01 NS098231; R01 NS104306 and P41 EB024495

Keywords: MRI, genetic programming, protein engineering

Poster Number: HFSB-15
Authors: Kevin Chen; S. Patrick Walton; Christina Chan
Title: Controlling Neural Stem Cell Differentiation by Genome Editing of Transcription Factor TBR1 and TBR2 via CRISPR-Cas9

Abstract: Cell-based therapies are attractive for treating neurodegenerative diseases. Various neuronal cell lineages can be generated through stem cell differentiation to restore impaired functions. The process of differentiation depends on the presence or absence of specific transcription factors, which is cell lineage-dependent. In mammalian cortical neurogenesis, the precise temporal activities of different transcription factors are critical for normal development of new neurons. For example, the transition between an intermediate progenitor to a postmitotic glutamatergic neuron has been correlated to the downregulation and subsequent upregulation of (T-Box, Brain) TBR2 and TBR1, respectively. Although different types of neuronal cells have been generated in vitro, these methods often lead to heterogeneous cell populations due to the generation of unintended/off-target cell types. Without an ability to precisely control the outcome of stem cell differentiation, potential health risks could emerge in human clinical trials that could impede the applicability of cell-based therapies. To address this challenge, we created knockout of specific transcription factors in human neural stem cell lines, to restrict the lineages, and reduce the heterogeneity of the cell population. We used CRISPR-Cas9 to restrict the differentiation of stem cell lineages. We hypothesize that human neural stem cells lacking TBR1 or TBR2 reduce the percentage of glutamatergic neurons as compared to wildtype control under the same differentiation condition.

This work was supported in part by NIH NRSA T32, NSF CBET 1547518, and CBET 1510895

Keywords: stem cell, differentiation, cell-based therapy, CRISPR, tissue remodeling

Poster Number: HFSB-16

Authors: Carolina Cywiak; Ming Zhong; Galit Pelled

Title: Repetitive Transcranial Magnetic Stimulation Facilitates Recovery in a Rat Model of Peripheral Nerve Injury

Abstract: Twenty million Americans suffer from peripheral nerve injury (PNI) due to diabetes, vehicle accidents and war related injuries. These patients often develop chronic pain and sensory dysfunctions. Repetitive transcranial magnetic stimulation (rTMS) is an FDA approved, non-invasive brain stimulation shown to induce long lasting neuronal excitability. Studies shown that rTMS can relieve chronic pain. Therefore, we hypothesized that rTMS can be helpful to alleviate pain associated with PNI. Here, we worked on a rat model of PNI and performed forepaw denervation on 18 rats, divided into 3 groups: Acute (rTMS delivered starting a day after PNI), Delayed (rTMS started after a month), and No-rTMS. We delivered rTMS three times a week for a month, and measured different aspects of recovery. The results show an enhanced mobility in the beam walking test in the Acute group (Acute, 6.29±0.43s; Delayed, 7.05±0.36s; No-rTMS, 26.40±3.42s; $p<0.05$; n=6), decreased depression and anxiety in the open field test (Acute, 0.0473 ±0.0016m/s; Delayed, 0.038m/s ±0.0028; No-rTMS, 0.0233 ±0.0014m/s; $p<0.05$; n=6), and in the novel object recognition test (Acute, 9.33 ±1.53; Delayed, 8 ±2.32 ; No-rTMS 1.5 ±1.504 ;$p<0.05$; n=6). The latter cognitive tests indicate that animals that receive rTMS suffer from less pain. In addition, fMRI results demonstrated enhanced neuroplasticity in the Acute group as was determined by the extent of activation (Acute, 123.4±22.95 pixels (n=5); No-rTMS, 73.6±22.06 pixels (n=5); $p<0.05$). Together, these results suggest that rTMS treatment can be an effective approach for enhance recovery even months after the injury.

This work was supported in part by NIH/ NINDS RO1NS072171

Keywords: transcranial margnetic stimulation, neuroplasticity, peripheral nerve injury, rehabilitation, neuromodulation

Poster Number: HFSB-17

Authors: Bailey Winter; Samuel Daniels; Joseph Salatino; Kylie Smith; Steve Suhr; Erin Purcell

Title: Direct Conversion of Astrocytes into Functional Neurons Using Ascl1 and Dlx2

Abstract: Implanted microelectrode arrays (MEAs) have become increasingly popular tools to study the nervous system and show great promise as treatment for neurological diseases. Implantation of these devices causes a reactive tissue response, resulting in glial encapsulation of the device and neuronal loss at the device – tissue interface. This foreign body response is thought to contribute to reduced device performance over time, limiting long-term device efficacy. We are exploring cellular reprogramming as a potential means to improve device-tissue integration. Conversion of astrocytes to functional neurons could restore the neuronal population in the interfacial region while mitigating reactive astrogliosis, potentially improving device lifetime. Here, we investigate the use of proneural transcription factors to directly reprogram astrocytes into functional neurons in vitro. Rat primary cortical astrocytes were infected with retroviruses to deliver either Ascl1, Dlx2, or a combination of both transcription factors for a period of 24 hours before maintenance in defined media. Whole-cell patch clamp recordings and immunocytochemistry were performed five to twenty-one days post-infection to assess the electrical activity and morphological identity of the infected cells. Antibodies for glial fibrillary acidic protein and beta 3 tubulin were chosen to identify astrocytes and induced neurons respectively. Scholl analysis was performed to quantify neuronal morphology and complexity of dendritic arbors. Our in vitro studies provide a foundation for the application of reprogramming strategies at the device-tissue interface in vivo.

Keywords: gene modification; reprogramming; astrocytes

Poster Number: HFSB-18
Authors: Kara Dean; Jade Mitchell
Title: Effect of Exposure Route on Threshold Levels of Concern for P. aeruginosa in Premise Plumbing Systems

Abstract: Pseudomonas aeruginosa is a gram-negative bacterium capable of growing and proliferating in biofilms in premise plumbing systems. P. aeruginosa is an opportunistic pathogen of concern for the immunocompromised, as it is the leading cause of pneumonia in cystic fibrosis patients. It is also responsible for community and hospital-acquired infections in immunocompetent individuals, including keratitis and pneumonia. The pathogen's presence is highly associated with the colonization of fixtures, and as such, face washing, hand washing, and showering events may pose a risk of exposure to contaminated water from colonized showerheads and faucets. This study completed a reverse quantitative microbial risk assessment (QMRA) for three different exposure scenarios to determine threshold levels of concern. A reverse QMRA addresses a set level of risk, for this study the 1 infection in 10,000 persons outlined by the U.S. Environmental Protection Agency, and by modeling the exposure assessment and dose response, calculates a concentration in the water responsible for the risk level of concern. This study aims to demonstrate the effect exposure route has on the risk of P. aeruginosa in premise plumbing and the subsequent recommended sampling and monitoring protocols. The threshold concentrations calculated in this study are important for decision makers involved in the construction, maintenance, and treatment of premise plumbing systems.

This work was supported in part by U.S. EPA National Priorities Research Grant

Keywords: Risk assessment, opportunistic pathogens, drinking water

Poster Number: HFSB-19
Authors: Alexander Farnum; Galit Pelled
Title: Developing a Non-Invasive, Magnetogenetic-Based Visual Prosthesis

Abstract: There are an estimated 253 million blind or severely visually impaired people in the world today. Electrode-based neuroprosthetics have been developed to stimulate specific neural regions for a diverse range of diseases, including vision loss. However, insertion of electrodes induces short and long term changes that can negatively impact normative functioning. The goal of this research is to develop next-generation non-invasive and cell-specific visual prosthetic.
We are developing a novel technology based on the electromagnetic-perceptive gene (EPG), which we isolated from the glass catfish, Kryptopterus bicirrhis. This gene has been shown to respond to electromagnetic fields. We engineered a subpopulation of neurons in the rat primary visual cortex (V1) to express the EPG via unilateral stereotaxic virus injections. We used in-vivo electrophysiology to record neuronal action potentials in V1 using multi-electrode arrays.
Light stimulus delivered to one eye evoked significant increase of neuronal responses (364±59%) in the contralateral V1 with a 75±25 ms delay. We found that electromagnetic stimulation of 6mT also evoked significant increase in neuronal responses (250±12%) in the EPG-expressing V1 with a 250±50 ms delay. The V1 without EPG did not exhibit any change in neuronal activity in response to electromagnetic stimulation.
Our results demonstrate that the EPG-based neuroprosthetic has the potential to be an effective approach to remote-control visual cortex function. We are now working on optimizing the technology and testing it in awake-behaving animals. Utilization of the EPG as a visual prosthesis would bypass many of the main detriments of invasive prostheses, such as structural and functional damage to neural tissue.

This work was supported in part by NIH/NINDS R01NS098231

Keywords: visual prosthesis, magnetogenetics, electrophysiology, neuromodulation, visual impairment

Poster Number: HFSB-20
Authors: David Filipovic; Peter Dornbos; John LaPres; Sudin Bhattacharya
Title: Modeling Genetic Diversity of Dioxin Disposition in the Liver with a Genetically Diverse Panel of Mouse Models

Abstract: The aryl hydrocarbon receptor (AhR) is a ligand activated transcription factor whose activation results in the induction of multiple downstream genes, including CYP1A1 and 1A2. The prototypical ligand for AhR is 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD). The induction of CYP1A2 is liver-specific and is responsible for additional sequestration of TCDD in the liver. Exposure to TCDD can result in AhR-pathway-mediated hepatotoxicity in animals and humans, although the exact mechanisms involved are not yet fully understood. Given that toxic effects of TCDD are closely related to its disposition, multiple physiologically based pharmacokinetic (PBPK) models of TCDD disposition, incorporating CYP1A2 induction, have been developed. In order to reduce uncertainties associated with extrapolation of these models across species, it is necessary that the mechanistic basis of TCDD sequestration in the liver be described as accurately as possible. To this effect, we are using PBPK modeling to investigate the mechanisms driving the hepatic dose response within a genetically diverse panel of mouse strains. We show that the differences in disposition across strains can be explained by a combination of AhR allelic categories, CYP1A2 induction and its binding affinity. Use of mechanistic insights from the mouse panel to refine PBPK modeling of TCDD will contribute to better understanding of TCDD induced hepatotoxicity and the reduction of uncertainty in risk assessment decision-making for dioxins.

This work was supported in part by NIEHS Superfund grant (P42ES04911)

Keywords: dioxin, AhR, pharmacokinetic modeling, PBPK, Liver

Poster Number: HFSB-21
Authors: Connor Grady; Alexander Bricco; Olivia Han; Assaf Gilad
Title: Biosynthesis of an MRI Contrast Agent

Abstract: MRI contrast agents are important tools to effectively enhance the contrast between different tissues. Here we use a bacterial system to generate enzymes needed to synthesize the known MRI imaging probe, 5-methyl-5, 6-dihydrothymidine (5-MDHT). This is done by a two-step enzymatic process of converting thymidine to 5-MDHT by using enzymes dihydropyrimidine dehydrogenase (DPD) and an S-adenosyl-methionine dependent methyltrasferase. As a first step we have cloned and expressed the DPD and tested its activity. We are planning to use evolutionary based approach (i.e., directed evolution of the active site) to select for the fittest enzyme. This biosynthetic approach provides several advantages over a purely chemical approach including elimination of unwanted isomers, reduction of toxic by-products and scaling up the production. This technique simplifies and theoretically increases the production and specificity of bioorganic contrast agents and could be used clinical diagnostics.

This work was supported in part by R01 NS098231; R01 NS104306 and P41 EB024495.

Keywords: synthetic biology, biosynthesis, MRI, bioengineering,

Poster Number: HFSB-22
Authors: Binbin Huang; Hao Wang; Jianrong Wang*
Title: Evolutionary Rewiring and Innovation of Large-Scale Gene Regulatory Networks by Transposable Elements

Abstract: Large-scale regulatory networks involve sophisticated interactions between regulatory elements and genes to precisely control tissue-specific transcriptional programs. It is of fundamental importance to understand the mechanism of how regulatory networks formed and rewired through evolution. Transposable elements (TE), as the most dynamic genomic units, have been suggested to contribute regulatory elements on gene expression and rewire the network topology and functions. To achieve a systematic analysis of the TE-rewired networks, We first developed a probabilistic graphical model to predict the positions of regulatory elements. This model uses the information from both experimental results and genome sequence, and takes the advantage of Gibbs sampling to iteratively optimize the whole system. By applying this model to a large dataset (more than 6000 ChIP-seq data), we are able to comprehensively dissect TE-derived networks genome-wide, including thousands of new TE-regulatory elements. We also developed an activity-module based probabilistic model. This model integrates genome-wide omics dataset for diverse human tissues, and catches both short and long range 3D genome interactions between our new discovered TE-regulatory elements and their target genes and pathways mediated by 3D chromatin.
Our analysis results revealed different waves of network innovation through evolution. Genetic variants disrupting these TE-regulatory networks are found to be associated with diverse functional roles, including cancer. Our integrated analyses on TE-derived network rewiring provides mechanistic insights on the dynamics of network evolution and genetic basis of phenotypes.

Keywords: machine learning, transposable elements, regulatory networks, multi-omics data, genome evolution

Poster Number: HFSB-23
Authors: Xue (Zoe) Jiang; Peter B. Lillehoj
Title: A Disposable Skin Patch for Rapid Malaria Infection Detection

Abstract: Malaria is one of the most deadly infectious diseases in the world with 219 million infections and 435,000 deaths in 2017. Currently, the most commonly used tests to detect malaria infection are rapid diagnostic tests (RDTs). While malaria RDTs are simple and inexpensive, they rely on blood sampling which requires trained medical personnel and pose risks of infection. To address these limitations, we demonstrate a blood-free skin patch for rapid malaria infection detection. This device combines a hollow microneedle array with an antibody-based lateral flow assay on a disposable adhesive patch. Experiments were performed to evaluate various device parameters, including the mechanical strength, skin penetration performance and fluid extraction capabilities of the microneedle array, and the sensitivity and specificity of the lateral flow assay. Proof of concept was demonstrated by using this device to detect Plasmodium falciparum histidine-rich protein 2 (PfHRP2), an important malaria biomarker, in a cadaver porcine skin model. The simplicity, low cost and blood-free nature of this approach makes it promising for malaria infection detection in resource-limited settings.

This work was supported in part by Partially funded by Bill & Melinda Gates Foundation

Keywords: Biosensor, point-of-care, malaria detection, microneedle

Poster Number: HFSB-24
Authors: Saranraj Karuppuswami; Mohd Ifwat Mohd Ghazali; Saikat Mondal; Deepak Kumar; Premjeet Chahal
Title: A 3D Printed UHF Passive RFID tag for Embedded Applications

Abstract: In this poster, 3D printing by additive manufacturing is employed to fabricate a UHF RFID tag compatible with direct integration into 3D printable plastic parts. A meandered dipole design is chosen for the transceiver antenna to receive the query signal and respond back with the identification information to the interrogator operating in the FCC approved RFID range (902-928 MHz). The antenna is printed on a plastic substrate with the RFID chip embedded using a face-up embedding process. Conductive traces are patterned onto the substrate using a damascene-like mechanical polishing process. The printed tag has a read range of 6 m making the performance comparable with UHF RFID tags. The tag can be easily integrated with plastic parts that are 3D printing compatible such as car bumpers, pill bottles, etc.

This work was supported in part by The Axia Institute

Keywords: 3D Printing; Embedded Actives; Packaging; RFID; Supply Chain

Poster Number: HFSB-25
Authors: Madeline A. Mackinder; Keliang Wang; Bocong Zheng; Qi Hua Fan
Title: Magnetic Field Enhanced Cold Plasma Sterilization

Abstract: Cold plasma sterilization offers a way to sterilize medical instruments without the negative traits of current cleaning methods. This study used a mixture of argon and oxygen gas to investigate the effects of adding a magnetic field and varying gas pressure on the efficacy of the sterilization treatment. A uniform amount of Escherichia coli was placed on glass slides and exposed to the plasma afterglow at different pressures with and without a magnetic field. A dielectric barrier discharge was used. The plasma was created inside the tube using a capacitively coupled RF power supply. Optical emission spectroscopy was used to characterize the species present. The addition of a magnetic field was shown to increase the intensity of the plasma, and the pressure of 100 mTorr presented the most effective treatment with a sterilization time of 57.9 seconds.

This work was supported in part by National Science Foundation (Grant No.1700785 and 1700787)

Keywords: plasma, sterilization, magnetic field

Poster Number: HFSB-26
Authors: Lisaura Maldonado-Pereira; Nama Naseem; Lisa Zou; Nicole Urrea; Ilce Medina-Meza
Title: Oxidative Lipidomics of the Most Consumed Home-Cooked Meats in US

Abstract: Cholesterol oxidation in food is promoted by: 1) food processing and meal preparation, and 2) food handling, packaging and storage conditions. Cholesterol oxidation products (COPs) are oxidized derivatives which accumulate in several tissues and organs due to the frequent consumption of COPs-containing foods, have been associated to the major chronic diseases, such as cancer, atherosclerosis, and several neurological diseases such as Parkinson and Alzheimer. The aim of this study was to evaluate the influence of different cooking methods the oxidative stability of most consumed meat products in the USA diet by a lipidomic approach. Raw samples showed a lower total fat content (3.20 g/100 g sample and 16.52 g/100 g sample for pork chop and ground beef 80% lean, respectively) compared to cooked samples which reached a total fat content of 15.26 g/ 100 g sample for pork chop and 22.53 g/100 g sample for ground beef 80% lean. Variability of these results are related with the difference of water, protein and other soluble compounds present in the raw sample compared to the dehydrated cooked samples. Cooking loss was higher in ground beef 80% lean with a 56.75% because of its highest water content and other soluble compounds. Oxidation of cholesterol reached a 69.3% in pork chop samples. A significant increase in total COPs content (mg/g fat) was observed between raw and cooked samples. In raw samples, a larger variety of COPs was observed in smaller amounts, but cooked samples showed higher amounts of COPs, mainly of 7-ketocholestanol and 7beta-hydroxycholesterol.

This work was supported in part by MSU Center of Research on Ingredient Safety (CRIS)

Keywords: lipidomics, cholesterol oxidation, cholesterol oxidation products, chronic diseases

Poster Number: HFSB-27
Authors: Saikat Mondal; Saranraj Karuppuswami; Rachel Steinhorst; Deepak Kumar and Premjeet Chahal
Title: A Wearable Batteryless pH Sensor for Health Monitoring

Abstract: pH is an important chemical property, which is monitored for acidic or basic property of a fluidic environment. Recently, electrochemical sensors became popular for biomedical applications due to their small feature size and integration with miniaturized electronics. A few wearable pH sensors have been proposed to monitor the salivary pH and glucose inside mouth. A correlation between pH and mouth diseases such as periodontitis and gingivitis are proposed earlier in [3]. However, the major problem with existing wearable pH sensors is that they are battery powered, which results in reduced shelf life and involved health risk with battery leakage, and also these systems are bulky.

Keywords: pH, wearable, passive, batteryless

Poster Number: HFSB-28
Authors: Oznur Caliskan-Aydogan; Evangelyn C. Alocilja
Title: Antibiotic-Resistant Bacteria in the Food Industry

Abstract: An antibiotic is an agent that kills bacteria (bactericidal) or stops their growth (bacteriostatic). However, several bacteria causing severe and common infections have developed a resistance to single antibiotic or multiple antibiotics. Thus, bacteria are no longer susceptible to the medicines used for treatments. Antibiotic resistance (ABR) has been a global threat to public health systems in the 21st century. The spread of ABR bacteria is reported by the World Economic Forum's Global Risks in 2014 as alarming as terrorism or climate change due to potential environmental, economic, geopolitical, and social threats. The growing worldwide phenomenon of ABR is linked with the overuse and misuse of antibiotics in human, veterinary medicine, and agriculture have also provoked the spread of highly drug resistant bacteria worldwide. The ABR in food-borne bacterial enteric pathogens in the food chain has been an issue for more than 50 years. One of the major food-borne antibiotic resistant bacteria are Salmonella in animal food products. Ampicillin, streptomycin, and nalidixic acid are commonly used in animal production as prophylaxis. Therefore, the overall goal of this study is to design a biosensor to quickly detect Salmonella resistant to ampicillin, streptomycin, and nalidixic acid in poultry production. As part of the biosensor development, Salmonella resistant to ampicillin, streptomycin, and nalidixic acid will be generated using a referenced procedure. This poster will describe the methodology and discus the current state of the situation of ABR in the food supply chain.

This work was supported in part by The Ministry of Turkish National Education

Keywords: antibiotic-resistance, prophylaxis, poultry, Salmonella

Poster Number: HFSB-29
Authors: Nathan Redman; Shakhlo Aminova; Yuki Harada; Masako Harada
Title: Extracellular Vesicle-Mediated Epigenetic Engineering for Treatment of Type 1 Diabetes Mellitus

Abstract: Type 1 Diabetes Mellitus (T1DM) is an autoimmune disease which involves the destruction of insulin-secreting beta-cells in the pancreas by immune cells such as resident macrophages. Experimental treatments such as beta islet grafts have so far shown limited success. We aim to develop a 'functional cure' for type 1 diabetes which will improve a patient's ability to regulate their blood glucose levels by preserving their own beta-cells.

The aim of this project is to confer immunotolerance in beta-cells to prevent their destruction by macrophages within T1DM patients. A novel epigenetic modification tool will be used to induce a well-characterized self-recognition marker, CD47, on the beta-cells' surfaces. CD47 gene expression is regulated by the methylation status of a proximal genomic region and can be induced by removing these methylation marks. Tet1CD (a catalytic protein domain which removes methylation marks) can be fused to dCas9 (a sequence-targeting protein) to allow removal of DNA methylation at specific genomic loci to induce CD47. This fusion gene is cloned into a minicircle expression cassette (minimal expression vector devoid of bacterial sequences) for efficient loading into extracellular vesicles (EVs). EVs are highly efficient and biocompatible delivery vehicles and can be engineered to display beta-cell targeting single chain antibodies (scFvs) on their surfaces.

This work may provide a persistent, non-invasive functional cure for T1DM through targeted EV delivery of minicircles which code for sequence-specific epigenetic regulators.

Keywords: vesicles diabetes epigenetic CRISPR immune

Poster Number: HFSB-30
Authors: Monica Setien; Cort H. Thompson; Samuel Daniels; Cory A. Rusinek ; Yue Guo; Robert Rechenberg; Michael F. Becker; Wen Li; Erin Purcell
Title: The Biocompatibility of Diamond Ultramicroelectrode Materials for Neural Sensing Applications

Abstract: The drive to better understand normal brain function and pathological states has intensified demand for new technologies which can interrogate the nervous system with enhanced spatiotemporal resolution. Our team is developing an all-diamond implantable ultramicroelectrode arrays to deliver chronic, stable recordings of extracellular bipotentials and neurochemical signals via cellular-scale site sizes (<50 μm2). Here, we report the results of an initial characterization of the biocompatibility of the novel diamond-based materials used in the array, including conductive boron-doped polycrystalline diamond (BDD) and insulating polycrystalline diamond (PCD). BDD is an attractive electrode material based on its high corrosion resistance, minimal background current, and long-term stability for neurotransmitter detection. Indium tin oxide (ITO), which is an electrically conductive material previously shown to enhance the electrophysiological responses and network formation of attached neurons, is included as a reference control material in addition to cell culture-treated plastic. Primary cultures of rat embryonic cortical neurons (E18) are seeded onto the different materials and maintained for 21 days, where patch-clamp electrophysiology and immunohistochemistry is performed at 7, 14, and 21-day time points. Our ongoing analysis compares the substrate materials on: (1) the degree of neuronal attachment and viability (as assessed by caspase-staining), (2) the excitability of neurons on each material assessed with patch clamp electrophysiology (based on the maximum number of action potentials in response to injected current, action potential amplitude, and maturity of passive membrane characteristics), (3) the associated expression of markers of excitability identified with immunohistochemistry (synaptic transporters and ion channels), and (4) the degree of neurite outgrowth from neurons on each material as assessed with Sholl analysis. The results presented will inform the transfer of the novel diamond substrate materials to sensing applications in the in vivo environment, where we expect to leverage the positive performance characteristics of the diamond materials displayed in vitro.

Keywords: diamond, microelectrodes, biomaterials, neural sensing

Poster Number: HFSB-31
Authors: Saad Asadullah Sharief; Nitya Kriti; Prem Chahal; Evangelyn C. Alocilja
Title: Synthesis of Gold Nanoparticles/DNA Conjugate as Unique Anticounterfeiting Tags and Their Rapid Detection

Abstract: Counterfeiting of valuable products is a global challenge that needs to be addressed at the earliest. Virtually all industries have been affected by this illicit operation leading to major health and monetary losses along with costumer dissatisfaction and unemployability. Although various technologies have been proposed as anticounterfeiting measures, including barcodes, quick responsive codes and RFID's, each is marred by one or more drawbacks. We propose the use of DNA as a unique identification tag which can not only be printed using the traditional printing technologies but can also be detected via a rapid and user-friendly method. DNA is conjugated with gold nanoparticles and synthesized as an ink which can provide a 2-level security for product authenticity. The first level of security is provided by the gold nanoparticles which gives a unique peak at 520 nm in the absorption spectrum. We propose to link these labels with a Blockchain-inspired technology which allows for the monitoring of the product as it moves along the supply chain. The second level of security is provided by the DNA probe sequences attached to the gold nanoparticles. The target for the probe sequences is conjugated on magnetic nanoparticles. The binding of the probe to target sequences, following magnetic separation will result in a peak at 520 nm, confirming the complementarity between the two sequences, thereby proving product authenticity. If the product label lacks the gold nanoparticles or probe DNA or both, no peak will be observed, confirming that the product is fraudulent. This poster will present our results confirming the synthesis of gold nanoparticles/ DNA conjugate ink.

This work was supported in part by Axia Institute

Keywords: anti counterfeiting, DNA detection, gold nanoparticles, magnetic nanoparticles

Poster Number: HFSB-32
Authors: Kylie Smith; Cody Pinger; Kurt Zinn
Title: Commercial Nebulizers as Nose-to-Brain Delivery Devices

Abstract: Nose-to-brain (N2B) delivery is gaining popularity due to its circumvention of traditional challenges associated with brain targeting via intravenous routes. Delivering drugs though the nasal cavity avoids first-pass metabolism and hindered transport by the blood-brain-barrier, resulting in improved concentrations in the brain compared to alternative methods. One drug of interest for brain delivery is insulin, which has been shown to protect against cognitive decline when administered intranasally in humans (Benedict et al., 2007). Further, a general method to evaluate and improve brain delivery in living organisms is currently lacking. This project is focused on developing intranasal delivery in combination with imaging as a platform technology for biomedical applications. Here we report on the initial phases of the research. Three low-cost nebulizers were modified with 3D-printed accessories and tested as intranasal delivery devices. Small molecules and proteins (insulin, albumin) were labeled with either radioactive or fluorescent probes and evaluated. Metrics included rate of nebulization and efficiency, as well as structure and function of the aerosolized molecules and proteins. Using commercially-available technology will improve the likelihood of translation to bedside, improves patient compliance, and provides a cost-effective solution. The results will be used to provide a detailed understanding of the limits of commercial nebulizers as intranasal delivery devices and allow selection of the most appropriate device for use in vivo. The long-term goal is improved intranasal drug delivery to brain to achieve better therapeutic outcomes.

Keywords: intranasal, insulin, imaging, nebulizer, delivery

Poster Number: HFSB-33
Authors: Victoria Toomajian; Masamitsu Kanada; Ashley Makela; Taeho Kim; Christopher H. Contag
Title: Macrophage-derived Extracellular Vesicle-coated Magnetic Nanoparticle Clusters for Imaging of Inflamed Tissues

Abstract: Extracellular vesicles (EVs) are being investigated as therapeutic delivery tools due to their biocompatibility and potential to cross various biological barriers. It is proposed that EVs derived from different cell types will naturally accumulate in different tissues of the body followed by selective uptake by resident cells. By coating superparamagnetic iron oxide nanoparticles (SPIONs) with membranes from macrophage-derived EVs, magnetic particle imaging (MPI) can be used to track EV-membrane directed uptake and distribution in vivo. MPI is an emerging non-invasive tomographic technique that directly images the distribution of SPIONs based on their magnetic properties. In this study, we propose to develop novel SPION clusters coated with EV-derived membranes as a sensitive and quantitative imaging tool to reveal bio-distribution of EVs. Poly(acrylic acid) coated, SPION clusters were obtained by self-assembling process in micro-emulsion. The resulting 3D clusters were then co-extruded with EVs derived from two macrophage cell lines, J774 or Raw 264.7, in order to coat the SPION clusters with their membranes. Quantitative analysis of the EV-coated SPION uptake in different types of recipient cells would support the selective uptake and guide subsequent in vivo studies by MPI and intravital microscopy that can be used to assess EV biodistribution and cellular uptake in vivo. This EV-coating approach will allow us to evaluate the hypothesis that EVs derived from macrophages selectively accumulate in inflamed tissues, relative to uncoated or control coated SPIONs, and can be directed to specific cell types for the purpose of developing inflammation-directed therapeutic delivery systems.

Keywords: MPI, extracellular vesicles, inflammation, delivery

MOBILITY, ROBOTICS

Poster Number: MR-01
Authors: Robert Jared Clark; Glen A. Simon; Michael A. Langford; Betty H.C. Cheng; Philip K. McKinley
Title: Enhancing the Performance and Safety of Autonomous Vehicles through Computational Evolution

Abstract: We explore the integration of evolutionary search into the design of autonomous vehicles in order to improve their performance and safety. While the methods developed are widely applicable, we currently target systems whose software infrastructure is based on the Robotic Operating System (ROS), which supports many types of autonomous systems in both industry and government. To this end, we have developed Evo-ROS, which couples a front-end evolutionary algorithm (EA) with parallel, physics-based simulation of individuals in the evolving population. Depending on the front-end EA, Evo-ROS can be applied in different ways, for example, evolving system components that respond better to adverse conditions, or detecting "unlikely-but-possible" situations that could lead to catastrophic failure. To evaluate the proposed methods, experiments are conducted with AutoRally, a 1:5-scale autonomous truck equipped with extensive sensing and computing resources. Future plans include experiments with CANVAS, a full-scale self-driving vehicle developed at MSU. Applying EAs to such complex systems is challenging due to computational demands, but the potential payoff is high, as improving the safety of autonomous vehicles has near-term and long-term societal impact.

This work was supported in part by Air Force Research Laboratory

Keywords: autonomous vehicle, evolutionary algorithm, robustness, assurance, safety

Poster Number: MR-02
Authors: Lai Wei; Vaibhav Srivastava
Title: Policies for Nonstationary Multi-armed Bandit Problems

Abstract: We study the non-stationary stochastic multiarmed bandit (MAB) problem and propose two generic algorithms, namely, Limited Memory Deterministic sequencing of Exploration and Exploitation (LM-DSEE) and Sliding-Window Upper Confidence Bound\# (SW-UCB\#). We rigorously analyze these algorithms in abruptly-changing and slowly-varying environments and characterize their performance. We show that the expected cumulative regret for these algorithms in either of the environments is upper bounded by sublinear functions of time, i.e., the time average of the regret asymptotically converges to zero. We also extend the single-player algorithms to distributed multi-player case. Numerical illustrations are provided.

This work was supported in part by NSF Award IIS-1734272

Keywords: multiarmed bandit, nonstationarity, minimax regret

Poster Number: MR-03
Authors: Wenpeng Wei; Guoming Zhu
Title: Powertrain System Modeling for a 4WD Vehicle

Abstract: In this research, the ultimate goal is to develop an algorithm to estimate the surface friction coefficient mu of the clutch inside transfer case for a 4WD vehicle. At present phase, the vehicle powertrain system model has been established with the calibration of some key components, such as torque converter, longitudinal stiffness. The dynamic model of the vehicle has been created for analyzing the vehicle accelerating performance in the future. Specifically, the transfer case system model, which includes clutch actuation system and transfer case torque model, is developed for the detailed clutch surface friction coefficient estimation. Finally, the transfer case input torque is estimated using the adaptive recursive least square algorithm based on the available data.

Keywords: powertain system, transfer case, clutch, friction coefficient, modeling

Poster Number: MR-04
Authors: Amer Allafi; Frank B. Mathis; Ranjan Mukherjee
Title: Apex Height Control of a Two-Mass Robot Hopping on a Viscoelastic Foundation with Inertia

Abstract: A majority of the results in the literature on hopping robots assume the ground to be rigid. Hopping on a foundation that can be modeled as a mass-spring-damper system poses challenges due to undesired vibration of the additional degree-of-freedom and dissipation due to impact and viscous damping. A hybrid control strategy is developed to converge the maximum jumping height of the center-of-mass of a two-link prismatic-joint robot to a desired value. The hybrid control strategy uses backstepping in continuous time and integral control in discrete time to control the internal degree-of-freedom and the total energy. Simulation results are presented to demonstrate the efficacy of the controller.

Keywords: robot, hopping, control

Poster Number: MR-05
Authors: Yasir Al-Nadawi; Xiaobo Tan; Hassan Khalil
Title: Inversion-free Control of Hysteresis Nonlinearity Using An Adaptive Conditional Servomechanism

Abstract: Smart material-based systems, such as piezoelectric nanopositioning stages, exhibit pronounced hysteresis nonlinearity that poses significant control challenges. Much of the existing work employs an inverse hysteresis operator to approximately cancel out the hysteresis nonlinearity. In this paper we propose an inversion-free approach to the control of systems with hysteresis, removing the computational complexity in constructing an inverse compensator. The hysteresis nonlinearity is modeled as a Modified Prandtl-Ishlinskii (MPI) operator. We utilize the properties of the MPI hysteresis model to transform the system into a semi-affine form, where one term has the control input appearing linearly and the other term represents the hysteretic perturbation. The proposed controller is designed based on an adaptive conditional servocompensator approach, which is a continuously-implemented sliding mode control law powered with an adaptive servocompensator. An analytical bound on the hysteretic perturbation is derived and used in the design of the sliding mode control law. A low-pass filter introduced to augment the control law, to avoid solving a complicated equation involved. Our stability analysis shows that, under a mild sector condition, the boundedness of the closed-loop system trajectories is ensured. Experiments conducted on a commercially available nanopositioner confirms the effectiveness of the proposed method as compared to the case when an inverse model is implemented; indeed, the tracking error is reduced by approximately 50% for sinusoidal references under the proposed controller.

Keywords: hysteresis, adaptive conditional compensator, sliding mode control, non-inversion

Poster Number: MR-06
Authors: Sanders Aspelund; Sheryl Chau; Ranjan Mukherjee; Mei-Hua Lee; Rajiv Ranganathan; Florian Kagerer
Title: A Seven Degree-of-Freedom Body-Machine Interface for Children with Severe Motor Impairments

Abstract: Children with severe motor impairments require the use of assistive devices to perform activities of daily living. Brain-machine interfaces are not suited for children due to various factors such as surgical risks. We present a non-invasive body-machine interface where upper body movements are recorded by wireless inertial measurement units (IMUs) and used to control a robotic arm. We develop a novel approach, called the virtual body model (VBM), which allows for control of high number of degrees-of-freedom (DOF). Our results show that a participant could use the VBM to control up to seven DOFs of a robotic arm and perform various real-world tasks. These results show the potential of this safe, non-invasive approach to allow impaired children to control high DOF robotic arms.

This work was supported in part by office of the Vice President for Research and Graduate Studies at Michigan State University and the National Science Foundation

Keywords: Body-machine interface, assistive devices, FEM, rehabilitation, robotics

Poster Number: MR-07
Authors: Shivam Bajaj; Shaunak D. Bopardikar
Title: Save the Earth Against Space Invaders: Autonomous Perimeter Guarding Against Radially Incoming Targets

Abstract: In this modern era, every physical asset can be defined by a perimeter and guarding these perimeters is critical from a security and safety perspective. In this work, we consider a problem in which a compact spherical goal area needs to be protected against multiple mobile targets. This problem is of immense significance in modern times in monitoring airport runways against rogue drones or protecting spaceships against debris. The targets are assumed to be generated stochastically and move radially, with a constant velocity, towards the goal. A single autonomous vehicle is tasked to intercept the targets and maximize the capture fraction.
In this poster presentation, we will present novel analytic results that summarize fundamental limits that can be achieved by any admissible motion planning "policy" for the vehicle in terms of a policy independent upper bound on the capture fraction. We will then analyze simple policies such as the First Come First Serve (FCFS) policy, present a lower bound on the capture fraction of the FCFS policy and show that it is optimal under certain circumstances. We will then present several innovative policies based on look-ahead and evaluate their performances numerically.

Keywords: dynamic vehicle routing, boundary guarding

Poster Number: MR-08
Authors: Connor Boss; Vaibhav Srivastava
Title: Actuator-Failure Tolerant Control of a Hexrotor via Multiple Models and Extended High-Gain Observers

Abstract: What were once seen as hobbyist aircraft have carved out a new segment in commercial aerial applications, bridging the gap between hobbyist and full-sized manned aircraft. With the increased reliance on these multi-rotor aircraft in many areas including aerial cinematography, agriculture, infrastructure inspection, search and rescue, and remote monitoring, serious consideration needs to be given to the reliability, and inevitably robustness, of these aircraft. Loss of the vehicle in these applications can have severe economic or operational consequences. This work presents a novel method for recovering from actuator failure during flight. The method presented is purely algorithmic, requiring no additional hardware or sensing capabilities. Continually monitoring the response of the vehicle dynamics to both control input and external disturbances, rapid failure identification and rectification can be made using extended high-gain observers in a multiple model setting. We present simulation results confirming the capabilities of the proposed method.

Keywords: fault tolerance, disturbance estimation

Poster Number: MR-09
Authors: Maria Castano; Xiaobo Tan
Title: Backstepping Control-Based Trajectory Tracking for Tail-Actuated Robotic Fish

Abstract: Growing global concerns for aquatic ecosystem sustainability has led to the need for autonomous aquatic robots that are capable of monitoring freshwater and marine environments in an efficient and accurate manner. Robots that propel and maneuver themselves like real sh, often known as robotic sh, have emerged as mobile sensing platforms for such environments. Accurate trajectory control is of importance for precise sensing and monitoring; however, the highly nonlinear and often under-actuated dynamics of robotic sh presents signicant challenges in control of these robots. In this work, we propose a backstepping-based trajectory tracking control for a tail-actuated robotic sh that accommodates input constraints. By considering the cyclic nature of tail actuation, the control design is based on an averaged dynamic model, where the bias and amplitude of the tail oscillation are treated as physical variables to be manipulated, while the tail beat frequency is fixed. Both simulation and experimental results support the efficacy of the proposed approach. The advantages of the proposed control approach are shown via comparison with alternative approaches.

This work was supported in part by National Science Foundation (DGE1424871, ECCS 1446793, IIS 1715714)

Keywords: robotic fish, nonlinear control

Poster Number: MR-10
Authors: Demetris Coleman; Maria Castaño; Xiaobo Tan
Title: Backstepping-based Trajectory Tracking with Input Constraints for Underwater Gliders

Abstract: Autonomous underwater gliders have become valuable tools for a myriad of applications ranging from ocean exploration to fish tracking to environmental sampling. For precise sensing and monitoring, accurate trajectory control is of importance. However, this class of robotic systems often present many challenges for autonomous control due to their highly nonlinear under-actuated dynamics, and coupled inputs. In this work we propose a backstepping trajectory tracking controller that tracks a time varying pose in the sagittal plane and incorporates input constraints. The effectiveness of the controller is demonstrated via simulations and it’s advantaged are shown via comparison with an alternative PID controller.

Keywords: underwater robotics, controls

Poster Number: MR-11
Authors: Osama Ennasr; Christopher Holbrook; Darryl W. Hondorp; Charles C. Krueger; Demetris Coleman; Pratap Solanki; John Thon; Xiaobo Tan

Title: Characterization of Acoustic Detection using a Gliding Robotic Fish as a Mobile Platform

Abstract: Within a stationary network of acoustic telemetry receivers, observations of fish migration patterns and spatial distributions are limited to areas covered by the network. While this approach to fish tracking is adequate for many applications, the number of receivers required for monitoring large ecosystems can be prohibitive in terms of cost and logistics. Recently, underwater gliders, wave gliders, and propelled autonomous underwater vehicles have been exploited to detect and track fish tagged with acoustic transmitters. We evaluated the applicability of a low-cost, energy-efficient, and portable gliding robotic fish, to acoustic telemetry. Detection efficiency for the receiver attached to the robot was similar to stationary receivers at 300 m in an inland lake (0.78 for stationary receivers; 0.76 for mobile receiver) but was lower than stationary receivers at greater distances. Effects of robot pitch angle (nose up or down), depth, and movement direction (towards or away from a target) on detection efficiency also were characterized. Namely, the detection performance varies depending on the depth, pitch, and robot heading, as the position of the robot relative to the transmitter can shield the signal from the receiver. Overall the results obtained from these trials indicate that the gliding robotic fish is a viable option as a mobile acoustic telemetry platform.

This work was supported in part by This work was supported in part by the U.S. National Science Foundation (ECCS 1446793), the Great Lakes Fishery Commission (2014_Tan_44058), and the United States Geological Survey Innovation Center for Earth Sciences. This work also was supported in part by funds from the Great Lakes Fishery Commission by way of Great Lakes Restoration Initiative appropriations (GL-00E23010). This paper is Contribution 66 of Great Lakes Acoustic Telemetry Observation System (GLATOS).

Keywords: acoustic detection; underwater glider; robotic fish

Poster Number: MR-12
Authors: Jason N. Greenberg; Xiaobo Tan
Title: Dynamic Optical Localization of a Mobile Robot Using Kalman Filtering-based Position Prediction

Abstract: Autonomous mobile robots operating in areas with poor GPS and wireless coverage (e.g., underwater) must rely on alternative localization and communication approaches. In this work, we present an LED-based system that achieves Simultaneous Localization and Communication (SLAC), where the line of sight (LOS) requirement for communication is exploited to extract the relative bearing of the communicating parties for localization. By using Kalman filtering to obtain the mobile robot's predicted position, the system is able to reduce the overhead of establishing the LOS and therefore significantly improve on the quality of the localization. The proposed design of the optical localization system is presented and its effectiveness is demonstrated with extensive simulation and experimentation in a two-dimensional setting, consisting of a mobile robot and two stationary base nodes.

This work was supported in part by National Science Foundation (ECCS 1446793, IIS 1734272)

Keywords: robotics, localization, LED-based localization

Poster Number: MR-13
Authors: Piyush Gupta, Vaibhav Srivastava
Title: Optimal Attention Allocation for Human-in-the-loop Queues

Abstract: We study optimal attention allocation for a human operator servicing a queue of homogeneous tasks. The service time distribution of the human operator depends on her cognitive dynamics and the level of attention allocated to service the task. Cognitive dynamics of the operator evolve as a Markov
chain in which the cognitive state increases (decreases) with high probability whenever she is busy (resting). The tasks arrive according to a Poisson process and each task waiting in the queue loses its value at a fixed rate. We address the trade-off between high quality service of a task and consequent loss in value of future tasks using a Semi-Markov Decision Process (SMDP) framework. We numerically determine the optimal policies and establish its structural properties.

This work was supported in part by NSF Award IIS-1734272

Keywords: optimization, human-in-the-loop, semi-Markov decision processes, robotics, human cognition

Poster Number: MR-14
Authors: Tianyi He; Guoming Zhu; Sean Swei; Weihua Su
Title: Sensor Positioning for Vibration Control of Flexible Wings

Abstract: This study focuses on the problem that how to determine sensor positioning to achieve optimal vibration suppression of BWB(Blended-Wing-Body) airplane flexible wing. For a given flight speed range, vibration behaviors of wing structure are evaluated by guaranteed H2 performance of closed-loop system with H2 LPV controller. Sensor location candidates are equally spaced on each wing, and the optimal combination is found by globally searching all possible combination of location candidates. With the LPV model of flexible wing and H2 controller synthesis conditions, simulation results give out the optimal sensor location combination when only limited number of sensors are available.

Keywords: vibration suppression, LPV control, sensor positioning, flexible wings

Poster Number: MR-15
Authors: Nilay Kant; Ranjan Mukherjee; Hassan Khalil
Title: Orbital Stabilization for a Class of Underactuated Systems

Abstract: A hybrid controller for stabilization of homoclinic orbits for a class of underactuated systems is proposed. The controller is comprised of continuos-time inputs, impulsive brakings, and virtual impulsive inputs for resetting of the passive coordinate. Impulsive brakings of the active coordinate result in instantaneous negative changes in the mechanical energy of the system. An impulsive dynamical system framework is adopted for modeling the hybrid dynamics and a Lyapunov function is defined for stabilization of the orbit. Sufficient conditions for stabilization are presented such that the Lyapunov function decreases monotonically under the action of the continuous inputs and undergoes negative jumps due to impulsive brakings. The control design is implemented on an inverted pendulum on a cart example. Simulation results are used to show fast convergence of system trajectories to the homoclinic orbit corresponding to the upright equilibrium configuration.

This work was supported in part by NSF Grant

Keywords: underactuated robotics, hybrid control, impulsive inputs

Poster Number: MR-16
Authors: Anuj Pal; Guoming Zhu
Title: Model Assisted Iterative Calibration of Internal Combustion Engine using Evolutionary Optimization

Abstract: Advancement in engine technology has made the system highly complex. Increase in instrumentation has made calibration process expensive as well as time consuming. Engine calibration could be performed using evolutionary optimization methods but it also requires large number of evaluations to get the near optimal solution. Use of high fidelity engine model also requires couple of days to perform the optimization process. The current project deals with problem of calibrating engine to get near optimal performance with constraints on total evaluation budget using surrogate model and evolutionary optimization. Initially, a surrogate model is developed using training data set. Next step is model improvement. Different strategies have been implemented to improve the surrogate model for accurately predicting near optimal solution. This method has been implemented for both single and multi-objective case. Result shows significant reduction in actual function evaluation using surrogate model with optimal solution close to actual optimal.

This work was supported in part by Ford Motor Company

Keywords: surrogate model, optimization, IC engine

Poster Number: MR-17
Authors: Xinda Qi; Thassyo Pinto; Mohand Alzuhiri; Yiming Deng; Xiaobo Tan
Title: A Snake Robot for Distributed Pipeline In-Line Inspection

Abstract: In this work, a snake robot has been proposed to achieve the internal pipeline inspection aided by a structured light sensor. The snake robot consists of four linked parts and is driven by two sets of active wheels and two roll wheels. The torsional springs in its joints not only provide the contact force between the pipeline and the robot but also give the robot adaptability for pipelines of varying diameters. In addition, an orientation control mechanism for the structured light sensor is designed to keep the sensor alined with the centerline of the pipe. The images from the structured light sensor are used as the feedback signals to control the sensor orientation via a servo motor, to enable good performance in pipeline in-line 3D reconstruction and automated pipeline failure detection.

This work was supported in part by Currently, there are no external funding sources for this work.

Keywords: snake robot, Internal pipeline inspection

Poster Number: MR-18
Authors: Shen QU; Tianyi HE; Guoming G. Zhu
Title: Modeling and LPV Control Design for EGR Valves with Dry Friction

Abstract: Engine EGR (exhaust gas recirculation) valves are highly nonlinear due to its nonlinear friction, especially at the low-velocity region, where the friction increases sharply, resulting in a large steady-state valve displacement error. Multiple friction factors are considered in this paper using a switched LPV (linear parameter-varying) model, where the scheduling parameter is the friction coefficient as a function of valve velocity. Gain scheduling LPV controllers are designed with hysteresis switching logic using the linear matrix inequality (LMI) convex optimization approach. The LPV controller performance is compared with that of PID controllers in simulation study, showing shows a notable improvement in the system response performance and robustness.

Keywords: control, friction, LPV, modeling, valve

Poster Number: MR-19
Authors: Pearce Reickert; Ryan Radawiec; Thomas Bos; Xiaobo Tan
Title: Underwater ROV for Diver Assistance and Local Exploration

Abstract: The Smart Microsystems Lab (SML) underwater Remotely Operated Vehicle (ROV) provides an expandable underwater platform for instrumentation and actuation. The ROV is actuated by three propellers at variable angles allowing for dynamic, rapid underwater movement in a local area. The variable angle propellers allow for more efficient application of force which results in better overall efficiency and control. The operator controls the ROV via a wireless bluetooth receiver in a floating buoy, which rests on the surface of the water and is tethered to the body of the ROV. This platform allows the operator to perform controlled tasks underwater and can be expanded and customized for various future applications.

This work was supported in part by This research was supported in part by the National Science Foundation (ECCS 1446793, IIS 173427)

Keywords: underwater, robotics, ROV, control, tether

Poster Number: MR-20
Authors: Montassar Aidi Sharif; Xiaobo Tan
Title: Angular Acceleration Sensor Inspired by the Vestibular System

Abstract: The vestibular system is a sensory organ that provides information necessary to control balance and movement in the three-dimensional space. The vestibular system is comprised of two sub-systems: the otoliths, which sense linear acceleration, and the semicircular canals, which sense the angular acceleration. Inspired by the semicircular canals, an angular acceleration sensor is proposed by exploiting ionic polymer-metal composite, a soft material with intrinsic mechanosensory properties. Unlike the biological counterpart that has three semicircular canals, the proposed sensor has one 3D-printed circular canal filled with a viscous fluid. Experimental results show that the proposed sensor is able to capture the angular acceleration of different rates. Finite-element simulation is conducted to provide insight into the experimental observations.

This work was supported in part by Office of Naval Research (grant N000141512246), Higher Committee Educational Development (HCED), Office of Prime Minister, Iraq

Keywords: angular acceleration sensor, vestebular system, canal neuromast, IPMC

Poster Number: MR-21
Authors: Thassyo Pinto; Arend Hintze; Christoph Adami; Xiaobo Tan
Title: Evolving Controllers for Soft Pneumatic Actuators Using FEM-based Simulators

Abstract: Recent advances in soft robotics have contributed to the development of several soft-bodied robotic systems with multi-materials, sophisticated shapes, and integrated sensing capabilities. A large range of applications can now benefit from these soft robots where softness provides safety and increase in performance, while reducing fabrication cost and assembly complexity. Despite these potential advantages, control design for soft robots is particularly challenging due to highly nonlinear deformations and large model uncertainties. In contrast to rigid-bodied robots, many soft robotic system behaviors, such as the nonlinear stress-strain relationship of hyper-elastic materials and the inhomogeneous load distribution of pressurized fluids, make modeling and control of soft robots a dauting task. In this work, we investigate the computational evolution of controllers for soft pneumatic actuators in a finite element method (FEM)-based simulator, which can perform real-time simulation of realistic material properties, rigid and soft body kinematics and dynamics, and collision detection. A comparison between different artificial intelligence models and genetic algorithms are performed. These controllers can potentially be transferred to real-world soft robots due to matched parameters between the simulated environment and realistic soft robots, facilitating prototyping. In addition, evolved controllers for a given coupled body-plan/actuation mechanism will contribute to building more adaptive and resilient soft machines in the near future.

This work was supported in part by MSU Foundation Strategic Partnership Grant Program (16-SPG-Full-3236); Coordenacao de Aperfeicoamento de Pessoal de Nilvel Superior (BEX-13404-13-0); National Science Foundation (DBI-0939454)

Keywords: soft robotics, robotic grasping, evolutionary robotics, artificial intelligence

Poster Number: MR-22
Authors: Yingxu Wang, George Zhu
Title: Control Algorithm Applied on Mini Segway

Abstract: The segway is the first transportation product to stand, balance, and move in the same way as human. It is a truly 21st-century idea. The aim of this research is to study the theory behind segway vehicle based on the stabilization of an inverted pendulum. An experimental model has been designed by running a proportional derivative algorithm on a microprocessor chip. The model has been identified in order to serve as an educational experimental platform for segways.

Keywords: Segway control

Poster Number: MR-23
Authors: Anshu Bamney; Devrishi Tiwari
Title: Study on Willingness to Use Non-Motorized Modes in a Tier 3 City: A Case Study in India

Abstract: Urbanization and population growth escalated Motorized Vehicles (MVs) use and caused serious environmental, health and traffic issues. These can be tackled by increasing Non-Motorized Vehicles (NMVs, walk and Bicycle) share and decreasing the MV usage. The purpose of this paper is to study the potential of NMVs usage in Rewa city (Tier 3), India. Many studies have been conducted in Tier 1 and 2 cities of India to get an insight on willingness to use NMVs but Tier 3 cities are seldom studied. This study is an attempt to explore the factors that influence NMV usage. Are these factors different from those of Tier 1 and 2 cities? Revealed Preference and Stated Preference data was collected using a paper questionnaire and both mandatory and non-mandatory trips were studied and certain MV restrictive and NMV oriented policies were asked. It was found that 27 and 11 percent of the respondents were currently using NMVs for mandatory and non-mandatory trips. It was also observed that as the age, occupation level, income level, vehicle occupancy increases the willingness to use NMVs increases and it decreases rapidly after 3kms in both types of trips. Logistic regression models were developed, to estimate the probability of willingness to use NMVs which showed an accuracy of 80 percent in the prediction of willingness level. The study gives an insight on factors influencing the NMV usage and are compared with large cities, moreover, it helps in understanding various infrastructural and policy provisions that can encourage NMV usage.

Keywords: Non-motorized vehicles (NMVs); willingness; logistic regression; tier 3 city; India

Poster Number: MR-24
Authors: Qiuqi Cai; Peter T. Savolainen
Title: Investigation of Reaction Time and Deceleration Rates During Crash and Near-Crash Events Using Naturalistic Driving Data

Abstract: Given the prevalence of driver error as a primary contributing factor in traffic crashes, research is warranted to better understand how drivers behave over the course of crash and near-crash events. The data resulting from the second Strategic Highway Research Program Naturalistic Driving Study provide a unique opportunity to investigate behavioral metrics such as reaction times and deceleration rates leading up to these safety-critical events. As a part of this study, driver performance during crash and near-crash events on freeways were examined. The average reaction times and deceleration rates in these events were 1.51 sec. and 9.53 ft/s2 (0.30 g), respectively, while the associated 85th percentile values were 2.60 sec. and 14.27 ft/s2 (0.44 g). Reaction times were strongly influenced by gender, as well as whether the driver was distracted at the time of the event. The reaction time also varied considerably based upon whether the event involve a rear-end conflict, a sideswipe conflict, or an unexpected object in the roadway. Deceleration rates were largely consistent across drivers and were not found to be influenced by distraction. Interestingly, deceleration rates tended to be higher when initial vehicle speeds were lower. Ultimately, this study provides insights of interest to highway design, in addition to improving understanding of the impacts of distraction on driver performance.

Keywords: reaction time, deceleration rate, naturalistic driving study, SHRP2

Poster Number: MR-25
Authors: Meghna Chakraborty; Steven Stapleton; Jonathan J. Kay; Timothy J. Gates
Title: Safety Performance of Median U-Turn Conversions in Michigan

Abstract: Alternative intersection designs can offer safety and operational benefits with potentially lower costs than conventional intersections when used in the proper setting. One such alternative intersection design that has been used extensively across Michigan for decades is the median U-turn (MUT), which accommodates left turns via a U-turn crossover within the median. This evaluation examined 28 stop-controlled MUT intersections as well as 100 signalized MUT intersections in order to help quantify the safety benefits of implementing MUTs. The percentage of angle collisions at stop-controlled intersections was substantially lower in the post-conversion period (5.7 percent) compared to the pre-conversion period (50.3 percent). The decrease in the proportion of angle collisions was offset by a notable increase in rear-end collisions (25.8 percent in the pre-conversion sites and 75.7 percent in the post-conversion sites). There was also a decrease in the proportion of head-on left-turn collisions in the post-conversion period (0.6 percent) compared to the pre-conversion period (2.8 percent) for signalized MUTs. Stop-controlled MUT intersections exhibited superior safety performance in terms of fatal and injury (FI) crashes over traditional intersections but experienced more property damage only (PDO) crashes as major approach volumes exceed 15,000 entering vehicles per day. Signalized MUT and traditional intersections performed similarly up to approximately 20,000 entering vehicles per day along the major approach, at which point MUTs experienced more FI crashes but fewer PDO crashes. Ultimately, fully-specified negative binomial regression models were developed to estimate the FI and PDO crash frequencies for both stop-controlled and signalized MUT intersections.

Keywords: median U-turns, alternative intersections, safety performance functions, stop-controlled intersections, signalized intersections; directional crossovers, Michigan left

Poster Number: MR-26
Authors: Meghna Chakraborty; Steven Stapleton; Mehrnaz Ghamami; Timothy J. Gates
Title: Safety Effectiveness of All-Electronic Toll Collection Systems

Abstract: An analysis of the safety impacts of all-electronic toll systems on selected state highways in Austin and Dallas, Texas was conducted. The evaluation focused on freeways in Austin that had been converted from traditional or hybrid toll plaza systems to open road tolling, and freeways in Dallas where the high occupancy vehicle lanes were converted to high occupancy toll lanes. As these conversions were implemented in beginning of 2013 in Austin, and in 2016 in Dallas, crash data were obtained from 2010 to 2013 and from 2013 to 2017 for the before and after periods of the toll system conversions on both mainline segments and exit ramps in Austin and Dallas, respectively. Empirical Bayes before-and-after analysis were separately carried out for the two study locations. The results reveal, not surprisingly, that an open road tolling system reduced crashes relative to what would be expected if the hybrid system were maintained. Similarly, a conversion from high occupancy vehicle lane to high occupancy toll system also resulted a reduction in crashes. Greater crash reductions were estimated for fatal and severe injury (KAB) crash types than that of possible injury and property damage only (CO) crashes for both types of conversions. However, compared to Dallas, greater crash reductions were found in Austin where the traditional and hybrid toll plazas were converted to open road tolling. Based on the results, authors believe that the location of the toll booth during the before period has an influence on the crash reduction potential of open road tolling.

Keywords: All-Electronic Toll Collection (AETC), Open Road Tolling (ORT), crash reduction

Poster Number: MR-27
Authors: Meghna Chakraborty; Peter T. Savolainen; Nusayba Megat Johari; Jonathan J. Kay; Timothy J. Gates
Title: Relationship Between Safety and Access Density on Urban Two-lane Non-freeway Segments

Abstract: In 2016, majority of the crashes occurred in urban areas both in the U.S. (52.3%) and in Michigan (60%). Urban roads are a critical component of the transportation network in Michigan, accounting for over 31% of total roadway miles. However, safety research investigating the impacts of access density on non-freeway urban road segments is limited. To address this knowledge gap, this study involves the development of safety performance functions (SPFs) for urban two-lane segments, with and without two-way left-turn-lanes (TWLTL) in Washtenaw County, Michigan. SPFs are regression models that are used to relate the expected crash frequency for a specific site type as a function of various factors, including traffic volumes, access density, and posted speed limits, among others. Crash data from 2013 to 2017 are analyzed for over 239 miles of two-lane roadway segments with posted speed limits between 25 and 50 mph. Mixed effects negative binomial regression models are estimated using a median type indicator to distinguish between two lane segments with and without TWLTL. Separate models are estimated for total, fatal and injury, and property damage only crashes as well as multi-vehicle, head-on, and rear-end crash types. Results of this study show that access density and traffic volumes are positively associated with crashes and each variable shows a non-linear relationship. However, the presence of TWLTL is not found to have a significant impact on crashes. Finally, access density is not shown to have a significant influence on head-on, and head-on-left-turn type crashes.

Keywords: urban roads, two-lane segments, access density, safety performance functions, crashes.

Poster Number: MR-28
Authors: Anthony Ingle; Timothy Gates
Title: Safety Performance of Rural Curved Corner Intersections

Abstract: This study evaluates the intersection of rural roads where the major flow of traffic turns to an orthogonal direction. The Highway Safety Manual (HSM) published by AASHTO in 2010 provides safety performance functions (SPFs) for a base condition intersection, adjusted by various crash modification factors (CMFs) for conditions that are not present in the baseline condition. This study compares the methodology of the HSM to new SPFs that are developed to specifically represent cases with intersections built to favor the major road traffic which turns in direction at the intersection. The outcome of this study shows that estimation of crash frequency at rural intersections where the major route turns are equivalent to a composite of three intersections. A system of three intersections in combination can be represented singly by the situation modeled in this paper as a curved corner intersection. This paper demonstrates the application of negative binomial regression modeling to produce analytical tools that are equivalent to the protocol to be followed in the first edition of the HSM.

This work was supported in part by Michigan Department of Transportation

Keywords: rural curve corner intersection safety

Poster Number: MR-29
Authors: Mohammadreza Kavianipour; MohammadHossein (Sam) Shojaei; Fatemeh Fakhrmoosavi; Mehrnaz Ghamami; Ali Zockaie
Title: Impact of Technological Advancements on Optimal Placement of Electric Vehicle Charging Station Infrastructure in Intercity Networks

Abstract: Limited driving range and long recharging time are two of the main barriers that have hindered the market acceptance of the Electric Vehicles (EVs). In intercity trips, the traveled distances can easily exceed the current EVs' range and make the time-consuming charging events inevitable. Therefore, studying the impacts of different batteries and charging technologies on experienced delays, and infrastructure investments and settings can provide insights into charging infrastructure planning in the future. In this study, we use a model recently developed by Ghamami et al. (2019) to find the optimum location of charging stations for different batteries and charging outlets technology. This model minimizes the total system cost consisting of investment costs (charging station and charging outlets) and delay costs (recharging time, waiting time in queue and detour time). The corresponding costs, delays, and energy demand for each battery and charging technology is reported and discussed. The results show that using more advanced charging technologies, even though more expensive in unit cost, can decrease the total system cost. The faster charging options also decrease the total delay as expected. More advanced batteries also decrease the total infrastructure investment cost, as they require less number of charging outlets/stations, while the average experienced delay almost remains constant.

Keywords: electric vehicles, charging station, charging delay, battery size, driving Range

Poster Number: MR-30
Authors: Mohammadreza Kavianipour; Ramin Saedi; Ali Zockaie; Meead Saberi
Title: Estimating Network Fundamental Diagrams in Heterogeneous Networks with Stochastic Demand and Supply: A Mixed Lagrangian-Eulerian Approach

Abstract: A Network Fundamental Diagram (NFD) represents the relationship between network-wide average flow and average density. Employing NFD in transportation planning stipulates the implementation of a new generation of traffic control schemes and enhances the mobility of transportation networks. Estimating the NFD for heterogeneously distributed traffic generated from a time-varying and asymmetric demand matrix is a challenging problem. Recent studies have incorporated both fixed measurements and probe trajectories to estimate NFD. However, they are often based on a given ground truth NFD for a single day demand or not considering day-to-day variations of network demand and supply. Stochastic variations in network demand and supply due to weather conditions, incidents, special events, work zones, and service interruptions may significantly affect the approximation of an NFD. In this study, we aim to propose a modified framework to estimate NFD, while capturing the stochasticity in transportation networks. A mixed integer problem with non-linear constraints is formulated to address stochasticity in the NFD estimation problem. To solve this NP-hard problem, a solution algorithm based on the Simulated Annealing method is applied. The problem is formulated and the solution algorithm is implemented to find an optimal configuration of loop detectors and probe vehicles to estimate the NFD of the Chicago downtown network and capture its day-to-day variations, considering a given available budget. Ground truth NFDs and estimated NFDs are calculated using a simulation-based dynamic traffic assignment model, which is the best available surrogate to replicate real-world conditions.

Keywords: network fundamental diagram, macroscopic fundamental diagram, stochastic network, probe trajectories, loop detectors

Poster Number: MR-31
Authors: Mohammadreza Kavianipour; MohammadHossein (Sam) Shojaie; Iliya Miralavi; Mehrnaz Ghamami; Sharlissa Moore; Wolfgang Banzhaf; Annick Anctil
Title: Exploring Determinants of Electric Vehicle Adoption through Logistic Regression and Genetic Programming

Abstract: Major dependency of the United States’ transportation on fossil fuels engenders energy security and environmental concerns. Transition to alternative fuel vehicles (AFVs) is proposed as a means to reduce oil use and promote sustainable transportation. Among varied AFV types, electric vehicles (EVs) have numerous superiorities, and thus are a promising technology. Aware of this, discerning influential determinants of public decision would contribute to broader EV adoption. In this study, online surveys were distributed to both conventional vehicle and EV users across the United States. The surveys inquire about demographics, infrastructure, policy, and travel pattern factors. With use of the gathered survey responses and adoption of two different modeling techniques, this study aims to model vehicle choice of the users. The first modeling technique deploys the traditional Logistic Regression (LR) method while the second framework adopts Genetic Programming (GP) as an evolutionary computation (EC) method. The two approaches are compared and results indicate that while evolutionary computation enables exploring more combinations of variables and better predictions, logistic regression models are easier to interpret and have comparable predictive power.

Keywords: discrete choice mode, logit model, evolutionary computation, genetic programming, electric vehicles

Poster Number: MR-32

Authors: Md Shakir Mahmud; Mark J Magalotti

Title: Comparing the Operational Efficiency of Signalized Intersections with Exclusive and Concurrent Pedestrian Phase Operations Considering Pedestrian Non-Compliance

Abstract: The Exclusive Pedestrian Phase (EPP) adds a phase entirely for pedestrian movement, which is believed to be the safest pedestrian crossing facility and has been installed in many places instead of Concurrent Pedestrian Phase (CPP). The research seeks to explore whether EPP has encouraged pedestrian non-compliance (crossing without the walk signal) and number of conflicting pedestrians (crossing in the direct path of a vehicle) or not and what are the impacts of such behavior on vehicular intersection delay. The research compared 8 pairs of two-lane intersections in Pittsburgh urban area representing both EPP and CPP operations. The pairs were selected based on similar area type and intersection geometry. Pedestrian crossings were observed and classified using video data. The results showed higher non-compliant and conflicting crossings for all EPP intersections than similar CPP intersections. Average non-compliance in intersection with EPP and CPP were found 23.17% and 7.94% respectively. Four intersections with EPP, in four different land use areas, were analyzed using the traffic simulation tool Synchro to evaluate the impact of pedestrian non-compliance and phase type. For highly non-compliant EPP crossing intersections, compliant behavior was considered in the simulation which resulted in slight decrease of around 1 second in intersection delay. When the EPP intersections were modelled as CPP, delay decreased by more than 50%, even when considered very high number of conflicting pedestrians. In summary, it was found that intersections with EPP encouraged pedestrian non-compliance behavior which increased intersection delay along with added delay due to additional pedestrian phase.

Keywords: exclusive pedestrian phase, synchro, signal optimization, pedestrain safety

Poster Number: MR-33

Authors: Raha Hamzeie; Megat-Usamah Megat-Johari; Iftin Thompson; Timothy P. Barrette; Trevor Kirsch; Peter T. Savolainen

Title: Examining Safety on Two-lane and Multilane Highways in Consideration of Access Spacing

Abstract: Access management strategies, such as the introduction of minimum access point spacing criteria and turning movement restrictions have been shown to be important elements in optimizing the operational and safety performance of roadway segments. The relationship between safety and these types of access policies is a complex issue, and the impacts of such features on traffic crashes is critical to the development of appropriate access management strategies. The purpose of this study was to provide a quantitative evaluation of how crash risk on multi-lane and two-lane highways varies with respect to access spacing in support of the development of a revised access management policy. Data were obtained for approximately 1,247 miles and 5,795 miles of segments across multilane and two-lane highways, respectively. Crash data were obtained for a five-year period from 2012 to 2016 and a series of random effect negative binomial regression models were estimated for each facility to examine the association between crash frequency, access point spacing, and traffic volume. For both facility types, crashes were found to increase consistently as the average spacing of access points along road segments decreased. Crash rates were highest when consecutive accesses were within 150 ft of one another and the frequency of crashes decreased substantively as spacing was increased to 300 ft and, particularly, 600 ft. With spacing beyond 600 ft., crash rates continued to decrease, though these improvements were less pronounced than at the lower range of values. These findings were generally consistent on multilane and two-lane highways.

Keywords: access management, access spacing, random effect negative binomial, access point, driveway

Poster Number: MR-34
Authors: Fatemeh Fakhrmoosavi; Ali Zockaie
Title: Exploring an Equitable Congestion Pricing Scheme Considering Travel Time Reliability for Multi-Class Users

Abstract: Congestion pricing is proposed as an effective control strategy to circumvent the congestion problem and generate revenue for transportation agencies to finance developmental projects or subsidize the public transportation. There are several studies in the literature that focus on finding optimal pricing strategies to minimize the congestion level or maximize the revenue of the system. However, due to equity issues, benefiting users only with high values of time is claimed to be one of the key preventing factors in implementation of such pricing policies. While many studies aimed to tackle the equity issues of toll pricing by certain welfare analysis, they failed to fully consider realistic features of user behavior. Given the variability of travel time in real-world networks and the impacts of pricing policies on travel time distribution, it is significantly important to take into account the users reliability valuations in addition to value of time to develop an effective pricing scheme. In this study, the existence conditions of a self-funded and Pareto-improving (SFPI) pricing scheme are presented considering travel time stochasticity and travelers responses to travel time reliability. This study captures travelers' behavior towards congestion pricing strategies more realistically by considering travel time reliability. The numerical results section demonstrates the satisfactory application of the mentioned conditions for two hypothetical single-OD networks and a general realistic network. Furthermore, the results show that neglecting travel time reliability can mislead the equity analysis in evaluating congestion pricing schemes.

Keywords: congestion pricing, equity, reliability, travel time variability

Poster Number: MR-35
Authors: Fatemeh Fakhrmoosavi; Mohammad Kavianipour; Peter Savolainen
Title: Investigating Driver- and Site-Specific Factors Associated with Cell Phone Usage Rate by Drivers

Abstract: Distracted driving is one of the most significant causes of traffic crashes. Cell phone use is perhaps the most prevalent type of technology-based distraction that diverts the attention of drivers from the road and deteriorates their performance. The risk perception of each individual driver towards risky actions, such as cell phone use, varies depending on the driver's demographic characteristics, vehicle type, and driving conditions. Therefore, it is imperative to better understand the contextual factors associated with cell phone use. There are several studies in the literature investigating the prevalence of phone use among different groups of drivers. Many of these studies used data from interviews with small samples of drivers. In addition, there are a few studies that examined the disaggregate-level trend of phone use while driving among individual drivers. In this study, we aimed to investigate the prevalence of cell phone use through a representative statewide direct observation survey. The data from approximately 200 roadway locations across the state of Michigan was used to examine cell phone use rates between 2014 and 2017. A logistic regression model is estimated to identify those factors associated with cell phone use, including demographics of drivers, presence of any passenger(s), vehicle types, location and time of observation, hourly volume, weather conditions, number of lanes, and seatbelt use. The results show that many of these variables are contributory factors in cell phone use. Understanding these factors can help policy-makers better plan for the future implementation of policies and programs to reduce the risks of crashes involving cell phone use.

Keywords: cell phone use, driver characteristics, driving conditions, logistic regression model

Poster Number: MR-36

Authors: Fatemeh Fakhrmoosavi; Mohammadreza Kavianipour; MohammadHossein(Sam) Shojaei; Mehrnaz Ghamami; Ali Zockaie

Title: Electric Vehicle Charger Placement Optimization in Michigan Considering Seasonal Traffic Demand Variations and Battery Performance

Abstract: Transportation systems are vital in every country as they enable mobility, and are essential to improving economy. In the United States, transportation mostly hinges on gasoline and diesel fuels which contributes significantly to energy insecurity and environmental issues. Plug-in Electric Vehicles (PEVs) are among the most suggested solutions to reduce the negative consequences of oil dependency. In order to attract diverse users to PEVs, further advancements are needed in charging infrastructure of these vehicles. Several studies are conducted to estimate the recharging needs of the anticipated PEV markets in residential communities and the highway and interstate corridors. In addition to the estimated recharging needs, interstate corridors should be prioritized and stations should be located according to driving patterns, vehicle specifications, and expected charging behaviors. Seasonal travel pattern variations and battery degradation in cold weather are other contributory factors in the location and number of charging stations and outlets in the Midwest states such as Michigan. Aware of this, the current study focuses on Michigan and its future needs regarding promotion of battery electric vehicles (BEVs), as a specific type of PEVs which solely rely on electricity for operation. This study sets out to develop a modelling framework, comparing anticipated demand scenarios in two target years of 2020 and 2030, in such a way that BEV users travel needs for completing their inter-city trips are satisfied. Also, seasonal travel demand variations across different months, as well as tourism demand are accounted for in this study to capture multi-view perspectives and better equip Michigan as part of the desired more electrified United States.
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Keywords: battery electric vehicle, intercity travel, demand variation

Poster Number: MR-37

Authors: Hadis Nouri; Mohsen Zayernouri; Timothy Gates

Title: One and Two-Dimensional Stochastic Macroscopic Model of Traffic Flow on Highways

Abstract: This research sought to develop an efficient computational framework for stochastic macroscopic modeling of traffic flow on highways. To this end, a stochastic advection equation was employed to model the transport of a single car and later a collection of cars in highways in one- and two-dimensional domains. To discretize the stochastic space, Monte-Carlo simulation was employed. To discretize the governing equations in space and time, a variety of numerical schemes were utilized, including: Lax-Friedrichs, upwind, Lax-Wendroff, and Godunov methods. The uncertainty quantification (UQ) of our model predictions was performed where sources of uncertainty included the initial configuration of traffic and uncertain measurements of car speeds. Moreover, two models describing the interaction between two cars are introduced, namely rigid-absorbing and viscoelastic models, which both ensures collision avoidance. This study will potentially lead to a suitable data-driven simulation and modeling of connected-vehicles in order to perform local real-time traffic data assessments in each car to reduce the risk of collision, monitoring, modeling, and better understanding of driving behavior. The results will also inform future highway design characteristics.

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Keywords: advection-equation, stochastic simulation, uncertainty quantification, data-driven modeling, connected-vehicles

Poster Number: MR-38
Authors: Ramin Saedi; Ali Zockaie
Title: Investigating Weather Impacts on Network-wide Traffic Flow Relationships

Abstract: Traffic state at network level can be described by network-wide traffic flow relationships such as network fundamental diagram (NFD), network travel time reliability (TTR) relation, total experienced delay, and characteristics of the hysteresis formed due to the network gridlock. The evaluation of in-field deployment and experimental analyses indicate that macroscopic traffic flow relationships are affected by changes in network supplies, such as climate change, signal coordination, number of accidents, and changes in the specifications of roadways and intersections. This study aims to explore the influence of weather changes on network-wide fundamental diagram and travel time reliability relation through a stochasticity analysis. To this end, 86 days' actual traffic data of Chicago downtown transportation network are employed to discover different relationships between traffic flow macroscopic exponents and weather descriptors like visibility and precipitation. DYNASMART-P traffic assignment tool is utilized to simulate the traffic flow in the network using the actual traffic data inputs. Results revealed the existence of robust correlations between the weather indexes and traffic state describing factors such as coefficient of reliability relation, heterogeneity of density distribution throughout the network, maximum of experienced network-wide average flow and density and the area restricted by hysteresis loop in both NFD and TTR diagrams. Findings of this research implies the necessity of incorporating a weather factor in network control strategies, demand management and traffic estimation and prediction systems.

Keywords: weather change, traffic flow theory, network fundamental diagram, travel time reliability, traffic hysteresis

Poster Number: MR-39
Authors: Ramin Saedi; Rajat Verma; Ali Zockaie; Timothy J. Gates; Peter T. Savolainen
Title: Evaluation of A Collision Avoidance and Mitigation System on Snowplows

Abstract: Winter maintenance is one of the key operations performed by transportation agencies in states experiencing adverse weather conditions. Due to low visibility during these kind of operations and lower speed of winter maintenance trucks relative to general traffic, safety is one of the main challenges. Recently, a collision avoidance and mitigation system (CAMS) is proposed to be used on snowplows with the objective of improving safety of motorists approaching them. The system includes a rear-facing radar sensor, a camera, a self-cleaning system, and a set of beacons. The system detects the relative headway of approaching vehicles towards the truck and activates a warning light if the headway is below a certain threshold. Michigan department of transportation (MDOT) defined a project to assess the effectiveness and performance of such systems. In this study, the system performance is evaluated, and its economic viability is estimated. The performance of the radar and cleaning systems are analyzed using datasets collected during actual maintenance operations. It is shown that the radar and washing systems need significant improvement and that their performances are integrally tied to each other. A benefit analysis is also carried out to test the potential of this technology for a statewide implementation. Michigan's crash database is used to identify and investigate crashes involving snowplows. Crashes preventable with a fully functional CAMS are used to estimate the potential benefits of the system. This study identifies a great potential of CAMS in improving the safety of winter maintenance operations. However, there are certain shortcomings associate with this analysis and performance of the proposed CAMS that need to be addressed to ensure achievement of its full potential.

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Keywords: winter maintenance, collision avoidance system, snowplow, intelligent transportation systems, performance analysis,

Poster Number: MR-40
Authors: Sam Shojaei; Mehrnaz Ghamami; Meead Saberi
Title: Investigating Commuting-Oriented Outlooks on a Multimodal Transportation System with Shared Conventional and Electric Bicycles

Abstract: The concept of bike-sharing systems is thriving globally. On the other hand, inclusion of electric bicycles in bike-sharing systems (known as E-bike-sharing systems) is also an emerging trend which is anticipated to attract more potential users. Despite the conceptual foundations, there is a major gap in the literature regarding E-bike-sharing systems. In this study, we aim to bridge this gap by investigating the perspectives of the target population of a planned mixed fleet bike-sharing system including both conventional and electric bicycles. An online survey was formed and distributed to a sample of Michigan State University faculty, students and staff to collect their current travel patterns, demographics and outlooks on the intended mixed fleet bike-sharing system. Consequently, discrete choice models were investigated which entail both classic factors of travel time and travel cost and contributory determinants such as emission cost and health benefit values of the proposed modes. Different models are explored in terms of generic or alternative-specific effects of variables. In the best fitting model, as expected, increase in travel time and travel cost of a contemplated mode are shown to decrease its utility. Increase in a mode's health benefit value and/or decrease in the influence of distance would elevate the related mode's utility. It is also found that increase in emission cost and/or the influence of distance would lead to increase in the utility of the associated mode. In terms of topographical influences, walking, shared/private regular bike are shown to become less utilitarian than private automobile under hilly circumstances.

Keywords: bike-sharing, E-bike-sharing, discrete choice modeling

Poster Number: MR-41
Authors: Sam Shojaei; Megat Johari; Peter Savolainen; Mehrnaz Ghamami
Title: Capturing User Preferences towards a Mixed Fleet Bike-sharing System under Varied Weather and Air Pollution Conditions: A Case Study of Michigan State University

Abstract: Bike-sharing systems are gaining increasing global recognition due to numerous benefits including flexible mobility, reduced fuel use and emission, and increased physical activity levels. Electric (E-) bikes are another emerging technology with benefits over regular bikes such as increased comfort, especially over hilly terrain, and ability to traverse longer distances. Aware of limited studies on electric bike-sharing (e-bike-sharing) systems and forward-looking studies on intended bike-sharing systems, our study contributes to the literature by realizing users' preferences towards an intended mixed fleet bike-sharing system. An online survey was organized and distributed among a random sample of commuters to Michigan State University (MSU) campus. Considering demographics and current travel patterns, users' mode choice in a multi-modal system including the mixed fleet bike-sharing system is investigated under different weather conditions and air pollution scenarios. Multinomial Logit (MNL) is used for this purpose. Results suggest that favorable weather conditions foster uptake of unsheltered modes compared to private automobile. Proximity to campus is found to increase the utility of less costly modes including walking, private regular bike, bike-sharing and bus. Mostly flat terrain is determined to make all modes more utilitarian than Private automobile. Students are found to be inclined towards other modes than private automobile, except private shared bike. Individuals with annual income below $20,000 mostly gravitate to modes other than private automobile. High pollution levels lead users towards sheltered modes. Also, less air pollution as well as proximity to campus increase utility of all modes compared to private automobile.

Keywords: mixed fleet Bike sharing, users preference, multinomial logit, utility

Poster Number: MR-42
Authors: Harprinderjot Singh; Mehrnaz Ghamami
Title: Challenges of Electric Autonomous Vehicles in a Shared Mobility System

Abstract: The growing adoption of electric vehicles (EVs) has significant impact on energy usage, emission production and operation cost. However, the limited range of current EVs and low density of charging stations hinders the growth of EVs. The autonomous driving technology has the potential to partially overcome these limitations by efficiently planning and relocating on its own, to the nearest charging stations. The autonomous technology synergizes EVs by further reducing emissions and operation cost due to efficient driving behavior. The autonomous electric vehicle (AEVs) will also improve safety and mobility of users. However, the additive cost of automated technology and battery, to the purchase price of the vehicles will affect the growth of AEVs. The above challenges of privately owned AEVs can be tackled by the emerging shared mobility systems. It is worth noting that the limited range of current EVs not only makes them unsuitable for long distance trips, but also makes the ride sharing services using these vehicles challenging, due to the additional vehicle miles traveled. Another important factor in adoption of these vehicles is their performance reliability under adverse weather conditions. However, technology advancements increasing charging stations through put, as well as improving driving range, by increasing battery size and efficiency are known to be the solution to market acceptance of EVs. This study aims to investigate the optimum fleet for future driving, under different technology and demand scenarios.

Keywords: transportation autonomous electric vehicles

Poster Number: MR-43
Authors: Harprinderjot Singh; Mehrnaz Ghamami; Hadis Nouri; Timothy Gates
Title: Estimating the Overall Impact of Autonomous and Shared Autonomous Vehicles on Transportation Systems

Abstract: Autonomous Vehicles (AV) are known to improve safety, roadway capacity and mobility in the transportation system. The adoption of autonomous and shared autonomous vehicles (SAV) increases drivers' travel time productivity and as a result reduces the Value of Travel Time (VOTT). The efficient-driving behavior of AVs may reduce emissions production. The shared mobility system can also reduce cold-start emissions. However, the adoption of these vehicles will increase vehicle miles traveled (VMT) and trip generation rates, which might increase travel time and emission production in the system. The higher purchase price of AVs, than that of Conventional Vehicles (CVs), may also affect the adoption of these vehicles. This study captures the trade-off between the above factors to estimate the overall impact of AVs/SAVs on the transportation system, considering users and investors costs. The results of this study revealed that the adoption of SAVs can be the optimal solution if, the VOTT is reduced (at least 30%), or replacement rate is low, or the purchase price of SAVs is below certain threshold. The adoption of AVs can be the optimal solution only if, there is significant reduction in VOTT , the SAVs' replacement rate is significantly high, and in most cases only the users with high VOTT would adopt AVs ($20/hr-$50/hr).

Keywords: autonomous vehicles, value of travel time, ownership, emissions

Poster Number: MR-44
Authors: Steven Stapleton; Anthony Ingle; Timothy Gates
Title: Characteristics Contributing to Vehicle-Deer Crashes on Rural Two-Lane Roadways in Michigan

Abstract: Deer-vehicle crashes (DVCs) continue to be a problem in the United States, with 1.2 million such crashes occurring annually. DVCs are particularly an issue on two-lane rural highways in Michigan, accounting for more than 60 percent of all crashes. Such a high proportion of DVCs limits the transferability of existing safety models, including those found in the HSM, that are often based on data from states with considerably lower proportions of deer crashes. To counter this, a cross-sectional analysis of deer crashes was performed using data from the state of Michigan. Four categories of rural, two-lane two-way highway segments were analyzed separately, including: state-maintained, county federal aid paved, county non-federal aid paved, and county unpaved (i.e., gravel) surfaces. Negative binomial regression models with spatial and temporal random effects were generated. The results showed that speed-related factors, including lane width and horizontal curvature, had a significant effect on vehicle deer crashes occurring on rural two-lane two-way roadway segments in Michigan. Wider lanes were associated with a greater occurrence of deer crashes, perhaps due to higher prevailing travel speeds. Conversely, the presence of curves with design speeds lower than the statutory speed limit was associated with fewer deer crashes, perhaps due to lower travel speeds on curved segments. Wider shoulders, which afford greater separation between the travel lanes and the roadside, were found to significantly reduce deer crash occurrence. Unfortunately, the concentration of hunting licenses, a potentially useful predictor for deer crashes, did not appear to have a consistent influence on DVCs.

This work was supported in part by Michigan Department of Transportation

Keywords: deer-vehicle crashes; rural; safety; safety performance functions; deer; county roads

Poster Number: MR-45
Authors: Rajat Verma; Ramin Saedi; Ali Zockaie; Timothy J. Gates
Title: Behavioral Analysis of Drivers Following Snowplows Enabled with Collision Avoidance System

Abstract: In this study, a new prototype radar-based rear-end collision avoidance and mitigation system (CAMS) was tested to assess its impact on the behavior of drivers following behind snow plow trucks. The CAMS system is designed to flash an auxiliary rear-facing warning light upon detection of a vehicle encroaching within an unsafe time gap of the rear of the plow truck. A field experiment was conducted to test driver behavior in response to CAMS warning light and two groups of behavioral measures were computed: (a) likelihood of driver encroachment beyond a safe gap threshold, and (b) the reaction and response times, defined here as the time taken by drivers to reach maximum deceleration and minimum time gap, respectively, after the warning light had been activated. Classification and regression tree models were created for identifying the relevant factors influential in determining the change in driver response. The results indicate that the CAMS warning light was effective in reducing the likelihood of the subject drivers encroaching within a gap of 4.5 seconds of the rear of the plow truck. It was also effective in reducing the reaction and response times of the drivers by 0.83 and 0.55 seconds (36% and 20% reduction) respectively. Further field testing is recommended before conclusions regarding the potential traffic safety impacts of the system are drawn.

This work was supported in part by Michigan Department of Transportation

Keywords: winter maintenance, intelligent transportation systems, collision avoidance, driver behavior

Poster Number: MR-46
Authors: Rajat Verma; Md Shakir Mahmud; Timothy J. Gates
Title: Evaluation of Large-Scale Speed Limit Increase on Traffic Operation and Safety on Freeways and Two-Lane Highways

Abstract: In 2017, the state of Michigan raised the speed limit of 614 miles of limited-access highways (freeways) from 70 mph to 75 mph and of 943 miles of state-operated two-lane highways from 55 mph to 65 mph. This study seeks to understand the short-term impacts of this change on measures of traffic speed, speed limit compliance, and associated safety measures at an aggregate level. To this end, traffic operation and crash data from the repositories of Michigan department of transportation were analyzed. The results show a mean increase of 2.56 mph in the 85th percentile speed on freeways where the speed limit increased by 5 mph and 2.50 mph on two-lane highways where it increased by10 mph. A statistically significant increase in speed variance was also found in both the road types. Speed limit violation rate was found to have decreased by 13.5 and 51.5 percent on freeways and two-lane highways respectively. A similar pattern of reduction in speed limit violation rate was observed at thresholds of 5 and 10 mph greater than the speed limit. With these key findings in the short-term, this study shows positive impacts of the increase in the speed limit in terms of traffic operation. It was also observed that the speed limit change led to a statistically significant increase in the overall crash frequency on freeways. However, more investigation is required to understand the safety impacts of the speed limit change in detail.

This work was supported in part by Michigan Department of Transportation

Keywords: speed limit, traffic speed, speed limit violation, traffic safety