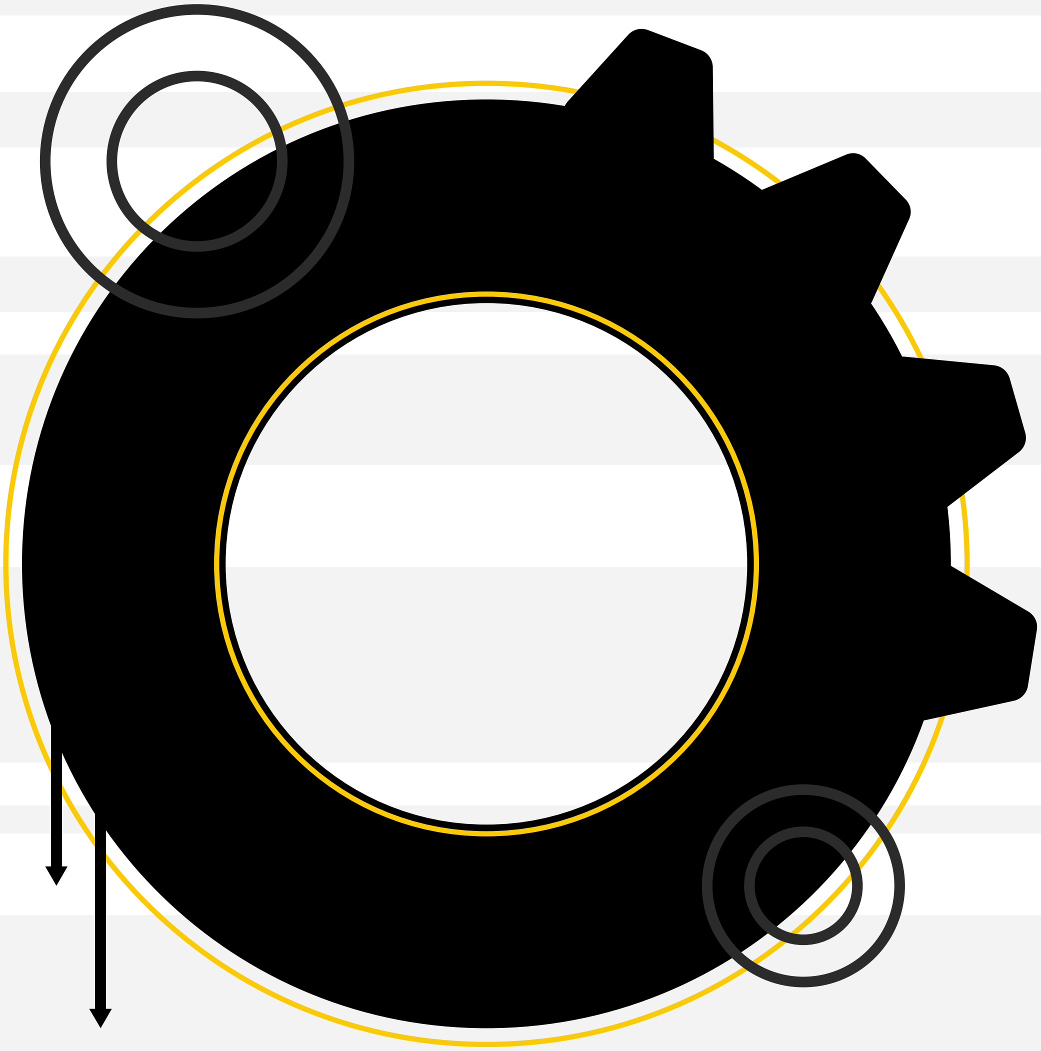

The University of Iowa
College of Engineering

RESEARCH OPEN HOUSE

April 11, 2019

The University of Iowa | College of Engineering

The 17th Annual College of Engineering Research Open House

Thursday, April 11th
Seamans Center for the Engineering Arts & Sciences
9:00 A.M. – 4:00 P.M.

The Research Open House will showcase, celebrate, and promote the research activities and accomplishments of the College of Engineering's faculty, staff, and students.

The event will also provide opportunities for graduate and undergraduate recruitment, develop new industrial contacts, and better inform the university and the local community about the research mission and capabilities of the College.

The 16th Annual Student Luncheon & Recognition Ceremony

Friday, April 12th
Hotel Vetro, Downtown Iowa City
11:30 A.M. – 1:30 P.M.

Honoring those students who participate in research, the Student Luncheon & Recognition Ceremony is open to all undergraduate and graduate students as well as the faculty and staff who have supported them.

Recognition will be accorded to students who have received awards during the past year (March 2018 – February 2019) and students who will graduate in the spring. As well, winners of the "Best Poster" and "Popular Choice" Awards from the poster competition held during the Research Open House will be recognized.

Research Open House Schedule of Events

Tuesday, March 12, 2019 (Preliminary Event)

2:00 pm – 2:30 pm "Effective Poster Design" Workshop — Eng Library Creative Space, 2001 SC

Presented by Scott Coffel, Director, Hanson Center for Technical Communication. Planning session for student poster creators and presenters to envision and develop research posters from concept to final layout. Session held in the Engineering Library Creative Space (2001C SC)

Thursday, April 11, 2019

9:00 am – 4:00 pm Research Open House: Student Poster Session — 2nd Floor Lobby, SC

Biomedical Engineering
Chemical & Biochemical Engineering
Civil & Environmental Engineering
Electrical & Computer Engineering
Industrial & Systems Engineering
Mechanical Engineering
Center for Bioinformatics & Computational Biology
Center for Computer-Aided Design
Center for Global & Regional Environmental Research
IIHR – Hydroscience & Engineering
Iowa Institute for Biomedical Imaging
Special Programs & Studies

10:00 am – 11:00 am "How to Navigate the IRB" — 3111 SC

This presentation is an introduction to the IRB at UI, and includes a discussion of research ethics, the IRB approval process, and forms to submit in the electronic submission platform.

11:30 am – 12:30 pm "Going to Graduate School Workshop" — 3111 SC

Presented by Allan Guymon, DEO Chemical & Biochemical Engineering. This work- shop is targeted to undergraduate students who are considering graduate school.

- The application process for graduate school
- Information about how to get financial support through fellowships & stipends
- Information on BS/MS programs
- Future job opportunities

There will be a significant amount of time devoted to questions. Undergraduate students from all disciplines are invited to attend. Refreshments provided.

Research Open House Schedule of Events

College of Engineering Research Week
Schedule of Events (Con.)

Thursday, April 11, 2019

3:00 pm – 6:00 pm — **UI Research Services Fair** — Mediacom Outdoor Room, Kinnick Press Box

Sponsored by Research Development Office (RDO), a unit of the Office of the Vice President for Research (OVPR)

Attendance is free, but registration is required: https://research.uiowa.edu/ui-research-services-fair

5:00 pm – 6:00 pm — **Scholz Symposium: "Introduction to Machine Learning"** — W10 PBB

Panel session - two panelists will each give a presentation followed by a moderated discussion and questions from the audience. The panelists are Asst Prof Stephen Baek, Industrial & Systems Engineering Dept and Professor Nick Street from the Tippie College of Business' Management Sciences Dept

Friday, April 12, 2019

11:30 am – 1:30 pm — **Student Luncheon &Recognition Ceremony** — Hotel Vetro, Iowa City

See next page for complete schedule.

Student Luncheon & Recognition Ceremony Program Schedule

11:30 am **Check-in & Registration**

For graduate and undergraduate students: If you presented a poster during the Research Open House, please make sure you receive a ticket for the prizes!

11:30 am – 12:30 pm **Lunch**

12:30 pm – 1:30 pm **Recognition Ceremony**

We will recognize students in advanced engineering degree programs. Please join Milan Sonka, Associate Dean for Graduate Programs, Research, and Faculty at the front of the room to have a photo taken in each of the groupings listed below.

- PhD Graduates
- Master of Science Graduates

Other Student Awards

Departments, centers, and programs will have the opportunity to recognize outstanding students and researchers by presenting annual awards.

Best Poster Awards & Popular Choice Awards

Winners from the Research Open House poster competition will be announced and recognized by Milan Sonka, Associate Dean for Graduate Programs, Research, and Faculty.

Drawing for Prizes

All students who presented posters at the Research Open House will be eligible to participate in a drawing for prizes. Tickets will be handed out at the door.

Individuals with disabilities are encouraged to attend all University of Iowa-sponsored events. If you are a person with a disability who requires a reasonable accommodation in order to participate in this program, please contact
Kristina Venzke, 319-335-5614

POSTER ABSTRACTS

The University of Iowa College of Engineering

Table of Contents

Poster Abstracts

Biomedical Engineering

“3D Aggregation of Human MSCs Alters their Immunomodulatory Potency”
Anthony Burand, Lin Di, Lauren Boland, Devlin Boyt, Michael Schrodt, and James Ankrum

Mesenchymal stromal cells (MSCs) have been studied for modulation of inflammatory disease. MSCs aggregate upon local injection in the body, however, most work exploring their immunomodulatory capacities has been done with cells in monolayers. In vitro, we have shown changes in gene expression and secreted factors in MSC aggregates, termed spheroids. We have seen that spheroids can suppress expression of inflammatory genes in macrophages, but, lack suppression of PBMCs. Alone, spheroids support PBMC proliferation, but in combination with a steroid, they exert a suppressive effect. This study provides therapeutic targets which can enhance the efficacy of MSCs in local injections.

“3D joint space width measures from weight bearing CT detect early joint changes”
Michael Ho, Kevin Dibbern, Michael Willey, J. Lawrence Marsh, Donald D. Anderson

The monitoring of early degenerative joint changes after intra-articular fracture treatment is challenging in a clinical setting. The use of 3D weight bearing CT scans has become readily available to measure joint space width (JSW). Clinically, JSW is measured in a single plane from 3D data, failing to use a majority of the feature-rich data available in these scans. Results showed the minimum 3D JSW was significantly smaller on injured ankles opposed to uninjured ones. This indicates weight-bearing CT scans enable 3D JSW analysis that can detect early changes associated with post traumatic osteoarthritis as soon as 6 months after treatment.

“3D-Printed Bio-Scaffolds for Bone Regeneration”
Matthew T. Remy, Adil Akkouch, Li He, Mason Sweat, Fang Qian, Xuan Song, Brad A. Amendt, Liu Hong

Critical-sized bone defects are challenging to treat using current tissue grafting methods; however, 3D printing allows for the design of synthetic grafts, which can be incorporated with biomolecules, such as microRNAs (miRs), to facilitate bone regeneration. This study aims to use 3D-printed scaffolds to promote bone regeneration using a hybrid materials-based approach where Î²-TCP scaffolds are incorporated with both collagen and miR-200c to enhance bone cell development and new bone tissue formation in critical-sized defects. The combined use of both collagen and miR-200c in the scaffolds significantly enhanced osteogenesis and bone tissue formation both in vitro and in vivo.

“

“Apoptotic Mesenchymal Stem Cells Polarize Macrophage Subsets to an Immunosuppressive State”
Lauren Boland, Michael Schrodt, James Ankrum

Mesenchymal stem cells (MSC) exhibit potent immunosuppressive responses after IV infusion, but only exist transiently. Recent research suggests MSC undergo apoptosis (apoMSC) and disposal by phagocytic cells within 24hr after infusion; therefore, we explored their therapeutic potential in death. Utilizing surface marker, gene expression, and cytokine profile analysis before and after incubating M0, M1, or M2c macrophages with apoMSC, we determined factors associated with macrophage immunosuppressive polarization upon phagocytosis of apoptotic debris. Functional suppression assays showed all macrophage subsets have immunosuppressive capabilities with M1 macrophages being the most immunosuppressive. These results provide insight into a novel therapeutic opportunity involving apoMSCs.

Comparing Actimetry Methods of Quantifying Physical Activity in ActiGraph”
Marissa Mueller, Ruth Chimenti (PT, PhD) Laura Frey-Law (PT, PhD)

Researchers use clinical-grade accelerometers and software platforms, such as ActiGraph, to objectively measure physical activity (PA). However, the specific impact of data-filters and equations within ActiGraph on PA metrics are not well understood. The purpose of this secondary analysis was to quantify this effect. GT3X-accelerometer data from 134 participants was analyzed using exhaustive combinations of 10 algorithms, the low-frequency-extension and wrist-hip correction. Measures of energy expenditure (kCal/METs), moderate-to-vigorous-physical-activity, and steps varied â‰¤83%, â‰¤100%, and â‰¤40% respectively, demonstrating that analysis specifications are not interchangeable. Standardization protocol (currently nonexistent) should be implemented to enforce detailed actimetry method documentation for accurate data interpretation.

“Design and Testing of a CRISPR-Cas9 Construct to Tag Endogenous CLN3”
Rion Wendland, Laura Bohrer, Kristan Worthington, Luke Wiley

Batten Disease is a neurodegenerative disorder caused by mutations in the gene CLN3, and concomitant changes in its corresponding protein. We designed a genome-editing approach to tag the CLN3 protein in order to study its function within cells. As a first step towards this goal, we created and evaluated the efficiency of CRISPR-Cas9 guide sequences and identified the most promising guide sequence. This information is critical for our approach to understanding Batten Disease and developing strategies for its treatment.

“Electrochemical Approach to Cardiac Output Monitoring”
Srivats Sarathy, Abdulsattar Al Saedi, Syed Mubeen, M.L. Suresh Raghavan

The blood flow rate in the heart, also known as cardiac output is a very important measurement/marker that corresponds to cardiac and cardiopulmonary function. It is a measure doctors rely on frequently after surgical procedures to determine the recovery of the heart. There are multiple ways to measure cardiac output, but all have substantial limitations in terms of accuracy, reproducibility and practicality. In this project, we aim to use the indicator-dilution principle with the physics of electrochemistry. The current /charge redistribution that would occur when a specific redox active liquid is injected into the blood stream can be measured by an electrochemical cell. This current will measurably dilute as the injectate dilutes in the blood stream since the current change is directly related to the concentration of the injectate. We propose the electrochemical response of a tracer molecule injected into a flowing physiological fluid, specifically its electrodilution time, will be a function of the flow rate of that physiological fluid. The goal is to have a pulmonary artery catheter that can be taken to the right ventricle of the heart, wherein the redox active species can be injected by an orifice along the length of the catheter and its "electrodilution current" be measured by the catheter tip.

“Fabrication Techniques of Chitosan Hydrogels for Retinal Tissue Engineering”
Jacob Thompson, Abigail Krueger, Brittany Allen, Arwin Shrestha, Luke Wiley, Kristan Worthington

Loss of photoreceptor cells (rods and cones) causes irreversible blindness known broadly as retinal degeneration. Cell replacement therapy is a promising treatment, but degradable scaffolds, preferably with low stiffness, are critical for successful transplantation. Biomolecule-based scaffolds for this purpose can be created using two fabrication techniques. Scaffold stiffness is readily tuned using dose-dependent exposure in a simple photopolymerization technique, while scaffold microstructure is precisely controlled using two-photon polymerization. Preliminary investigation of cell-material interactions indicate that these materials are favorable for retinal tissue engineering. Overall, these results contribute to the development of effective treatment strategies for retinal degeneration.

“Generation and Immortalization of Retinal Progenitor Cells”

Brittany Allen, Matthew Miller, Joseph Giacalone, Luke Wiley, Budd Tucker, Kristan Worthington

Cell replacement therapy is a promising option for treating retinal degeneration, in which photoreceptor cells (rods and cones) are lost. However, studying photoreceptors in the laboratory or generating a sufficient quantity for transplantation is challenging; differentiation requires months of careful care and the use of expensive growth factors. In this work, photoreceptor cell-like populations are being created using immortalization of human retinal progenitor cells (RPCs) for studying cell behavior in the laboratory. Meanwhile, we are working to accelerate the process of RPC generation by finding the optimum substrate stiffness and topography to induce stem cell differentiation into RPCs.

“How You Slice It Matters: Calibrating Lung Cancer Risk Models for Better Decision Making After Pulmonary Nodule Detection”

Johanna Uthoff, Rolando Sanchez, Richard M. Hoffman, Jessica Sieren

Post-imaging mathematical prediction models (MPMs) can guide clinicians in managing pulmonary nodules by providing a lung cancer risk score. We created a web-based application enabling users to calibrate thresholds and to determine the resulting diagnostic performance of the MPMs in their own site-specific specific cohort. Four post-imaging MPMs were compared using both the original MPM- threshold versus calibrated thresholds using 100 subjects for calibration and 217 subjects for MPM validation. Applying the uncalibrated recommended threshold for biopsy of 0.03 risk on the validation cohort achieved 100% sensitivity but only 2% specificity; comparatively, using the calibrated thresholds yielded: 76%-sensitivity, 74%-specificity.

“Integration of Magnetic Tweezers and Deformation Tracking/Traction Force Microscopy for the Exploration of Keratinocyte Mechanobiology”

Waddah I. Moghram, Anton Kruger, Edward A. Sander, and John C. Selby

In this poster, we present the design, construction, calibration, and operation of a single-pole magnetic tweezers device integrated with substrate deformation tracking microscopy/cell traction force microscopy for investigating force transmission within multicellular human epidermal keratinocyte tissue constructs in vitro. This device is built on real time control of the magnetic flux density generated within a soft ferromagnetic microneedle using a cascade control scheme, PID gain scheduling, LabVIEW software, and off-the-shelf electronics hardware.

“Modeling Mucociliary Transport in Porcine Airways”

Carley G. Stewart, Brieanna M. Hilkin, Michael J. Welsh, Mahmoud H. Abou Alaiwa

Mucociliary transport (MCT) is an innate host defense mechanism of the airways. Failure of this defense is implicated in many airway diseases including cystic fibrosis. To date, it is not clear what variables determine MCT, and whether the shape of the airways has any effect. Here, we built a statistical shape model of the porcine airway. We correlated the features that support the shape to measures of MCT obtained in vivo. This model will allow us to determine the spatial distribution of MCT within the airways. It will also allow us to examine whether the shape of the airways alters MCT.

“Optimization of Fluid Shear Parameters for Emerging Cancer Diagnostic Technology”

Allison Rowe, Ben Krog, Sarah C. Vigmostad, Michael D. Henry

It is known that malignant cancer cells are more resistant to fluid shear stress than normal body cells; emerging technology utilizes this principle to enhance cancer surveillance and analysis. This project focuses on optimizing the parameters for this technology by methodically varying the fluid shear rate and number of pulses to which a given suspension of cancer cells is exposed. The results of this study have already been extended to analyze the abilities of the technology to enrich cell suspensions that contain a mixture of live and dead cells.

“Optimizing the Quantification of Mouse Brain Proteins Using the Western Blot Technique and Stain-Free Total-Protein Normalization”

Alexandra A. Haugen, Mason Robert Marshall, Hiroyuki Kawano and N. Charles Harata

The goal of this project is to optimize a protocol for the western blot technique which characterizes and quantifies specific proteins. Western blotting involves extracting proteins from homogenized samples, separating proteins through gel electrophoresis, gel-to-membrane transferring of proteins, and protein detection using an antibody-based imaging method. In standard protocols, the amount of a target protein is typically measured with respect to a single reference protein, but its expression can be affected under various conditions. We introduced normalization with respect to the total protein in a sample as visualized by Stain-Free method and optimized the protocol for analyzing mouse brain proteins.

“Two Photon Polymerization of Poly(caprolactone) Scaffolds for Retinal Tissue Engineering”

Arwin Shrestha, Jessica Thompson, Luke Wiley, Kristan Worthington, Budd Tucker

Retinal degeneration caused by loss of photoreceptor cells (rods and cones) leads to irreversible blindness. While cell replacement therapy is a promising option for treating this condition, successful transplantation requires a biodegradable scaffold. In this work, fabrication of micro-structured poly(caprolactone) scaffolds was achieved with the use of two-photon polymerization, a type of high-resolution 3D printing. The printing parameters, size and geometry of horizontal crosspores were optimized to promote cell-to-cell communication and nutrient flow. This refinement of the crosspore design lays the groundwork for using such scaffolds to accommodate photoreceptor cell interactions with each other and retinal tissue.

“Umbilical Cord Mesenchymal Stromal Cells Show Enhanced Resiliency to Palmitate Exposure Under Xenogeneic-free Culture Conditions”

Lauren K. Boland, Anthony J. Burand, Devlin Boyt, Hannah Dobroski, Lin Di, Jesse N. Liszewski, Michael V. Schrodt, Maria Frazer, Donna Santillan, James A. Ankrum

Questions in mesenchymal stromal cell (MSC) therapy have arisen in how variations in host environments, such as palmitate effect immunosuppression, could be addressed. Given the negative impact of palmitate we sought to determine if altering compositions between xeno-free and xeno-based media would aid the MSCs in resisting palmitate challenge. MSCs from 7 donors were isolated in both conditions; their kinetics, metabolism, apoptosis, and immunosuppression were compared. Overall, challenging with palmitate led to xeno-free MSCs showing a higher susceptibility to palmitate-induced metabolic disturbance, less susceptibility to palmitate-induced apoptosis, and resistance to palmitate-induced conversion to an immunostimulatory phenotype.

Chemical & Biochemical Engineering

"Directed network Structure Through Radical Controlled Photopolymerization"

Huayang Fang, Allan Guymon

Photo-polymerization techniques are increasingly being utilized in production methods, such as thin film coating, 3D printing, dental materials, where fast polymerizations and low volatility starting products are valued. However, currently, photopolymers do not exhibit both high toughness and high elasticity, limiting their industrial application. Reversible addition-fragmentation chain transfer agent (RAFT) and nitroxide mediated photopolymerization initiators (NMP2) are potential candidates to improve photopolymers toughness and elasticity. Using addition-deactivation chain transfer agents to control cross-link formation may allow more uniform networks to form.

"Evaluating WRF-Chem Model Simulated Cloud Properties over Lake Michigan"

Behrooz Roozitalab, Maryam Abdi-Oskouei, Megan Christiansen, Charles Stanier, Gregory Carmichael

Earth energy budget caused by incoming radiation flux is one of the main drivers of atmospheric phenomena. High cloud albedos lead to more extinction of incoming radiation flux making them a key factor in ozone formation. However, cloud simulation is a complicated atmospheric process. In this study, we use MODIS (Aqua and Terra) and GOES-16 satellites data to evaluate the ability of WRF-Chem in simulating cloud fields over Lake Michigan. The results show that WRF-Chem can correctly estimate the presence of clouds but generally misses the cloud type.

"Fabricating Conductive Polymer Systems with Graphene Oxide for Medical and Energy Applications"

Rachel Buck, C. Allan Guymon, Syed Mubeen

Graphene oxide (GO) is a carbon-based material that has excellent mechanical, thermal, and electrical properties. Over the course of this PhD project, GO's ability to enhance the properties of polymer systems and create an electrically conductive response will be investigated with the future goal of applying GO/polymer coatings to various devices to protect them and improve their capabilities, performance.

"Hierarchical Structures for Supercapacitor Application"

Abdulsattar H. Ghanim, Jonathan G. Koonce, Alan M. Rassoolkhani, Austin MaKee, Marisol Contreras, Wei Cheng and Syed Mubeen

One-dimensional array architecture such as nanotubes and nanowires has been widely used to enhance the energy storage devices. In this study we are fabricating 3-D structure (Hierarchical) MnO_2 nanowire with high surface area, low toxicity, high abundance, low cost, and environmental friendliness to increase the power density of supercapacitors. Al with less than 1 atom % Cu will be used to form a 3-D porous template during the anodization process. Presence of Cu impurities in an Al film introduces horizontal pores interconnecting the vertically aligned pore structure of the anodized aluminum oxide (AAO) template.

“Introduction to Plasmonically-Mediated Electrochemistry”

Austin McKee, Syed Mubeen

Plasmonically-mediated electrochemistry is electrochemistry that utilizes the illumination of a plasmonically-active surface material to enhance the surface catalysis of the material. The main applications for this process include enhanced conversion rates from reactants to products, higher selectivity of desired products, and enhanced electron energy for higher-order product synthesis at lower applied potentials. This educational poster will attempt to teach a complex topic to anyone, no matter their background, who shows a true interest in the process.

“Kinetically-Controlled Photo-Induced Phase Separation for Hybrid Radical/Cationic Systems”

Erion Hasa, Jon P. Scholte, Julie L. P. Jessop, Jeffrey W. Stansbury and C. Allan Guymon

Controlling phase separation in polymer systems has shown significant promise in combining properties of different components. We investigate the effect of photo-induced phase separation on polymer morphology and properties in radical/cationic systems compromised of butyl acrylate (BA) and di-functional oxetane (DOX). By increasing the irradiation intensity, the morphology changes from one with a continuous soft BA domain to one with co-continuous BA (soft) and DOX (hard) domains. At higher irradiation intensity, the domain size of each phase is decreased due to fast photopolymerization. The smaller domain size enhances the flexibility and strength of the phase-separated polymers. On the other hand, irradiation intensity has little to no effect on polymer structure or properties for systems that do not phase separate. Dynamic mechanical analysis demonstrates that higher irradiation intensity contributes to a 40-fold increase in toughness. This study demonstrates that the morphology and properties of polymers can be controlled by altering the initiation irradiation intensity.

“Mitigation of Bacterial Biofilms Using Combined Application of Antibiotics and Thermal Shock”

Haydar Aljaafari, Yuejia Gu, Hannah Chicchelly, Eric Nuxoll

When bacteria colonize a medical implant surface, they form biofilms that cannot be eradicated chemically. These infections are a $5 billion problem in the U.S. alone, affecting over 100,000 patients annually. By applying a localized thermal shock, we have shown these biofilms can be reduced and eliminated. In this research, we successfully minimized the thermal shock and its damage to the surrounding tissue. Biofilms were completely eradicated after exposed to a thermal shock at 70â°C for only one minute combined with ciprofloxacin (4ug/ml) for 48 hours. These results are crucial step toward developing alternative treatment to surgical explanation of infected implants.

“Photoelectochemical Systems for the Production of Value-Added Products

Alan Rassoolkhani, Wei Cheng, Jonathan Koonce, Abdulsattar H. Ghanim, Austin McKee, Joun Lee, and Syed Mubeen

Despite significant attention, water oxidation remains one of the largest bottlenecks for solar water splitting. This reaction produces oxygen gas which has minimal economic value while introducing kinetic losses to the system. While most research focuses on improving the kinetics, minimal efforts have been undertaken to utilize other oxidation chemistries. Here we report the photoelectrochemical production of chlorine gas, an oxidation product possessing superior kinetics and higher economic value. This process is carried out using both in house synthesized metal oxide light absorbers (bismuth vanadate) and commercially available triple junction silicon solar cells.

“Predicting Dose Rate Effects of EB-Initiated Polymers Using Monomer Chemistry”

Nicole Thiher, Sage Schissel, Julie Jessop

Electron beam (EB) polymerization is an environmentally friendly process used to make millions of tons of ink, thin film, coating, and adhesive products every year. Some EB formulations exhibit different polymer properties during pilot scale tests compared to industrial scale processes. These changes in polymer properties are called dose rate effects (DREs), and it is difficult to predict for which formulations they will occur. This research demonstrates DREs are impacted by monomer chemistry and chemical modeling software can be used to help predict if a formulation will experience DREs before any experiments take place.

“Thermal Shock Dynamics on Biofilm Viability”

Haydar Aljaafari, Parham Parnian, Eric Nuxoll

Approximately 4% of implanted medical devices in the U.S. become infected by antibiotic resistant bacterial biofilms which result in the need for implant removal and reimplantation. Not only do these treatments cost billions of dollars, but also increase the risk of re-infection by twofold. Previous studies proved that the biofilms can be eliminated via thermal shocks. The current study indicated that if the population density of Pseudomonas aeruginosa biofilms was thermally dropped by 104 CFU/cm2, the biofilms would not be viable anymore. Additionally, it was observed that inoculating the thermally shocked biofilms by fresh bacterial inoculum delays the biofilm formation.

“Three-Phase Electrochemistry on High-Entropy, Chemically-Treated Silver Surfaces”

Austin McKee, Avik Samanta, Syed Mubeen, Hongtao Ding

High-entropy, chemically-treated surfaces have the potential to revolutionize many different fields. One such field is electrochemical reactions that occur an interface such as three-phase electrochemistry. The two main reactions tested here are the Oxygen Reduction Reaction (ORR) [used in fuel cell technology] and the Carbon Dioxide Reduction Reactions (CO2RR) [inverse combustion reaction]. Being able to control and enhance either of these reactions could change energy utilization through adapting the Fuel Cell fields or changing how some products are synthesized. The results show varying degrees of enhancement or control with both the ORR and CO2RR and could lead to novel discoveries.

“Toxicity of Citrate-Stabilized Gold Nanoparticles on Lung Epithelial Cells”

Michael Leyden

Research is being conducted on the possible incorporation of gold nanoparticles in a dry powder inhaler drug delivery system. For this study, citrate-stabilized gold nanoparticles 100 nm in diameter were synthesized, and their interactions with proteins and cells lining the deep lung were quantitatively analyzed. The toxicity of protein coated and noncoated gold nanoparticles on A549 lung epithelial cells was evaluated using the Promega Cell Titer 96 Proliferation Assay. Coated nanoparticles tested were bovine serum albumin (BSA), lysozyme, lactoferrin and immunoglobulin G (IgG) due to their significant presence in the lungs.

Civil & Environmental Engineering

“An Economic Analysis of a Multijurisdictional Approach to Flood Prevention”
Max Brourman, Craig Just

Rural communities often struggle to secure federal funding for flood mitigation projects that do not meet minimum benefit-cost requirements. The benefit-cost ratio may be improved through a multijurisdictional approach that joins small cities and the surrounding county within a watershed boundary. But a multijurisdictional approach has not been pursued in Iowa since the additional planning and technical analysis required is often viewed as unachievable. Our research uses computer simulations to generate flood reduction scenarios to assess flood-control wetlands that provide flood loss avoidance for crops and small cities. Our results show that this multijurisdictional approach increases the benefit-cost ratio.

“Biodegradation of PCBs by Burkholderia xenovorans LB400”
Christian Bako, Jessica Ewald, Andres Martinez, Keri Hornbuckle, Jerald Schnoor

Polychlorinated biphenyls (PCBs) have been recorded in all realms of the Earth’s biosphere including air, water, and even within living organisms. Because of their toxic and recalcitrant nature, PCBs pose a direct threat to human and ecological systems. One approach to minimizing human exposure to PCBs is to remediate them in sediment using a process called bioremediation. Bioremediation utilizes the natural metabolism of microorganisms. To test the biodegradation capability of Burkholderia xenovorans LB400, cells were incubated with a commercial mixture of PCBs (Aroclor 1248) in aqueous solution for 1-week. To measure the rate and extent of PCB biodegradation, samples were collected from incubation vessels to detect all 209 PCB congeners using GC-MS/MS. Over the course of the incubation period, there was a significant decrease ($p < 0.05$) in total PCB concentration ($\sum$PCB) in vessels containing LB400, relative to dead-cell controls. A wide spectrum of PCB congeners was biodegraded, up to hexachlorobiphenyls. Concentrations of both higher and lower-chlorinated congeners decreased significantly ($p < 0.05$). These results suggest that bioaugmentation using Burkholderia xenovorans LB400 may serve as a method to bioremediate PCB contamination in the environment.

“Constructing and Evaluating a Semi-Autonomous Inline Chlorination System for Disinfection in Rural Resource-Constrained Communities”
Kalley Matzen, Ruijie Wang, Megan Lindmark, Craig Just

Chlorine-based, drinking water disinfection systems for rural communities in developing countries frequently break down and often do not create safe water. Fluctuating water inflows cause chlorine tablets to dissolve unpredictably and variable consumption rates impact the disinfection time in water storage tanks. Furthermore, technicians are unable to assess system performance remotely. To address these issues, we designed, built and tested a semi-autonomous, inline chlorination system that uses an oxidation-reduction potential sensor to control chlorine dose. Ultrasonic sensors measure the chlorine tablet stack height and tank water level. A microprocessor adjusts setpoints and alerts technicians when maintenance is required.

"Evidence of Construction and Environmental Sources in Air of Urban Homes Near PCB-contaminated Waterway Pre- and Post-Dredging"

Maeve Bittle, Rachel F. Marek, Peter S. Thorne, Keri C. Hornbuckle

This project will determine airborne concentrations of persistent, toxic polychlorinated biphenyls (PCBs) inside and outside homes in urban East Chicago, Indiana. These homes are located near a PCB-contaminated waterway currently being dredged. Other possible sources of PCBs include modern pigments in paint and historical Aroclor mixture sources. Air samples were previously collected by field staff using polyurethane foam passive air samplers (PUF-PAS) pre- and post- dredging. The hypotheses to be addressed are: 1. The effect of dredging can be detected at East Chicago homes using PUF-PAS. 2. PCB sources can be identified inside homes.

"Growth of Dehalococcoides spp. And Increased Abundance of Reductive Dehalogenase Genes in Anaerobic PCB-contaminated Sediment Microcosms"

Jessica Ewald, Shelby Humes, Andres Martinez, Jerald Schnoor, Timothy Mattes

Polychlorinated biphenyls (PCBs) represent a serious risk to human and environmental health. One promising strategy to remediate PCB contaminated sediments utilizes organohalide respiring bacteria that dechlorinate PCBs. However, functional genes that act as biomarkers for PCB dechlorination processes are poorly understood. We developed anaerobic sediment microcosms that harbor an OHRB community dominated by the genus Dehalococcoides. During incubation, Dehalococcoides 16S rRNA sequences increased two orders of magnitude, and at the same time PCB118 decreased by 70%. In addition, the OHRB community dechlorinated penta- and tetra-chlorinated congeners including PCBs 66, and PCB110. A survey for RDase genes revealed sequences similar to rd4, and rd8. Our results suggest candidate functional genes with previously unexplored potential could serve as biomarkers of PCB dechlorination processes.

"Investigating the Potential for Disinfection By-Product Formation in Drinking Water Systems Using a Unique Chlorine-Based Disinfection Agent, Trichloroisocyanuric Acid"

Megan Lindmark, Craig Just

Disinfection by-products (DBPs), formed when chlorine-based disinfectants react with natural organic matter in source water, pose a significant long-term public health threat. We hypothesize that trichloroisocyanuric acid (TCCA) will provide a more stable chlorine residual and decreased DBP formation compared to a free chlorine only disinfection approach. To compare DBP formation between TCCA and traditional calcium hypochlorite, we performed a series of experiments that encompassed a variety of water chemistries and temperatures. We analyzed water dosed with both forms of chlorine to quantify disinfection by-product formation. Results and ongoing work regarding DBP formation can have significant impact for drinking water systems in resource constrained communities globally.

"Maximum CO_2 Utilization by Nutritious Microalgae"

Hannah Molitor, Emily Moore, Jerald Schnoor

Microalgae are a promising alternative to soy for more rapidly and sustainably produced protein-rich animal feed. However, there are significant barriers to growing nutritious salable microalgae, recovering nutrients from wastewater, and fixing CO_2 from industrial emissions in full-scale operations. Currently, it is assumed that microalgae, including Scenedesmus obliquus, are inhibited by CO_2 levels characteristic of power plant emissions. Modeled experiments indicated that CO_2 levels comparable to power plant emissions do not inhibit S. obliquus growth, with careful pH control. The model indicated maximum biomass productivity of 640 Â± 100 mg/L/d at 4.5% CO_2, which exceeds previous measurements at inhibitory CO_2 concentrations. Protein and amino acid concentrations of S. obliquus and soy were comparable.

"PCB Emissions from Paint Colorants"

Jacob Jahnke, Keri Hornbuckle

Polychlorinated Biphenyls (PCBs), a known human carcinogen, are currently produced as byproducts of pigment manufacturing used in consumer paints. We hypothesize that use of paint is a major source of PCBs to air. We quantified the emissions of total PCBs from paint over time using a passive emissions sampler and used the data to predict the concentration in a room. Our results show that PCBs associated with pigments readily volatilize. A currently manufactured source of PCBs could be an important source of toxic air pollutants in residential and school environments that has only recently been recognized.

"Development of a Broadly Applicable Method for Identification and Analysis of Polychlorinated Biphenyl Sulfates in Human Serum"

Duo Zhang, Panithi Saktrakulkla, Kris Tuttle, Rachel Marek, Hans-Joachim Lehmler, Keri Hornbuckle, and Michael Duffel

Our project mainly focuses on developing a broadly applicable method for identification and analysis of polychlorinated biphenyl sulfates (PCB sulfates) in human serum. We proposed a method that employs acetonitrile extraction of the PCB sulfates from serum followed by differential analysis with, and without, hydrolysis to OH-PCBs catalyzed by a sulfatase from Helix pomatia. Our results on the specificity of a crude preparation of this enzyme for PCB sulfates indicate the feasibility of its use for their quantitative hydrolysis. We are now finalizing the method by performing l-tyrosine-ethyl-ester (TEE)-Sepharose affinity column to completely remove glucuronidase from crude Helix pomatia juice.

“A fully Automated Airway Tree Segmentation Algorithm Using Deep Learning and Iterative Topological Leakage Correction Approaches”

Syed Ahmed Nadeem, Eric A. Hoffman, Punam K. Saha

Automated segmentation of human airway trees is essential for COPD research. Segmentation failure due to missing branches and/or leakages, warrants manual revision for all cases which is a bottleneck in large multi-site studies. We present an airway segmentation algorithm which combines deep learning and conventional image processing methods to automatically segment airway trees from CT images at TLC. The algorithm has been evaluated on chest CT images from a COPD study and the results are compared with an industry standard semi-automated software.

“A New Algorithm for Local Blur-Scale Computation and Edge Detection”

Indranil Guha and Punam K Saha

Precise and efficient object boundary detection is the key for successful accomplishment of many imaging applications involving object segmentation or recognition. Blur-scale at a given image location represents the transition-width of the local object interface. Hence, the knowledge of blur-scale is crucial for accurate edge detection and object segmentation. In this paper, we present new theory and algorithms for computing local blur-scales and apply it for scale-based gradient computation and edge detection. The new blur-scale computation method is based on our observation that gradients inside a blur-scale region follow a Gaussian distribution with non-zero mean. New statistical criteria using maximal likelihood functions are established and applied for local blur-scale computation. Gradient vectors over a blur-scale region are summed to enhance gradients at blurred object interfaces while leaving gradients at sharp transitions unaffected. Finally, a blur-scale based non-maxima suppression method is developed for edge detection. The method has been applied to both natural and phantom images. Experimental results show that computed blur-scales capture true blur extents at individual image locations. Also, the new scale-based gradient computation and edge detection algorithms successfully detect gradients and edges, especially at the blurred object interfaces.

“Adaptive Multi-coil Resonant Wireless Power Transfer Systems using Receiver Feedback”

Michael Salino-Hugg, David R. Andersen, Raghuraman Mudumbai, Anton Kruger

We considered wireless power transfer systems that combine the use of multiple transmitting coils with high-Q resonance to achieve enhanced range and performance. Specifically, we considered an inductive wireless power transfer (WPT) system where a number of transmitting coils seek to efficiently transfer the maximum possible amount of power to a receiver with all the transmitting and receiving coils designed to self-resonate with high-Q at a common frequency. While there exists substantial literature on WPT systems using both multi-coil transmitters and coupled resonance, previous work has been limited to small-scale and simple transmitters because of the difficulty of constructing physically accurate models for analyzing and optimizing such systems. Our key novelty is to use receiver feedback to avoid the need for such models. This simple and powerful idea opens up the possibility of WPT systems with potentially large numbers of resonant coils that may be coupled to each other and the receivers. We present new theoretical and experimental results on the properties of such multi-coil coupled resonant systems. Our theoretical results generalize the well-known phenomenon of frequency-splitting to a system with multiple transmitters. We also present a simple adaptive approach to optimizing such a system and present experimental results to illustrate the benefits of multi-coil resonance in efficiency and total power delivered.

"An Information-Theoretic Explanation for the Adversarial Fragility of AI Classifiers"

Hui Xie, Jirong Yi, Weiyu Xu, Raghuraman Mudumbai

We present a simple hypothesis about a compression property of artificial intelligence (AI) classifiers and theoretical arguments to show this hypothesis successfully accounts for the observed fragility of AI classifiers to small adversarial perturbations. We also propose a new method for detecting when small input perturbations cause classifier errors and show theoretical guarantees for the performance of this detection method. Our experimental results, with a voice recognition system, demonstrate this methodology. The ideas in this paper are motivated by a simple analogy between AI classifiers and the standard Shannon model of a communication system.

"Data Augmentation for Deep Learning Image Segmentation"

Alexander Powers, Professor Hans Johnson

Supervised deep learning requires massive amounts of labeled data. It is often infeasible to label so much data, so one way to maximize the information gained from each sample is to augment the existing data. In medical imaging, we are able to apply permutations of different image transforms to drastically increase the size of the dataset. Using a U-Net architecture for the image segmentation, we trained multiple models on different subsets of the augmented data. By systematically removing images from the training data, we were able to interrogate the complexity of problems that could be solved using datasets with a minimal number of samples.

"Electromagnetic Simulation of Biphasic Pulse Excitation for Transcranial Magnetic Stimulation"

Kumar Digvijay Mishra, Anton Kruger, Hiroyuki Oya

Amplitude modulation of sinc pulse during electromagnetic field propagation inside a human skull requires a windowed truncated signal that extends over higher frequencies. Expensive computational time and memory for the solution of electromagnetic equations require a judicious choice of solution methods amidst available finite difference time domain, finite element, Fourier domain, physical optics, and uniform theory of diffraction. Surface currents were computed along meridional and sagittal slopes on a human skull. Nonlinear factors including skull anatomy resulted in heterogeneous distribution of magnetic fields.

"Evaluating the Use of Neighborhood Influenced Predictions for Query-Dependent Survival Prognosis Prediction in Oropharyngeal Cancer Patients"

Keegan Shay, Guadalupe Canahuate, David M Vock, Joel Tosado, G. Elisabeta Marai, Baher Elgohari, Dr. Clifton D. Fuller

This study investigates the application of query-dependent predictive modeling to overall survival and recurrence-free survival prediction for oropharyngeal cancer patients. Query-dependent models were trained using neighborhoods of similar patients. We created a hybrid distance function in order to combine our heterogeneous feature space and pairwise interpatient similarities meaningfully. This hybrid distance function was used to determine the k-nearest-neighbors for a given query patient, forming a neighborhood. Neighborhoods were used to train local models directly, as well as to create locally weighted ensembles of globally trained models. The goodness of fit, as well as the discriminative ability, was evaluated for survival prediction at multiple survival times up to five years.

"Experimental Analysis of Cancerous and Healthy Cell Lines Utilizing Mid-infrared Interband Cascade Lasers"

Eric Larson, Dr. Fatima Toor

This poster will present results on the work to ablate cancerous cells using a mid-infrared (MIR) interband cascade laser (ICL). Traditionally, MIR ICLs used for cancer treatment are bulky and expensive, for example, free-electron or CO2 lasers. We are utilizing compact (3 mm by 15 microns by 300 microns) ICLs to enable handheld MIR laser ablation systems. The hypothesis of our project work is that cancerous tissue can be preferentially ablated utilizing MIR lasers while minimizing damage to surrounding healthy tissue. Initial results indicate successful ablation of sarcoma cell lines utilizing a 3.3-micron emission ICL.

“High Sensitivity Silicon Nanowire Biosensor for Estrogen Detection”
Wenqi Duan, Bingtao Gao, Hui Zhi, Gregory LeFevre, Fatima Toor

Discharged estrogens are not filtered out in water treatment plants, leaking into water streams, disrupting the local wildlife and raising concerns of excess estrogens entering the human food chain. We are developing vertically oriented silicon nanowires (SiNWs) based biosensors for detecting natural (E1) and synthetic (EE2) estrogen. The SiNWs are etched into Si substrates and converted into optoelectronic sensors utilizing microfabrication process steps. By functionalizing the SiNW sensors with estrogen receptors, we can detect low levels of E1. We demonstrate selectivity by confirming the sensor shows no response to androgen, and the advantage of SiNWs over planar Si using fluorescence.

“Holo Reality: Live 3D Video Streaming for Mobile Devices and Augmented Reality”
Matthew G. Finley, Tyler Bell

Progress in 3D imaging techniques has enabled real-time, high-resolution 3D imaging systems which are directly beneficial to many applications. Currently, however, these systems can generate up to 1-2 Gbps of data, which is well beyond current wireless network capabilities; especially on mobile devices. To enable applications that require real-time 3D data communications,”such as crime scene digitization, telemedicine, and 3D video chats”, efficient methods of compressing the 3D data are necessary. This poster presents our recent work on a novel 3D data compression method that enables real-time, low-bandwidth 3D video communications for use in augmented reality on mobile devices.

“InAs and InAs/GaSb Core-Shell Nanowires for Tunable Infrared Optics”
Alex Walhof, Xinxin Li, John Prineas, Fatima Toor

Group III-V nanowires (NWs) are an exciting 1-D structure for infrared optical devices due to control over band structure and the potential for new lattice-mismatched material combinations. Using selective area epitaxy ordered growth, InAs NWs have been grown catalyst-free on a silicon substrate. Adding a GaSb shell allows for tunable emission with a wavelength from 3 to 10+ microns. After growth, NWs must be protected from oxidation by encapsulation. We explore a variety of encapsulants and monitor the normalized photoluminescence over time to determine the optimal material combination. Ultimately, these improvements may lead to developing infrared NW lasers.

“Interpreting Different Features of Shallow Water Acoustic Channels Using Braid Manifolds”
Ananya Sen Gupta and Ryan McCarthy

We explore different representations of the shallow water acoustic channel using braid manifolds with the objective of interpreting diverse channel phenomena. We propose a novel channel model based on braid manifolds that have the natural ability to detect topologically connected channel features across diverse channel representations in time, delay and their spectral components. We demonstrate the need for different representation domains based on localization goals of channel features across time, frequency and varying degrees of channel sparsity. We also provide a comparison between braid interpretations of the time-varying shallow water acoustic channel across different channel representations based on experimental field data collected in the SPACE08 experiment.

“Localized Surface Plasmonic Resonance of Silver Nanoparticles on Silicon Solar Cells”
Bingtao Gao, Wenqi Duan, Fatima Toor

In this work we develop a time- and cost-effective method of fabricating a light trapping structure on silicon (Si) solar cells utilizing the localized surface plasmon resonance (LSPR) of silver (Ag) nanoparticles (NPs). Covered with an aluminum oxide (Al_2O_3) layer, the NP decorated Si surface exhibits a broadband light absorption enhancement, having a low weighted average spectral reflectance (Rave) value of 9.5%. Compared to the reference Si solar cell without NPs, the NP decorated cell exhibits the highest absolute gain of 19.2% in external quantum efficiency at 700 nm, and an overall 20% relative increase in efficiency.

“Support-Constrained Mixed Norm Optimization Techniques for Interpreting Multipath Activity in Shallow Water Acoustic Channels”

Ryan McCarthy, Ananya Sen Gupta, Emma Hawk, and Adam Golding

We employ a suite of support-constrained mixed norm optimization methods to track shallow water acoustic channels that exhibit rapidly fluctuating high-energy multipath activity across different regions of the channel support. This scenario describes many real-life oceanic conditions of interest, and as such, is of importance to naval communications and oceanic surveillance activities. The main contribution of our work is channel interpretation: we aren't only tracking the high-energy channel components but tracking the sub-regions of the channel delay spread that correspond to the multipath activity that created them. Knowing where the significant multipath activity lies is important because it can inform underwater acoustic sensor networks to avoid them as well as inform naval surveillance systems of oceanic conditions or unknown reflectors within the oceanic environment. The scope of this work is not to model the shallow water channel, but rather harness existing channel models to track and interpret the multipath activity using a suite of mixed norm recovery methods that offer different trade-offs between precision, tracking time and channel interpretation. We present our results over experimental field data from the SPACE08 experiment as well as over simulated channels that exhibit different degrees of oceanic activity.

“Virtual Stage Sensors: Alternative Approaches for Smartphone-Based Crowdsourced Water Level Measurements”

Yusuf Sermet, Ibrahim Demir

Accurate and widespread monitoring of river stages is vital for modeling water resources. While current embedded monitoring systems provide accurate measurements, replicating these systems on a large domain is prohibitively expensive. This project describes a new method to accurately measure water levels using smartphone sensors. Pictures of the same point on the river's surface are taken to perform calculations based on GPS location and spatial orientation of the smartphone. The proposed implementation is significantly more accessible than existing water measuring systems while offering similar accuracy. A case study is performed to evaluate the accuracy and sensitivity of the measurements.

“Flux Gate Magnetometer for ICI-5 Sounding Rocket Mission”

Suman Sherwani, David Miles

The purpose of this research project is to build a dual-sensor magnetometer payload for the ICI-5 sounding rocket, which will be launched from Svalbard, Norway in December 2019. The magnetometer will be technically demonstrating multipoint in-situ measurements of ionospheric plasma structures related to GPS scintillation, as well as interpreting the particle measurements and testing for the presence of plasma waves.

Industrial & Systems Engineering

"Development of an Online Self-Report System for Agricultural Injuries and Near-Misses"

Nicole Beckligner, Geb Thomas

The agricultural industry has high occupational injury and fatality rates. Current surveillance methods do not provide detailed information necessary for successful interventions. An online, self-report system for agricultural injuries and near misses seeks to improve surveillance. The system was developed with feedback from 26 agricultural workers and 23 agricultural safety and health professionals over three iterations. Interviews identified key features to the success of a self-report system and improved the design. Improvements were measured with a 10-point-scale, rating both the self-report survey and the website. Ratings improved significantly between the first and third versions of the system for both groups.

Mechanical Engineering

"A Novel Laser-based Metasurface Fabrication Method for Tunable THz Bandpass Optics"

Qinghua Wang, Michaella Raglione, Huixin Wang, Fatima Toor, Mark A. Arnold, Hongtao Ding

Terahertz (THz) imaging/sensing has attracted much attention as an emerging nondestructive evaluation technique. We developed a new Laser-based Metamaterial Fabrication process for terahertz bandpass metasurfaces on dielectric substrates such as quartz and polymers. The LMF process involves a simple fabrication process, ease of scaling up, and lower manufacturing cost. More importantly, our research presented a new electronically tunable THz bandpass optics which is also highly transparent in the visual spectrum. Our results render an economical technique capable of treating large area multi-functional metamaterials and provide a viable solution for fabrication of tunable THz lens for sensing and imaging.

"CFD Simulation of Submarine Operating Near Free Surface"

Yagin Kim, Dr. J. Ezequiel Martin, Prof. Pablo M. Carrica

A submarine operating near the free surface experiences very complicated hydrodynamic forces induced by the presence of the air/water interface. Unlike in deep operation, an underwater vehicle moving at periscope depth interacts with the free surface to form gravity driven waves which may adversely affect the propulsion efficiency, sea keeping ability and maneuverability. In this study, the generic submarine BB2 Joubert with actual discretized propeller and sail and tail planes is studied numerically for near-surface operation. The CFD code REX, developed at the University of Iowa, is used focusing on effects on resistance and propulsion, motions and flow characteristics.

"Characterization of Surface Nanostructure on Metal Alloy for Superhydrophobicity Using Image Processing"

Jianwei Hu, Avik Samanta, Hongtao Ding

Integrated laser texturing and flurosilanization on the metal surface creates a series of nanostructure on the surface and changes the macroscopic surface wettability to superhydrophobicity. While direct relation between the nanostructure density and hydrophobicity can be observed by experiments and scanning electron microscopy, quantifying the degree of surface nanostructuring is challenging. In this study, various image processing methods have been implemented to quantify surface nanostructuring effect. Results from the analysis will provide a guideline to optimize the processing conditions to tune the hydrophobic wettability.

"Co-existence of Superhydrophilicity and Superoleophobicity on Laser Textured Metal Surface by Controlling Surface Chemistry"

Avik Samanta, Scott K. Shaw, Hongtao Ding

The co-existence of oleophobicity and hydrophilicity seems uncharacteristic as classic surface energy theory suggests oleophobic surfaces should behave as hydrophobic. In this study, an aluminum surface is produced using integrated laser texturing and surface chemistry control. A water droplet can spread on the surface while the oil droplets can roll off the surface. This kind of oleophobic-hydrophilic surface has enormous potential for oil-water separation and anti-oil fouling self-cleaning application.

“Comparing the Tension-Length and Tension-Velocity relationships of skeletal muscles (Anterior Tibial group) and carbon fiber/polydimethylsiloxane (PDMS) based artificial muscles”

Parth Kotak, Caterina Lamuta

The purpose of the project was to compare the tension length and tension velocity relationships of skeletal muscles (anterior tibial group) and carbon fiber/polydimethylsiloxane (PDMS) based artificial muscles. The contraction of our skeletal muscles depends on the natural resting length and velocity of movement of the muscles. The effect of resting fiber length and velocity of movement on muscular contraction is referred to as the tension length and tension velocity relationship respectively. In order to design lower limb prosthetic devices from artificial muscles, experiments were conducted to understand these relationships and compared to skeletal muscles.

“Experimental Investigation of Cutting Force and Temperature during Shear Cutting of Sheet Metal using a Novel Bionic Cutting Tool”

Huixin Wang, Qinghua Wang,Hongtao Ding

Design of the shear cutting blade needs to be reconfigured due to the high cutting force and temperature during cutting hard materials. A novel oblique shear blade was fabricated using the badger teeth curve as a model. The experiment results indicated the bionic shear blade exhibited lower cutting forces and chip temperature during the shear cutting process. In addition, the bionic shear blade showed better capability in terms of reducing the cutting forces when shearing sheet metal with higher thickness. It can thus be concluded a tool design using a bionic curve will greatly benefit the shear cutting process.

“Hierarchical FE-DE Multiscale Modeling Approach for Off-Road Vehicle Mobility Prediction”

Guanchu Chen, Hiroki Yamashita, Yeefeng Ruan, Paramsothy Jayakumar, Hiroyuki Sugiyama

This study presents a hierarchical FE-DE multiscale tire-soil interaction simulation capability that can be integrated in general multibody dynamics computer algorithms for high-fidelity HPC off-road mobility simulation. The terrain deformation is modeled by FE meshes. Stress responses of complex granular material within the element are predicted by physical RVE models using a DE approach to address the limitations of existing single-scale terrain models. The proposed multiscale off-road mobility simulation model is validated against the soil bin mobility test data under various test conditions, hence demonstrating the potential of the proposed method for resolving challenging vehicle-terrain interaction problems.

“Innovative Laser Surface Patterning for Fabrication of Flexible and Transparent Conducting Heaters”

Haoxuan You, Zach Lowery, Qinghua Wang, Hongtao Ding

Recently, transparent conducting films have become the key components for various optoelectronic devices such as solar cells and touch screen panels. Due to the disadvantages with the existing materials and fabrication methods, there is a strong need for development of a time-efficient and cost-effective fabrication method for large-area transparent conducting films. In this work, an innovative laser surface patterning method was developed to fabricate transparent conducting films with excellent optoelectronic properties. The laser patterned surface also exhibits outstanding mechanical durability and heating performance. This innovative laser patterning method could enable high yield production to meet a variety of industrial requirements.

"Vorticity Transport and the Role of Spanwise Convective Flux on a Rolling Wing"
Randall Berdon, James Buchholz, Kyle Johnson, Brian Thurow

This will examine the mechanism governing the generation and evolution of a Leading-Edge Vortex (LEV) on a flat plate of aspect ratio 2 in the initial stages of a rolling maneuver for advance coefficient of J=0.54. The sources and sinks of circulation were investigated to elucidate mechanisms governing vortex stability on a rotating platform. The spanwise convective contribution is seen to have three distinct behaviors across the span of the wing, where three different regions exhibited different LEV behavior. The inboard region observed a weakening of the LEV structure with in outboard flow, the middle region was influenced by vortex induction from an arch structure, while the outboard region exhibited tip effect with both inboard and outboard flow.

Center for Bioinformatics & Computational Biology

"A Mobile App to Collect Expert Inherited Deafness Diagnosis Data to Support Personalized Genomic Medicine"

Chibuzo Nwakama, Thomas Casavant, Richard Smith, Rae Corrigan

As part of the NIH-supported AudioGene project, audiograms (graphical records describing a patient's hearing acuity) are analyzed by expert clinician-scientists to determine genetic diagnoses. Other information such as age, gender and family relationships are important and need to be recorded as well. A robust portable collection tool is needed to collect this data. This tool is a mobile app which runs on an Android platform to systematically record and securely store this information. Using an agile software engineering strategy, this app follows a schedule of releases for each upcoming version.

"A Pipeline for RNAseq-Based Differential Expression Analysis of Neuroendocrine Tumors"

Bartley J. Brown, Professor Thomas L. Casavant, Dr. James Howe, Professor Terry A. Braun

We have built a pipeline for the identification of differentially expressed genes and pathways in neuroendcrine tumors in small bowel and pancreas. The pipeline consists of community-developed tools Salmon, Tximport and Deseq2 run in a Linux environment on the University of Iowa's High-Performance Computer Cluster. Samples include tumor, normal, liver metastasis and lymph node metastasis. We will continue our ongoing efforts in the expansion and enhancement of the pipeline to accommodate the study of novel transcripts, tissue deconvolution, fusion genes, GSEA, genotyping and the combining of Whole-Exome with RNAseq data.

"Comparative Analysis of Computational Folding Methods for Nucleic Acids in Fixed Charge and Polarizable Force Fields"

Rae Ann Corrigan, Emily Lavering, Michael Schnieders, Thomas Casavant

Small RNAs have recently shown immense promise: from biological roles to therapeutic potential in cancer and AMD. Understanding 3D molecular structure is paramount to understanding function. Computational ergotic sampling across conformational space will help accurately determine key properties - such as lowest free energy structure. Herein, we compare force fields (fixed-charge vs. polarizable) and sampling methods (equilibrium molecular dynamics vs. a novel biased sampling method that accelerates overcoming folding barriers) to determine optimal RNA-folding protocol. Predicted structures are analyzed based on coordinate RMSD from experimental structures and force field energy. Key interatomic distances are measured as an additional quality metric.

"Machine Learning with the TCGA-HNSC Dataset: Improving Usability by Addressing Inconsistency, Sparsity, and High-Dimensionality"

Michael Rendleman, Chibuzo Nwakama, John M. Buatti, Terry A. Braun, Brian J. Smith, Bart Brown, Reinhard Beichel, Thomas L. Casavant

With precision oncology and publicly-available datasets, the data available for each patient has dramatically increased. From clinical variables and PET-CT radiomics measures to DNA-variant and RNA expression profiles, this variety of data presents many challenges. Large clinical datasets are subject to sparsely and/or inconsistently populated fields, and sequencing profiles introduce the problem of high-dimensionality. We present novel deployment of machine learning techniques to handle data sparsity and evaluate unsupervised transformations of RNA data for prognostic prediction, improving the usability of more than 500 patient cases from TCGA-HNSC for enhancing oncological decision support for Head and Neck Squamous Cell Carcinoma.

Center for Computer-Aided Design

"Additive Manufacturing of Ceramics Based on Hydrothermal-assisted Powder Bed Fusion"
Fan Fei, Li He, Baizhuang Zhou, Ziyang Xu, Xuan Song

This innovative method can fabricate ceramic parts with high density utilizing water, pressure and heat.

"Linear Temporal Logic Path Planning for Mobile Robot"
Cai Mingyu, Baike She, Zhen Kan

Linear Temporal logics (LTL) naturally express robot specifications such as reaching a goal or avoiding an obstacle, but also more sophisticated specifications such as sequencing, coverage, or ordering of different tasks. The synthesized controller autonomously ensures that the robot will satisfy the LTL-based task

"Multi-scale-material 3D Printing of Biodegradable Microneedles as Drug Delivery Devices"
Wenbo Wang

A multi-scale-material, ultra-precision 3D printing system was developed with capability of printing parts with different materials at resolution of tens of micrometers. Here we apply this technique to print microneedles as a pain-free alternative of conventional syringe and needle for drug delivery. Each microneedle (300Âµm x 800Âµm) can be printed with different materials or drugs for different locations. With the multi-scale feature, a large microneedle patch can be fabricated to meet a client's demand. The patch then can be applied onto the skin and the microneedles with the drug will dissolve in the body. We also demonstrated other micro-geometries fabricated by this system.

"Local Source Characterization using Positive Matrix Factorization"

Charles Stanier, Megan Christiansen

The purpose of this study was to research what local emission sources where influencing the Zion, IL sampling site during the 2017 Lake Michigan Ozone Study (LMOS). Measurements of volatile organic compounds (VOCs) and airborne particulate size distribution data obtained in Zion, IL during the month long LMOS campaign were analyzed using the U.S. Environmental Protection Agency (EPA) positive matrix factorization (PMF) receptor model. Factors obtained from PMF were further evaluated using conditional probability function plots, pollution roses, and bivariate polar plots to determine to the direction in which sources are located. Comparison of emission sources apportioned by PMF with data obtained from continuous emission monitoring systems (CEMS) allows for characterization of primary source influences at the sampling site.

"Seasonal Variations of South Korean NO_2 from the TROPOMI Satellite"

Beiming Tang, Charles O. Stanier, Gregory R. Carmichael

NO_2 is an air pollutant of global concern. It is linked to unhealthy urban and regional air quality, acid rain, and reactive nitrogen deposition. The observation and prediction of NO_2 is essential to human health. We demonstrate the use of a new high-resolution satellite (TROPOMI) for NO_2. The data flow from TROPOMI is up to 2.04x106 pixels per day for NO_2. To complement a recent air quality campaign over Korea (KORUS-AQ), TROPOMI NO_2 was investigated. Spatial and temporal patterns are clearly visible, winter NO_2 over Korea is three times higher than summer NO_2. The ability of log-normal probability distributions to fit the NO_2 distributions, with parameter fitting by gradient descent, was investigated.

"Size-resolved Aerosol Measurements During the Lake Michigan Ozone Study (LMOS 2017)"

Megan Christiansen, Charles Stanier, Brad Pierce, James Szykman, Elizabeth A. Stone, Dagen D. Hughes, Austin Doak, Sherrie Elzey

The Lake Michigan Ozone Study 2017 occurred during summer 2017 to investigate high ozone episodes at lake-land interfaces. Highly time-resolved particle size distributions (PSD) were continuously measured at a rural site influenced by local and regional sources of air pollution. Particle number and mass were positively correlated with ozone and its precursors. Combining collocated integrated aerosol filters (chemical speciation), remote sensing products (ceilometer and Aeronet) with surface in-situ PSD measurements allow for an improved characterization of pollutants impacting the site.

Iowa Institute for Biomedical Imaging

“A Deep Learning Approach for Detecting Dysphagia in Video Fluoroscopic Swallowing Exams”

Patrick T. Wilhelm, Douglas J. Van Daele, MD, and Joseph M. Reinhardt

Video fluoroscopic swallowing exams (VFSE) are the gold standard for determining a patient’s degree of swallowing function, and the presence of dysphagia. In this work, we propose a deep learning approaching using a hybrid convolutional-recurrent neural network for detecting the presence of dysphagia in a VFSE. This project has been conducted in collaboration with faculty from the Carver College of Medicine, Department of Otolaryngology.

“Clustering the Risk: Quantitative Imaging Features of Chronic Obstructive Pulmonary Disease Associated with Lung Cancer”

Johanna Uthoff, Sarah Mott, Brian Smith, Jessica C. Sieren

We hypothesize quantitative computed tomography (qCT) measures analyzed at a lobar level, and incorporating covariance across lobes, will be related to lung cancer risk in a cohort of 278 subjects with identified pulmonary nodules detected in qCT with histopathology confirmation. The top ranked predictors from k-medoids clustering were the covariance among lobes in histogram skewness (Odds = 1.36), lobe total volume (Odds = 0.73), and covariance among segmental airway wall thickness (Odds =1.29). Preliminary investigation demonstrates lobe-specific and covariance between lobes of quantitative extracted features relevant to COPD are informative of malignant pulmonary nodule distinction.

“Current and Varifold-Based Diffeomorphic Registration of Pulmonary CT”

Amanda Pan, Wei Shao, Christopher Guy, Ougz Durumeric, Joseph Reinhardt, Geoff Hugo and Gary Christensen

This poster presents a varifold-based registration algorithm to register pulmonary CT images that require large deformations. We compared current and varifold-based registration with 300 pairs of 2D eye fundus images. Our results show that using varifold-based registration gives better results compared to using current-based registration. We applied a total of 900 registrations of 2D shapes to study the robustness of varifold-based registration with respect to missing information. We also registered 18 pairs of 3D pulmonary CT images with lung cancer and atelectasis. Our results demonstrate that the varifold approach can register shapes that have significant differences.

“Geodesic Regression for Artifact Correction in 4DCT”

Wei Shao, Yue Pan, Sarah Gerard, Taylor Patton, Oguz Durumeric, Joseph Reinhardt, John Bayouth, Gary Christensen

This poster describes a Geodesic Density Regression (GDR) algorithm that mitigates motion artifacts in 4DCT. Our approach uses image regression to correct artifacts in one breathing phase by using artifact-free data in corresponding regions of the other breathing phases. Binary artifact masks are used to exclude regions of artifacts from the regression, i.e., the GDR algorithm only uses artifact-free data. The GDR algorithm performance was evaluated using 2D and 3D CT time-series images with simulated known motion artifacts. The results show that regression using artifact masks were similar to regression results using artifact-free data.

“Volumetric Quantification of Calf Muscle Shape and Morphology from 3D MR Images: Fully Automated Deep LOGISMOS Approach”

Zhihui Guo, Honghai Zhang, Ellen van Der Plas, Laurie Gutmann, Peg Nopoulos, Milan Sonka

Quantitative volumetric analysis of muscle is vital in the development of a biomarker for disease progression in DM1. We report a fully automated method for volumetric segmentation and quantification of calf muscle compartments in 3D MR images. Deep learning coarse-to-fine convolutional neural networks yielded robust but approximate initial segmentations. Followed by 3D LOGISMOS (layered optimal graph image segmentation of multiple objects and surfaces), accurate segmentation of 5 calf muscle compartments was obtained for each leg. 30 MR images from 30 subjects (10 healthy, 20 DM1) were analyzed using 6-fold cross-validation. The left/right combined analysis accuracy was high for each muscle compartment. DICE similarity coefficients for the anterior, deep posterior, soleus, gastrocnemius, and lateral compartments were 0.86Â±0.22, 0.87Â±0.08, 0.83Â±0.18, 0.85Â±0.17 and 0.85Â±0.17, respectively (meanÂ±std).

“Volumetric Segmentation of PET-CT Scans using Deep Convolutional Neural Networks to Facilitate Radiation Treatment”

Xiaofan Xiong, John M. Buatti, Reinhard R. Beichel

The goal of our work is to facilitate the planning of radiation treatment as well as assessment of treatment outcome by utilizing deep convolutional neural networks for volumetric segmentation of anatomical structures of interest. For this purpose, three different networks are implemented and compared regarding their performance (Dice coefficient) in two applications: cerebellum and vertebra segmentation in PET-CT scans. Results show that a modified version of the U-net network architecture has the best segmentation performance and represents a promising segmentation approach with broad applicability.

IIHR - Hydroscience & Engineering

"A Statistical Model for Predicting the Relative Responses of Unidentified OH-PCBs"

Panithi Saktrakulkla, Kai Wang, and Keri Hornbuckle

Hydroxylated polychlorinated biphenyls (OH-PCBs) are oxidative metabolites of PCBs and residuals found in original Aroclors. OH-PCBs are known to play roles as genotoxics, carcinogens, and hormone disruptors. The studies of OH-PCB levels in human tissues, organisms, and environmental matrices are then of interest. Of 837 possible mono-OH-PCBs congeners, there are only ~70 methoxylated PCB (MeO-PCB) standards commercially available. Because OH-PCBs are normally found in pico- to nano-gram scale, the quantitation of those unknown or unidentified OH-PCBs by structure elucidation is impractical and is challenging. The unknown OH-PCBs are sometimes reported by assuming the peak responses of other available compounds in the same homologs which can bias the results due to the choices and the availabilities of standards. To overcome this issue, we investigated the peak responses of all available MeO-PCB standards with gas chromatography (J&W DB-1701 in Agilent 7890B) coupling with triple quadrupole (Agilent 7000D) mass spectrometer (MS), with positive Electron Impact (EI) at 20 – 70 eV in Selected Ion Monitoring (SIM) mode. We found correlations between the relative peak responses (RRFs) and the number of chlorines in the molecules of MeO-PCBs (#Cl). Among the studied models, the square function of #Cl is the most suitable model in the RRF prediction (RRF = B1×#Cl^2 + B0) when the peak responses are captured at 30 eV. The reproducibility in different GC-MS system (Supelco SPB-Octyl in Agilent 7890A – 1000D), the comparable results with synthetic MeO-PCB standards, and the preliminary application in sediment samples indicate the potential of this statistical model in quantifying unknown OH-PCBs allowing us to move beyond the limit of standard availability.

"Assessment of Boundary Layer Transition Models for Naval Hydrodynamics Applications"

Dongyoung Kim, Juan E. Martin, Yagin Kim, Jiajia Li, Robert V. Wilson, Pablo M. Carrica

Boundary layer transition is a complex phenomenon that involves multiple physical mechanisms. In naval hydrodynamics problems, boundary layer transition can have considerable effects on skin friction, noise, propulsion efficiency and maneuverability. It is especially so for model scale and small craft such as unmanned and autonomous surface or underwater vehicles. To investigate capabilities and limitations of boundary layer transition models for naval hydrodynamics application, several recently developed models are implemented to the overset computational naval hydrodynamics code REX and validated against experimental results. Correlation-based transition models using local variables, including extended models for crossflow transition effects, and methods based on stability theory using an amplification factor were implemented in one- and two-equation RANS turbulence models. Extensive validation is conducted for 2- and 3-dimensional geometries with experimental data including flat plates at zero-pressure gradient, an ellipsoid, and a sickle wing. Additionally, computations on model propeller 4119, which has some experimental data, and the much more complex generic submarine Joubert BB2 were performed and analyzed.

"Automated Detection of Bats in IR Video Recorded at Wind Turbines"

Bingchun Huo, Corey Markfort, Anton Kruger

Over the summer of 2018, researchers at IIHR deployed IR cameras at wind turbines at Macksburg, Iowa. This field campaign was part of larger effort to study the interaction of bats and wind turbines. The video archive consists of 18,000 files, each half an hour long. We estimate that only about 10 percent of the files contain useful video with embedded bats. Our project focuses on the automated detection of these files. The main challenges are removing the turbine and tower and discriminating between bats and background clouds.

"Bat Recording Interface for Analyzing Wind Turbine Interaction"
David Wu

Wind energy's possible negative environmental impacts have yet to be examined closely. Specifically, there is limited knowledge of the adverse effects and prevention of bat fatalities around wind turbine sites. We developed a system that autonomously captures infrared video data of turbine sites to track bat interaction and collision. This data is combined with physical modeling and video analysis to accurately predict the outcome of a bat-turbine impact and develop deterrents to avoid bat fatalities. We deployed 16 systems in collaboration with MidAmerican Energy on August 12, 2018 to reliably capture the data required to analyze bat behavior.

"Design and Validation of a Robust 3-D Shape Sensing System"
Isaac M. Di Napoli, Casey M. Harwood

Shape sensing refers to the reconstruction of deflections of flexible bodies. These deflections give insight into the structural health and operating conditions of engineering structures. The work presented describes a robust and low-cost method for shape sensing using a shape sensing spar. The shape sensing spar, when embedded into a parent structure, provides real time deflection monitoring of engineered structures. This task is achieved using a kinematic model and discrete bending and torsional strain measurements along the spar to reconstruct the deflections. The kinematic model is validated against finite element simulations of the spar under various loading cases.

"Developing Technologies for Detecting and Understanding Bats Emergence within a Wind Farm"
Jian Teng, Anton Kruger, Corey Markfort

Wind energy is the fastest growing renewable energy source in the U.S. However, bat fatalities associated with wind turbines are a rising concern in the development of wind energy industry. In 2018, we deployed a X-Band Polarimetric Doppler Radar to detect bats and study their behaviors within the wind farm. Using measurements from nearby weather stations, wind turbine SCADA data, and locally-deployed radar, new models are being developed that may advance our understanding of the conditions when bats are at highest risk and develop mitigation strategies to limit wind energy impacts on bats.

"Experimental and Computational Comparison of a Bluff and Streamlined Submersible Object"
Kyle Mosqueda, Casey Harwood, Pablo Carrica, Ezequiel Martin

An investigation into the hydrodynamic properties of a bluff and streamlined submersible object was compared using a combination of experimental and computational methods. This project aims to mitigate negative flow effects on a notional bluff submersible with the addition of a front and rear fairing to a streamlined design. Experiments were done in the IIHR towing tank and simulations were done using the CFD code REX, developed at the University of Iowa.

"Experimental Investigation of Aerodynamic Characteristics of Bat Carcasses"
Shivendra Prakash and Corey D. Markfort

This research presents a new methodology for estimating the empirical drag coefficient (Cd) of bat carcasses for which no data is available. Field investigation in a wind farm resulted in the discovery of three bat species: Eastern Red Bat, Hoary Bat and Evening Bat. Carcass drop experiments were performed to acquire the position time series data using high-speed photography. Ballistic model was fitted to the measured data and multivariable optimization was performed to give the best-fit yielding the optimized drag coefficient estimate.

“Experiments and CFD for DARPA Suboff Appended with Propeller E1658 Operating Near the Surface”

L. Wang, J. E. Martin, P. M. Carrica, M. Felli, M. Falchi

Vortex evolution in a propeller wake plays an important role in engineering applications due to a direct correlation to vibration, noise, and structural problems, but the mechanisms leading to instabilities in propeller wake are not fully understood. In this study, experimental and computational fluid dynamics results of the appended notional submarine DARPA Suboff fitted with the E1658 propeller while operating near the free surface are presented. Work mainly focuses on the propeller wake and influence of the free surface on wake stability, and in analyzing the ability of the CFD approach to reproduce experimental observations, and on limitations.

“Hydroxylated Metabolites of 4’-Methoxy-4-Monochlorobiphenyl in Whole Poplar Plants”

Yanlin Li, Christian Bako, Jerald Schnoor

Some metabolites of polychlorinated biphenyls (PCBs) can be more toxic than the parent compound. To date, there is limited knowledge on the interconversion between two metabolites, hydroxylated polychlorinated biphenyls (OH-PCBs) and methoxylated polychlorinated biphenyls (MeO-PCBs) in plants. In this study, poplar (Populus deltoides × nigra, DN34), a model plant, was used to investigate the metabolism of 4’-methoxy-4-monochlorobiphenyl (4’-MeO-PCB 3). Results show that poplar plants can take up and metabolize 4’-MeO-PCB 3 to 4’-hydroxy-4-monochlorobiphenyl (4’-OH-PCB 3). These findings provide new insight into potential transformation and fate pathways of OH-PCBs in the environment.

“Modeling Bubble Entrainment and Transport using Hybrid RANS/LES Methods”

Ben Yuan, Dr. Jiajia Li, Dr. Pablo Carrica

Prediction of bubbly flow is of crucial importance in naval hydrodynamics. While simulations using Large Eddy Simulation (LES) methods provide details of the flow that cannot be achieved with Reynolds-averaged Navier-Stokes (RANS) models, they lack the turbulent kinetic energy and dissipation used by bubbly flow models. We propose a new Hybrid RANS/LES method based on the standard Delayed Detached Eddy Simulation (DDES) approach, which to some extent can remove the limitations described above. The resulting turbulent kinetic energy and dissipation are in good agreement with RANS.

“Per-Period Analysis of Wave Dynamic Response”

Andrew Arnold, Casey Harwood

Conventionally, the dynamic response of a loaded hull to surface water waves is experimentally determined by logging motions for a large number of wave encounters to approximate the limit cycle response through pure statistics. The applicability of this assumption diminishes in the case of few wave encounters or significant wave-to-wave variation. This presentation explores an approach to interpreting the motions of a powered, unrestrained vehicle as variables of a stochastic, dynamical system to easily reduce experimental uncertainty in such cases.

“Probabilistic Modeling of Cavitation Inception in the Subgrid Computational Cell”

Mehedi Bappy, Dr. Ezequiel Martin, Dr. Jiajia Li, Professor Gustavo Buscaglia, Professor Pablo M. Carrica

The simulation of a cavitating flow is a challenging and evolving area of investigation, complicated by the requirement of accurately solving a complex multiphase flow. A reliable, physics-based method to estimate the likelihood of cavitation events, based on well-established single-phase computation methods, represents a valuable tool to understand the properties of naval systems with respect to the prediction of conditions for which cavitation will not occur. A novel methodology for the inception prediction is presented which uses probabilistic description of pressure fluctuations from isotropic homogenous turbulence simulations to characterize the sub-grid pressure of a computational cell.

"SaferTrek: System Development and Deployment for Farm Vehicle Road Safety Study"
Nichole Griffith

In order to evaluate the effectiveness of public awareness campaigns, data involving farm equipment interactions with other highway vehicles is needed. The SaferTrek project's goal is to create a device to collect this data and then quantify driver behavior in these vehicle interactions. Our solution is a box that attaches to multiple types of farm vehicles with an adaptable magnet-based mounting system. While the farm vehicles are on the road it records GPS data and videos with time-stamp information.

"Ship Airwake Flow Field and Spectral characteristics with Wave-induced Motions"
Austin Krebill, James Buchholz, etc.

The aerodynamics of a ship's flight deck is highly complicated due to atmospheric boundary layer inflow, bluff-body shape of the ship's superstructure as well as wave-induced motions. Therefore, predicting the airwake is very difficult. In this investigation, an ONR Tumblehome ship's airwake is probed experimentally with scaled ship motions to develop an extensive CFD validation data set, characterize the airwake for a given sea and wind state, and to understand interactions between the driving flow mechanisms.

"The Effects of Climate and Land Use on Baseflow in the U.S. Midwest"
Jessica Ayers, Gabriele Villarini, Keith Schilling, Chris Jones

Baseflow is a critical water source because it sustains streams during drought. We identified factors influencing baseflow in the Midwest with a simple statistical modeling framework. The model selects a set of predictors from climate (precipitation, temperature, and antecedent wetness) and land use (agriculture) using data from 458 United State Geological Survey (USGS) streamflow gages. Results indicated that increases in both precipitation and antecedent wetness lead to more baseflow throughout the entire region and year. A positive relationship with temperature was prominent in the winter which could be associated with snowmelt. In the summer a negative relationship with temperature was detected throughout the region. Agricultural was selected during the spring and summer (March-August) in the Corn Belt region. On the other hand, a negative relationship was present between agriculture and baseflow in Kansas and Nebraska. Water resources management requires an accurate understanding of baseflow because it sustains streams during low flow and drought periods.

"Web-Based Framework for Flood Mitigation Practices"
Enes Yildirim, Ibrahim Demir

In this study, a web-based framework is created to support flood mitigation practices. Historic data has been provided by Iowa Homeland Security and Emergency Management Department. The data is utilized for creating visual data analytics capabilities, cost benefit analysis of acquired buildings, and historic damage assessment for the existing buildings. Results are shared through user-friendly web-based environment.

COLLEGE OF ENGINEERING DEAN'S FELLOWS (CURRENT)

The Dean's Graduate Engineering Fellowship provides four years of support to the brightest incoming PhD students in the College of Engineering. These students demonstrate the greatest promise to significantly improve the quality, productivity, and research involvement of the departmental graduate student cohort. Fellowships will be awarded every year; one per graduate program as well as one or two additional fellowships with a diversity-enhancing focus. Reflecting the highest quality, each Dean's Fellow is expected to complete their research, publish results, and successfully defend his/her PhD thesis within four years. An overview of this year's Dean's Graduate Fellowship recipient's research follows:

Allen, Brittany, Biomedical Engineering
Photopolymerized cytomimetic substrates with variable stiffness as stem cell fate-directing biomaterials

Bannavti, Moala, Civil and Environmental Engineering
Modern polychlorinated biphenyl emission characterization profiles in minority-predominant public schools throughout Iowa

Contreras, Marisol, Chemical & Biochemical Engineering
Quantifying economic and environmental impacts of renewable hydrogen production.

Corcoran, Nicole, Industrial and Systems Engineering
The human aspect of the future of autonomous vehicles: how and where do humans fit and what are the implications

Di Napoli, Isaac Miguel, Mechanical Engineering
Development of new shape sensing techniques to aid in the accurate modeling and adaptive control of hydroelastic lifting surfaces

Fei, Fan, Industrial and Systems Engineering
Additive Manufacturing Method of Hydrothermal-assisted Powder Bed Fusion

Gao, Bingtao Electrical and Computer Science Engineering
The design, fabrication, and testing of nanostructured silicon solar cells and biosensors

Kotak, Parth, Mechanical Engineering
Smart Multifunctional Material Systems: Dynamic Characterization of Artificial Muscles and their application in prosthetic and human-assistive robotic devices

Lindmark, Megan, Civil and Environmental Engineering
Optimizing and monitoring rural drinking water supply systems to maximize public health benefit

Smith, Riannon, Chemical and Biochemical Engineering
Development of sprayable, antimicrobial hydrogels for treatment of infections in burn wounds

Tang, Beiming, Chemical and Biochemical Engineering
Study of seasonal variations of reactive nitrogen from satellite, aircraft, ground stations data and WRF-Chem simulations outputs in South Korea

College of Engineering Dare to Discover Students

In January 2016, the Office of Research and Economic Development launched the “Dare to Discover” campaign showcasing researchers, scholars, and creators from across the University of Iowa, including a series of banners throughout downtown Iowa City. The College of Engineering was represented by 11 graduate and undergraduate students from all five Engineering academic departments:

Carolan, Maggie, PhD student, Sustainable Water development
Purifies drinking water

Gonzalez, Humberto, MS student, Civil and Environmental Engineering
Engineers clean water.

Grant, Amina, PhD student, Civil and Environmental Engineering
Investigates lead levels

Hansen, Alexis, BS student, Biomedical Engineering
Examines airway pathogens

Nino, Marco, BS student, Biomedical Engineering
Analyzes the brain

Pradhan, Ojas, BS student, Chemical Engineering and Computer Science
Designs lung therapies

Asgharzadeh Shishavan, Amir PhD student, Electrical and Computer Science Engineering
Advances solar power

Uthoff, Johanna, PhD student, Biomedical Engineering
Uses aritfical intelligence to assess cancer

Yildirim, Enes, PhD student, Hydraulics and Water Resources
Aids disaster recovery

CBE:5405 Green Chemical and Energy Technologies

"A Technoeconomic Analysis of Hydrogen Production using Seawater Brine from a Desalination Plant"

Marisol Contreras, Charles O. Stanier, and Syed Mubeen

The economic viability of the photoelectrochemical (PEC) hydrogen production from desalination brine is studied using H2A modelling methods. This research intends to identify the components of a PEC system with the largest contribution to the levelized cost of hydrogen (LCOH) production. Final LCOH is given in terms of production cost per kg of hydrogen produced ($\$/kg\ H_2$). Calculations are based on the conceptual integration of PEC technology to the Claude 'Bud" Lewis Carlsbad Desalination Plant in California.

"End-of-Life of Photovoltaic Solar Cells: An Environmental Assessment"

Marisol Contreras

This research details the end of life and environmental impacts of recycling PV solar panels. Specifically, the major components of photovoltaic modules are identified and quantified based on current solar panel installation in the United States. Environmental impacts include solid waste toxicity for conventional disposal methods and GHG emissions presented in CO_2e for solar panel recycling.

"Environmental Comparison of Disposal Methods for Standard Polyethylene and Biodegradable Plastic Bags"

Jonah Marks, Lisa Eischens

This research explores the environmental fate of polyethylene plastic bags and biodegradable plastic bags for four different end-of-life destinations. These four destinations are: the ocean, burning, landfills and recycling. The aspects in consideration are the mechanisms by which the bags decay in each scenario, the emissions produced, potential for electricity generation, and impacts on wildlife in the ocean.

"Environmental Impact of Solar & Wind Energy"

Alexander Kaffka, Jeremy Wallace

The purpose of this analysis is to determine the environmental cost of developing and operating solar and wind farms. This should include the impact of the production, transportation, and lifetime use of solar panels and wind turbines. Included in the calculations will be a life-cycle analysis (LCA), eco-efficiency analysis, tier 1 analysis involving energy and CO2e to the relevant pollutants, and the cost of production. These will be compared to the most popular alternative, natural gas.

"Environmental Impact Review of Dairy, Soy, and Almond Milks"

Joe A'Hearn

The goal of this project is to provide a comprehensive review of the current available data on the environmental impact of Dairy, Soy, and Almond milk industries. Three impact categories are considered to produce the milks, including: Water Use, Equivalent Carbon Dioxide Emissions, and Land Use.

"Envisioning a Biofuel Transportation Economy for Iowa"

Jackson Solsma

Iowa and the Midwest states have potential for a sustainable biofuel economy, but little is known about what a macroscopic biofuel economy would look like. Literature values for current emissions from transportation in Iowa were considered and compared to values of common biofuel technologies. Expected fuel range, price per gallon, and 6 Kyoto gas footprints were estimated for a biofuel economy. Drawbacks and benefits of biofuel and other transportation technologies were thoroughly compared.

"Fuel Cell vs. Electric Automobiles and Factors Impacting Market Size"
Nathan Jarvey, Austin Doak

The objective of this project is to compare fuel cell and electric automobiles to determine which type has a smaller environmental impact throughout its life cycle, as well as what factors impact the growth of the market size of each type of car beyond lack of infrastructure and discuss some potential solutions for the future. The focus will be on the U.S. market, and will include economic, cultural, design, and environmental factors in order to better understand the current standing and treatment of the alternative-fuel automobile market in both its major offshoots.

"Iowa City's EV Future"
Noah Gavin

This report aims to estimate the future needs of Iowa City infrastructures and policies with regards to Electric Vehicles (EV). Many different approaches have been proposed: government subsidies for EV buyers, increasing EV infrastructure above projected needs with diverse locations, incentives for dealerships to push EVs, and implement policies to target student EV use. Multiple car dealerships were interviewed for their firsthand perspective as the seller of EVs, and the potential for their role in maximizing the efficiency of government involvement.

"Is Traveling by Air Greener than Traveling by Car?"
Xuanfeng Hua, Jing Wang

By comparing the emissions of production and usage of jet fuel and gasoline when the starting point and the destination are the same, we could determine which type of traveling could be greener. The key is the comparison of emission per person of the two types of transportation verses the distance. In this way, we can recommend the greener way to the public when the two types of transportation are available to reduce emissions

"Key Factors in Environmental Friendliness of Alcoholic Beverages"
Ryan Bingen, Sydney Kerr

Our purpose is to determine the greenhouse gas emissions of crafting alcoholic beverages. This will be focused on the source of carbohydrates for ethanol. The emissions of the production process of different beverages such as beer, wine, and spirits will be studied. This will be done using a Scope 3 analysis. The results of this study can further be used to inform environmentally conscious consumers of the beverage selection with the lowest carbon footprint.

"Life Cycle Analysis of a Styrene Production Process"
Benjamin Canby

The objective of this research is to study the environmental impacts of an original styrene production process. Starting from a process flow diagram in Turton et. al., I improved on the design and simulated it in Aspen Plus. I then performed a life cycle analysis on the process with kilograms of styrene as the functional unit.

"Life Cycle Analysis of Lead-Acid Batteries with a Focus on Recycling"
Nicholas Graham

To use the ideology of life cycle assessment (LCA) to quantify the environmental impacts (e.g., greenhouse gas (GHG) emissions, toxicity concerns) of lead-acid battery. Both past and present technologies in lead-acid battery manufacturing process will be analyzed and compared to propose a solution to the issue. A focus will be placed on the recycle portion of the life cycle.

“Reduction of Iowa City's CO_2 emissions through the use of electric vehicles”
Caleb Keegan and Kyle Wersinger

The goal of this experiment is to calculate the number of electric cars in use in Iowa City to determine the effect their use has on greenhouse gas emissions and how much less GHGs are released compared to an all fossil fuel powered transportation market. The number of electric vehicles (EV) and hybrids will be estimated and analyzed to determine a comprehensive picture of CO_2 emissions. The emission data will then be used to calculate the number of electric vehicles needed to meet Iowa City's emission reduction goal.

“The Life Cycle Analysis of Consumer Product Waste Streams to Landfill vs. Incineration”
Eugene Nzau Tsasa, Megan Christiansen

Management of solid waste disposal is a growing concern as the global population continues to rise. Landfills consume valuable land and pollute groundwater while incineration can cause air pollution and is costly. A life cycle assessment (LCA) of two solid waste disposal (SWD) strategies, landfill and incineration, of a manufacturing facility will be presented. Costs of transportation and final disposal and environmental impacts of each stream will be considered in the analysis.

“The GREET Model of a Li-Ion Battery”
Michael Zepeda, Noah Gavin

The report considers the energy intensity of manufacturing a lithium ion battery and its associated emissions, from a cradle-to-gate perspective, with a focus on cathode material production. A process analysis will quantify the equivalent emissions by way of a tier 1 analysis. The report will contain an original contribution of approximate GHG emissions, which assumes processing occurs in the Midwest United States. The results will compare emissions from an internal combustion engine vehicle to an electric vehicle.

CREATIVE "KICK-START" PROGRAM

Creative Kick Start is a program developed by the Engineering Library and the Engineering Technology Centers for engineering students (undergraduate and graduate) to submit a proposal to receive funding for prototyping/finishing their projects using the services offered through the Creative Space, Engineering Electronic Shop, and Machine Shop. Kick-Start award winners for 2018 – 2019 are:

"Air Chair"

Olivia Laux, Jared McClung, Kaylin Slinskey, Bryan Williams, and Lucinda Williamson

Traveling is stressful for most people but, imagine getting off a flight to discover you cannot get to your destination. This is the fear of wheelchair users every time they separate from their chairs. Our goal is to design a way to reduce damage to an individual's rigid, manual wheelchair during commercial travel in order to encourage confident and independent experiences. After consideration of the various approaches to solving the problem, protection of the wheelchairs is the focus. Stimulations of potential forces through impact and usability testing of the case will be performed to ensure the effectiveness of the design.

"Asonus Tech"

Adam Hoffman, Brandon Williams

For those with hearing loss, it can be a struggle to notice important environmental noises. This project focused on using noise classification software, on a wearable device, to alert users of important noises (e.g. doorbells, smoke detectors, alarms). Initial development of such a device began by using noise classification on a raspberry pi and 3D printing a housing to hold all other electrical components. This has now shifted to delivering the noise classification software through existing smart devices.

"Body Betty"

Libby Chelsvig, Emily Leibold

Body Betty is an interactive toy that educates anatomy through a fun app and doll. The app quizzes the user on basic anatomy and physiology of the human body. Betty wears different outfits, each of which is able to be connected to the doll, telling her what to ask the user. Both the app and the Body Betty doll can be used together or on their own. Through the use of fun graphics and the doll, this toy will be ideal for young girls as a way to teach them STEM concepts.

"Car Turbo Jet Engine"

Walker Jarvie, Greg Beaver

The objective of this project was to build a jet engine out of a common turbocharger from a car. The engine needed a commonly found fuel source and needed to be easily manufacturable using a MIG welder and common tools. The only goal of this project was to create a running engine, no thrust or efficiency requirements were set.

"Optimus Prone: Improved Shoulder Rehabilitation"

Jayme Waite, Cecily Calcopietro, James Cory, Isaak Moore, Dakota Streit

The purpose of this project is to develop a device to improve the rehabilitation for shoulder injuries. Current methods do not allow for appropriate muscle activation while performing various exercises. We are designing a device that allows for full range of motion, bilateral movement, and correct execution of exercises for shoulder rehabilitation.

“Root Canal Pal”

Annie Cahill, Ethan Slater, Collin Zweifel, Shao Yang Zhang, and Nina VanDerZanden

Existing research suggests that simultaneous stimulation of pressure-sensing nerve fibers can obstruct the perception of pain. This design functions to apply vibration to a key location of the facial area to reduce the pain experienced during dental procedures. This device could be utilized in clinical testing as an alternative pain reduction method.

“The Kineta Safety Device”

Ashley Mathews

Kineta is a wearable safety gadget used to pinpoint an individual's exact location in the event of a physical assault. The user's location is detected by a global positioning device (GPS). Upon button activation, Kineta immediately sends a signal to law enforcement while simultaneously emitting a 120dB sound to deter the perpetrator as well as drawing attention to the scene. The system specifically operates and functions using C++.

"Autonomous Detection of Martian Ion Trails Using Geometric Computational Techniques Mirela Kapo"

From previous missions to Mars, we learned that billions of years ago Mars had a denser atmosphere and liquid water on its surface. To understand where the atmosphere went, there was a need for an algorithm that would enable a large-scale automated statistical analysis of ion trails in the Martian atmosphere. We analyzed MAVEN data from the Solar Wind Ion Analyzer (SWIA) and applied two different mathematical techniques to develop an algorithm that would track and characterize the trails of escaping ions across multiple scales and apply it extensively across large volumes of SWIA data.

"Correcting Flat Feet by Reconstructing the Spring Ligament Using Fiber"

Casey L. Blaylock, John E. Femino, Karthikeyan Chinnakkannu, Jessica E. Goetz

The cause of flat feet stems from weakness in the spring ligament. Two cadaveric ankle specimens were mechanically tested to determine how the bones of the midfoot rotated when a torque of 8.5 Nm was applied to the tibia. Fiber tape was used to surgically repair several ligaments after they had been cut to create a flat foot model. As fixation of the navicular to the calcaneus increased, the axial rotation of the navicular decreased but when the navicular was fixed to the tibia and the calcaneus, the axial rotation of the navicular increased with the tibia.

"Development and Analysis of Viable Impaction Method of Dry Powder Antibiotic Aerosols on Pseudomonas aeruginosa Bacteria"

Christine Czarnecki, Mason Shriver, Jennifer Fiegel, Michael Crain-Zamora

Due to the presence of bacterial biofilms, bacterial infections in the lungs are often difficult to eradicate. This reduces the effectiveness of traditionally administered antibiotics. Our lab is developing combination therapies to increase the susceptibility of bacteria to antibiotics. The objective of this study is to develop a method for impaction of dry powder antibiotic aerosols on Pseudomonas aeruginosa bacteria. The antibiotic powders used in this study were generated using a spray dryer and contain a nutrient dispersion compound to increase bacterial exposure to the drug. The developed method involves viable impaction and image analysis using the ImageJ processing program.

"LCA analysis of Ultra HVDC Charging and Detachable Battery Packs"

Jingwen Chen

The purpose of this project is to determine which HVDC Charging and Detachable Battery Packs is most environmentally friendly throughout their life cycle.

"Microalgae-Yeast Co-Cultures to Improve Separability of Microalgae from Solution"

Emily Moore, Hannah Molitor, Jerald Schnoor

Microalgae grown on waste resources, such as powerplant emissions and wastewaters, are a sustainable alternative to resource-intensive conventional agriculture. Soy is one such resource-intensive crop that is typically used as a protein supplement to animal feed. High-protein microalgae can provide protein to animal feed while consuming fewer resources. However, there are still significant cost barriers to harvesting microalgae from dilute solutions; typical separation techniques require additional energy or chemical inputs. Growing co-cultures of microalgae with flocculating yeast provides an opportunity to reduce separation costs and maintain end-product nutrition. Here we show early results of the separability improvement between pure microalgal cultures and yeast-microalgae co-cultures.

“Photopolymerization Induced Phase Separation”
Katie O'Rourke, Erion Hasa, Dr. Allan Guymon

Polymers have their own distinct set of properties. Phase separation could lead to harnessing a better control over the properties of polymers. By selecting two monomers that utilize different reaction mechanisms phase separation was achieved. Different reaction mechanisms ensured that the monomers would not react with each other, thus creating their own domains of polymers. By creating different domains within a polymer, properties from each monomer can be combined into one polymer.

“Quantifying and Validating Computer Vision Algorithms for Ergonomic Analysis”
John Golec, Stephen Baek

Musculoskeletal Disorders, such as carpal tunnel syndrome, are the single most common workplace injury, affecting two million people a year. This is a result of poor work practices involving posture, repetition and force. Current practices for motion capture involve viewing long hours of video footage and adhering uncomfortable sensors to workers for task analysis. Furthermore, in these practices there is no scientific way to measure ergonomic risk in an epidemiological sense. Instead, with the use of Computer Vision, Deep Learning algorithms, and the REBA Assessment, we can quantify real-time ergonomic in an epidemiological way.

“Role of CDK8 Activity in Cardiovascular Disease”
Allison Vaske, Chad Grueter, Rachel Minerath, Duane Hall

After a traumatic event, such as heart attack, the heart has very little regenerative capacity. Failure of heart muscles encompasses numerous complex alterations at the molecular and cellular level, which often results in cardiac remodeling. Cardiac remodeling is characterized by change in size, structure, and function of the heart. Hyperactivity of CFs results in cardiac fibrosis, a scaring process by which fibroblasts accumulate and secret excess collagen. Excess collagen can generate stiffness, deformation, and interfere with electrical signaling within the heart. Although the role of CFs in cardiac remodeling has been established, relatively little is understood about the cardiac fibroblast transformation. Here we are investigating the role of the CDK8 gene in the transformation of fibroblast into cardiac fibroblast.

“Terahertz Rabi Oscillations in 2D Graphene-like Materials”
Qiutong Jin, David R. Andersen

When placed in a strong light field, electrons in a lattice tend to jump between energy bands with a certain frequency, which is known as Rabi frequency. The oscillation of electrons is also called Rabi oscillation, which contributes to the generation of current density. By conducting Fourier analysis of the current density, its harmonic spectrum (frequency spectrum) can be obtained. Here we extend the Rabi theory to Line-Centered-Square (LCS) lattice and graphene superlattices, and show that, when the lattice is subjected to a strong light field, it can exhibit Rabi oscillations, generate current density and show a unique frequency spectrum in a terahertz regime.

“TRACERS Spacecraft: ACE Structural Analysis”
Jesslyn Coghlan, Dr. Craig Kletzing, Dr. Scott Bounds, Rich Dvorsky

This research was performed to investigate the structural adequacy of the NASA proposal TRACERS's small science instrument called the Analyzer for Cusp Electrons (ACE). The findings of the analysis will provide physicist and engineers with benchmark data to determine if the current model design can withstand the random vibrations and peak accelerations experienced during spaceflight. Research was conducted using a 3D CAD model of the ACE instrument as well as Creo Simulate finite element analysis software. The idea is to provide insight into the model's weaknesses and propose remedies to the structural design flaws.

List of Poster Presenters by Academic Department

BIOMEDICAL ENGINEERING

Allen, Brittany
Blaylock, Casey
Burand, Anthony
Corrigan, Rae
Dobroski, Hannah
Guo, Zhihui
Haugen, Allie
Ho, Michael
Hu, Jianwei
Laux, Olivia
Moghram, Waddah
Mueller, Marissa
Remy, Matthew
Sarathy, Srivats
Schrodt, Michael
Shrestha, Arwin
Slater, Ethan
Stewart, Carley
Thompson, Jacob
Uthoff, Johanna
Waite, Jayme
Wendland, Rion
Xiong, Xiaofan

CHEMICAL & BIOCHEMICAL ENGINEERING

A'Hearn, Joe
Aljaafari, Haydar
Alsaedi, Abduldattar Hashim Ghanim
Buck, Rachel
Canby, Benjamin
Chen, Jingwen
Christiansen, Megan
Contreras, Marisol
Czarnecki, Christine
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