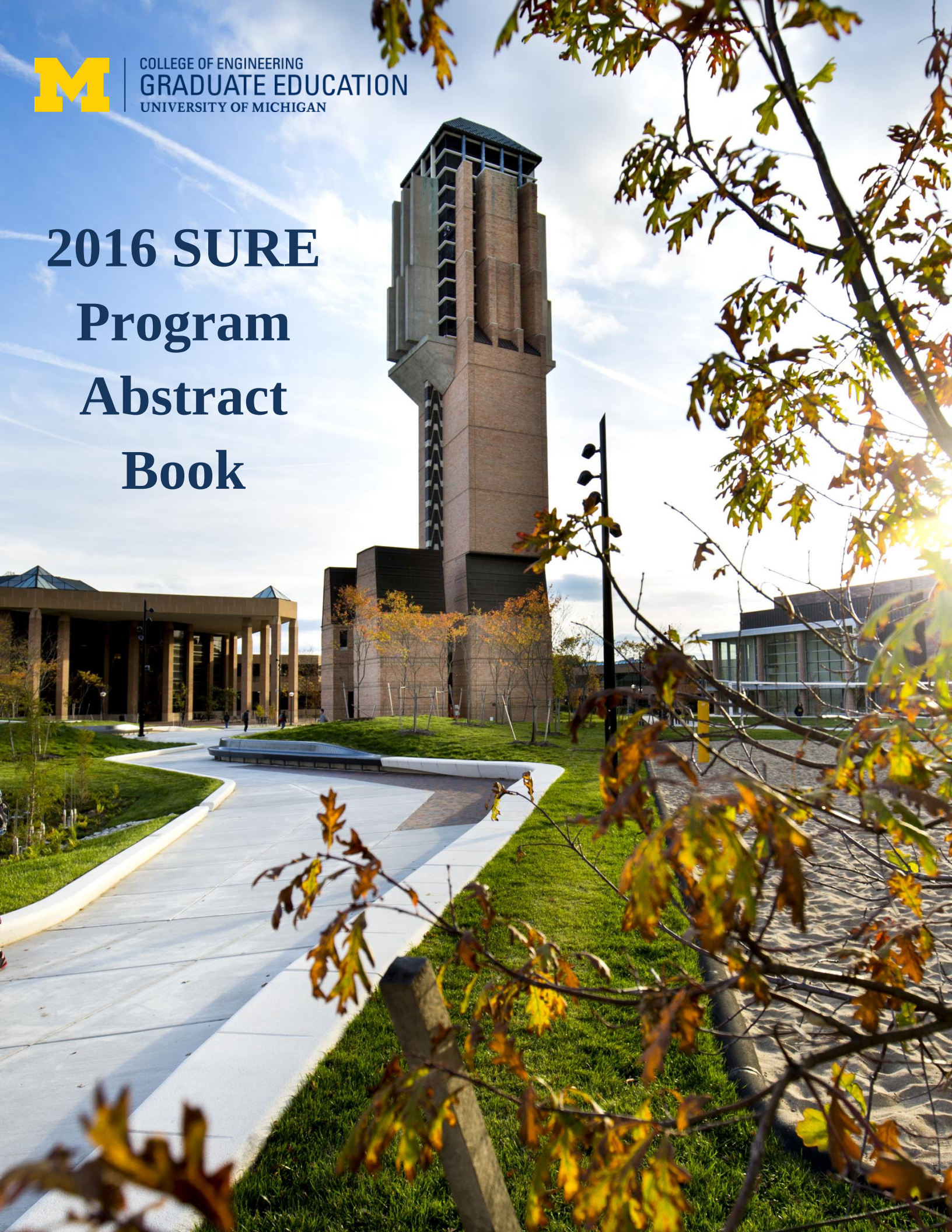
COLLEGE OF ENGINEERING
GRADUATE EDUCATION
UNIVERSITY OF MICHIGAN

2016 SURE Program Abstract Book



MDOlab Summer Research Experience

Josh Anibal[1]

[1]*Aerospace Engineering, University of Michigan, Ann Arbor, Michigan*

In traditional engineering design a system is pasted from one discipline to the next and optimized at each stage. However, because of the interactions between the different disciplines this process rarely results in the overall optimum design.
The research of the Multidisciplinary Optimization lab (MDOlab) is focused on using numerical tools to analyze the many disciplines that compose systems and finding a truly optimum design by considering the interactions of every discipline. The main numerical tools used are computational fluid dynamics (CFD) for aerodynamic analysis and finite element analysis (FEA) for structural analysis. Within the field of CFD there are many different variants, two the prominent are Euler based and RANS based CFD. In addition, there are a multitude of aerodynamic analysis methods with lower fidelity than CFD, one notable method being the panel method.
My research project was to use each of these different analysis methods at varying Mach numbers to optimize the shape of airfoil by reducing the drag while adhering to lift and moment constraints. The objective of the project is to characterize the differences between the levels of analysis so that by adjusting the results of a lower fidelity analysis the same accuracy of higher fidelity analysis can be achieved at less cost. In addition to that project, I was given the freedom to briefly experiment with analyzing the acoustic signatures of bodies under supersonic conditions. I learned a great deal from my summer research project and highly recommend the MDOlab and the SURE program in general.

Temperature and Power Dependencies in a Funtana Aircraft

Kathryn Henry[1]

[1]*Aerospace Engineering, University of Michigan, Ann Arbor, Michigan*

Small Unmanned Aircraft Systems can overheat in flight. Heat sources inside the fuselage include the battery and processors. This research focuses on characterizing temperature trends inside a Funtana aerobatic aircraft under different air flow and power demand conditions to identify what causes the plane to overheat. This can help prevent future overheating by managing heat load induced by the motor and processing systems.

Eight temperature sensors and two power sensors were distributed throughout the fuselage containing a LiPo battery, NVIDIA Jetson TK1 processor, and Arduino Uno microprocessor. This setup was tested over different load percentages of the Jetson central processing units (CPU) and graphics processing units (GPU), aircraft motor power load, ambient temperature, solar insolation, and location (outdoors or in a wind tunnel).

Tests determined that the Jetson reaches maximum temperatures while running high percentages of the CPU and GPU in direct sunlight on a hot day. Running the motor at low speeds maintains temperatures at steady state values except near the battery where it increases. At high motor speeds, fuselage temperatures are more affected by the rising battery temperature than the cooling airflow. After the motor is shut off, the battery temperature peaks and then cools. Therefore, the Funtana is most likely to overheat while running the CPU and GPU in sunlight with the motor off which corresponds to the grounded plane before or after flight. Additionally, maximum temperature values are reached after running the motor at high speeds for an extended time which causes overall temperatures to rise.

Auto-Merging System Using Non-Linear MPC Approach

Lixing Huang[1], Dimitra Panagou[2]

[1]Electronic Engineering and Computer Science, University of Michigan, Ann Arbor, MI [2]Aerospace, University of Michigan, Ann Arbor, MI

This project considers a road configuration in which a car intends to make a right turn from road A to road B or a car that is trying to merge from the ramp to the highway. The goal is to design a controller that leads our ego vehicle to perform a smooth transformation from following the center of the previous lane to the next lane and avoid any possible collision with the vehicle running on target road. The Model predictive control (MPC) method is introduced to solve this problem by computing an optimal trajectory in a finite horizon regarding to several constrains. The optimal control value in the first horizon will be applied on the system for one control interval. After this control interval, the new state of the system will be viewed as another initial state and the optimization problem will be solved again. This process keeps looping when the system evolves. Main tasks of this project is developing a nonlinear vehicle dynamics model, formulating the problem needed to be solved into MPC form and designing an object function that gives an appropriate assessment of the system. The proposed controller is the simulated in MATLAB code and the result suggests that the controller achieves the goal successfully. The main defect is that the computational time of solving the optimization problem takes too much time which makes the controller impracticable.

A Summary of Work in Spacecraft Relative Motion Control Lab

Sheng Li[1]

[1]*Aerospace Engineering, University of Michigan, Ann Arbor, MI*

This documentation keeps a record of my work in Spacecraft Relative Motion Control Lab in the summer 2016 from May to July. This Lab is still under construction. The purpose of Spacecraft Relative Motion Control Lab is to scale down the motion of real spacecraft to the Lab scale in both time and length, and to emulate the motion of spacecraft with Omni-directional robot. My summer work focuses on camera tracking system, robot control, and MPC controller. The main achievement of my work includes realizing the multiple-object tracking function for the motion capture codes which run on Raspberry PI, finding the method of automatic C code generation for MPC Simulink model, building a simple version of estimator for MPC controller in Simulink, having a primary understanding of the robot controller codes developed by Dominic Liao-McPherson and Richard Sutherland and how to control the motion of robot with their codes. My colleague Weitao Sun has developed the scaling blocks in Simulink. An integrated Simulink model includes scaling blocks, MPC controller blocks and estimator blocks is to be built for the next step.

A Combined Entropy Adjoint Approach to Mesh Refinement and Performance Analysis

Liang Liu[1]

[1]*Aerospace Engineering, University of Michigan, Ann Arbor, Michigan*

Meshes are used for spatial discretization in computational fluid dynamics, and mesh refinement is a common way, to obtain accurate flow predictions by selectively reducing mesh size in important areas. As sensitivities of the output of interest to local residuals, adjoints have been shown to be good indicators for mesh refinement in many previous works. In this work, we propose and implement a new combined adjoint approach, which uses output-based adjoint and entropy adjoint as two layers of indicators. The motivation of this new approach is the observation that the entropy adjoint alone tends to allocate extra refinement in regions with spurious entropy generation, while output-based adjoint alone tends to over-refine adjoint singularities. Proposed approach only refines the region where output-based adjoint and entropy adjoint agree, so we expect that less refinement will be allocated in two undesired regions, and thus computation cost can be reduced. For performance demonstration, the proposed approach is applied to a 2D NACA 0012 airfoil in laminar inviscid flow. Compared with other existing alternatives, the proposed approach shows a smaller computation cost to reach accuracy at the same level, in subsonic, transonic and supersonic conditions. Therefore, we conclude that the combined adjoint approach is a better indicator for the 2D inviscid airfoil model. We also notice that this conclusion potentially can extend to viscous and 3D cases with more tests.

SURE Experience: Active Aeroelasticity and Structures Laboratory

Aaron Lu[1]

[1]*Department of Aerospace Engineering, University of Michigan, Ann Arbor, Michigan*

High altitude long endurance (HALE) aircraft, such as Facebook's Aquila aircraft, are a stunning example of the increasing capabilities of aircraft. The Active Aeroelasticity and Structures Laboratory (A^2SRL) at the University of Michigan is developing a small-scale HALE aircraft to collect information about the flight characteristics of this class of aircraft. During the summer of 2016, the X-HALE project was working towards a ground vibration test (GVT) and a flight test of the vehicle; I had the opportunity to work with both projects.

The GVT is meant to test the natural frequencies of the X-HALE aircraft. However, before testing on the aircraft, similar vibration tests were conducted on aluminum beam. Using a shaker system and accelerometers, we could excite the beam and sweep across a frequency range. The accelerations and corresponding frequencies where then used to verify predicted natural frequencies from FEA solvers.

In preparation for the flight test, I conducted wing loading tests to determine bending and torsional constants which allowed us to verify tests from previous years. Also, I performed center of gravity and moment of inertia tests on the aircraft spines in preparation for the flight test. Additionally, the aircraft required new motor, electronic, and battery mounts which I was able to manufacture using various equipment such as a mill and 3D printer.

Overall, this was an enjoyable and exciting research project that allowed for practical, hands-on interaction with an aircraft. Many thanks to Professor Cesnik, Jessica Jones, and the members of A^2SRL for an excellent summer.

Simulation and Experiment for Multi-agent Dynamic Coverage Networks

Zhipeng Xu[1]

[1]*Aerospace Department, University of Michigan, Ann Arbor, United States*

I work with Prof. Dimitra Panagou and William Bentz in Aerospace department this summer for my SURE program. My task is developing a simulation environment and an experiment based on Prof. Dimitra Panagou and William Bentz's work on the Multi-agent Dynamic Coverage Networks. Prof. Dimitra Panagou has built local and global coverage strategies which force the agents to collaboratively search a domain of interest, and avoidance strategies which waive the assumption on only pairwise interactions among agents. I studied the Gazebo package in ROS(Robot Operating System) and established a simulation environment. The environment includes realistic obstacles like buildings people and cars. I wrote a cpp program to spawn and control 3 quadrotors in the Gazebo environment based on Prof.Dimitra and William's algorithms.

Then, I studied Rviz package in order to create a front camera on the quadrotors in the Gazebo environment. The camera can display the image in front of the quadrotor when the quadrotor is working in Gazebo simulation.

In the experiment part, I work on AscTec hummingbirds to realize the algorithm in the lab environment. First, I studied the Vicon package in ROS environment. I used the Vicon package to upload the position data of the quadrotor from the camera system in the lab into computer programs. Then, I studied the Quad package in ROS environment. I used radio module to communicate with quadrotor through the wireless network in the lab. Using the Quad package, I can control the quadrotor to move according to the commands and get position data from the quadrotor. Finally, I established the experiment environment successfully and let one quadrotor operating steadily according to the algorithm.

I think I made great progress in the SURE program. I get familiar with ROS environment both in simulation field and experiment field. The program also increases my ability in researching and establishing experiments. Thanks a lot to University of Michigan and Prof. Panagou for offering this great chance to me.

Designing, Manufacturing and Testing Porous Media Vaporizer

Flora Yoon[1], J.P. Sheehan[1], Ben Corson[2].

[1]Aerospace Engineering, University of Michigan, Ann Arbor, Michigan
[2]Mechanical Engineering, University of Michigan, Ann Arbor, Michigan

CubeSats, cube-shaped nanosatellite of 10 cm side length, offer small-scale space technologies for low cost and low mass. To broaden CubeSat application, a propulsion system is necessary for maneuvering. Water is an eco-friendly fuel that has many benefits. It has high specific impulse, it is safe and non-explosive, and has a high density, which makes it easier to be stored in a form of liquid. The SmallSat Water Tank Project team of University of Michigan is designing a device that stores and supplies water as its CubeSat propellant management system. The water passes through a vaporizer composed of porous metal disks, which then limits the flow direction and slows down the flow rate low enough to be vaporized. Using Darcy's Law and other basic fluid equations, flow characteristic assumption was made. Given the entering pressure from the water tank and assuming that water was kept at a constant heat, the simulation of density, pressure, viscosity and velocity of water theoretically stated that all water characteristics were to remain linear until the very end of the vaporizer. In addition to designing and manufacturing the vaporizer, the summer research was conducted to confirm the validity of these simulations. The preliminary tests with vacuum chamber and heating system validates the required length of 1 in and porosity of the overall vaporizer to be 14% in order for a surface vaporization to occur. The vaporizer produces 7.48 sccm of gas flow, a value suitable for the team's propellant management system.

Autonomous Vehicle Control by Finite State Machine Approach

Mengxuan Zhang[1]

[1]*Aerospace Engineering, University of Michigan, Ann Arbor, MI*

This project focuses on a finite state machine approach for autonomous vehicle control algorithms. We assume that we can make use of reasonable and accessible indicators (measurements) from previous work; then we leverage them for multi-lane highway vehicle control. We design a finite state machine that defines three longitudinal driving modes based on the preceding car's relative distance and speed, where each of the states corresponds to a specific control law. The vehicle may also consider a lane change behavior when the controller ensures both safety and larger rewards. The lane change function runs in parallel to the longitudinal motion. To seek more comfort satisfaction, we smooth out the acceleration jump between modes by adding dead bands and intermediate modes. To demonstrate this approach, we implement the state machine controller on a traffic simulator. The vehicles under different control policies interact well and perform reasonable driving behaviors and have reasonable collision rates for different traffic densities.

Working through the design process during in vivo testing to develop new testing equipment

Tess Bradley[1, 2], Lauren Zimmerman[1, 2], Kora Dreffs[3], Tim M. Bruns[1, 2]

[1]Department of Biomedical Engineering, University of Michigan, Ann Arbor, MI [2]Biointerfaces Institute, University of Michigan, Ann Arbor, MI

[3]Department of Neuroscience, Emory University, Atlanta, GA

Background: Female sexual dysfunction is a problem that affects up to 28% of women (Giraldi et. al 2013). Several studies have pointed to the effectiveness of in vivo models to measure the effect of arousal on vaginal blood flow using a Laser Doppler Flowmeter (LDF) probe. The main problem with the LDF probe during in vivo testing is trying to stabilize the probe to get accurate bloodflow readings without movement artifact.
Methods: This problem with the experimental setup led to a design challenge. Through emic observations and interviews with the primary users of the device within the lab, I was able to identify the main needs of the users during LDF use. From these, I identified user requirements and translated them into engineering specifications. Using several design ideology techniques, I came up with 100+ solutions for this design need and sorted them using a weighted design matrix. Then, I went through several rounds of prototyping-- starting with several common materials found in the laboratory and grocery stores and testing them in vivo.
Results: The type of material that has produced the most stable results comes from attaching a cuff of viscoelastic low-resilience polyurethane foam to silicone tubing (inner diameter 1.00 mm) using silicone glue. A testing apparatus made of 80/20 aluminum was added to give repeatability to the experimental setup. This design has led to stable readings during the two-hour trial window and satisfied both user requirements and engineering specifications.

Semi-Automated Measurement of Sarcomere Lengths of Engineered and Native Muscles

Marcus Lee[1], Brian Syverud[1], Lisa Larkin[1, 2]

[1]Department of Biomedical Engineering, University of Michigan, Ann Arbor, MI
[2]Department of Molecular and Integrated Physiology, University of Michigan, Ann Arbor, MI

Scaffold-less tissue engineered skeletal muscle units (SMUs) have potential to repair muscle damage. To translate engineered muscle through clinical trials to repair injuries such as volumetric muscle loss, noninvasive methods to ensure SMUs have the desired structure are needed. Two-photon microscopy can excite endogenous auto-fluorescence, removing the need for external labels in muscle, utilizing 2nd harmonic generation to "combine" infrared photons and double the energy absorbed by the target molecule to visualize myosin in muscle sarcomeres. However, researchers lack methods for quantitating resulting images. We hypothesize that a MATLAB function can measure sarcomere length (*L*s) efficiently and that *L*s of engineered and native muscle are comparable. Currently, *L*s is measured manually using ImageJ with some inefficiency, person-to-person variability, and lower precision. Instead, using MATLAB the Z-lines were identified to mark the bounds of sarcomeres, the basic structural units of muscle. In native muscle, *L*s measured with ImageJ was 1.60 ± 0.396 μm and this value was indistinguishable from *L*s (1.60 ± 0.355 μm) measured using MATLAB (p=0.999). *L*s of engineered muscle measured with ImageJ was 2.58 ± 0.102 μm again very similar to *L*s (2.58 ± 0.096 μm) measured using MATLAB (p=0.98). Importantly, previous work has shown average rat *L*s is 2.54 μm[1], and this value agrees closely with the *L*s in engineered muscle. The lower *L*s of native muscle may be due to tissue freezing and cryosectioning, unlike the engineered muscle. In conclusion, this program could help future success rates by ensuring only the most viable SMUs are implanted.

Dynamic transcription factor characterization of olaparib resistance in BRCA mutated cancer cells

Lauren Liebman[1], Joseph Decker[1], Lonnie D. Shea[1, 2]

[1]Department of Biomedical Engineering, University of Michigan, Ann Arbor, Michigan
[2]Department of Chemical Engineering, University of Michigan, Ann Arbor, Michigan

Poly(ADP-ribose) polymerase (PARP) inhibitors are used to treat BRCA mutant cancers by targeting DNA repair pathways. Olaparib, a PARP inhibitor, is approved for treating ovarian cancer, but its efficacy is compromised by the development of resistance. The dynamic regulatory changes that lead to PARP inhibitor resistance are not well understood. We investigated the dynamics during acquisition of Olaparib resistance in BRCA-mutated cells using a transcriptional activity cell array (TRACER). TRACER uses a series of luciferase reporter constructs to dynamically measure transcription factor (TF) activity in living cells. Lentiviral transduction of reporter constructs led to stable signal of the reporter construct, which allowed us to dynamically measure TF activity during acquisition of resistance to PARP inhibitor therapy. Over a period of six weeks, we induced Olaparib resistance in HCC1937 cells through treatment with increasing concentrations of Olaparib. The cells were transduced with TRACER reporters for 30 TFs and luminescence was measured six days per week for six weeks. The luminescence data was background corrected, normalized to a control reporter, and log transformed, after which statistics were performed comparing treated and untreated cells using the *limma* R package. Reporters for multiple TFs, especially MYC, PEA3, and RXR, showed significant differences ($p<0.05$) between control and treated cells beginning in the third week of treatment, with differences becoming more extreme with increasing olaparib concentration. Ongoing studies investigate the roles of these factors in the development of Olaparib resistance, with the objective of identifying targets to limit resistance and improve patient response to therapy.

MicroRNA Detection in Human Serum

Lili Tian[1], Nicholas Emery[2], Allen Liu[1,2,3]

[1]Biomedical Engineering, University of Michigan, Ann Arbor, MI
[2]Celluar and Molecular Biology, University of Michigan, Ann Arbor, MI [3]Mechanical Engineering, University of Michigan, Ann Arbor, MI

A low-cost, sensitive, and robust technology for cancer detection is the Holy Grail in cancer research. The purpose of this research is to detect circulating microRNA (miRNA) 141 in human plasma or serum, which could be a potential diagnostic and prognostic parameter in clinical applications. Our approach is inspired by the recent demonstration of paper-based microfluidics using synthetic biology approach based on cell-free expression and a RNA device called toehold switch for detecting miRNA. In order to detect the relatively low concentration of miRNA 141, a two-step, one-pot miRNA extension and amplification reaction is designed and used. MiRNA 141 acts as a primer which binds to a synthetic ssDNA oligonucleotide, initiating DNA synthesis by BSU DNA polymerase. Using the synthesized dsDNA as a template, an in vitro transcription reaction produces ssRNA that contains the sequence of the original miRNA plus a short extension sequence. The extended miRNA then acts as a primer for the BSU DNA polymerase reaction, allowing for exponential amplification. The extended and amplified miRNA 141 can trigger the toehold switch also present in the reaction, causing the in vitro translation of a colorimetric reporter protein. This research may lead to a cheap, easy, quick, and simple-to-use technology for early cancer diagnosis using miRNA as a biomarker.

Characterization of the long-term performance of a neural optoelectrode system

Mingxiao Zhang, Carlos Anaya, Komal Kampasi, John Seymour, Euisik Yoon

Department of Electrical Engineering and Computer Science, University of Michigan, MI

Optogenetics involves manipulation of neural circuits using a reliable light source of known irradiance while simultaneously recording electrical data from neurons. In this work, we characterized the long-term performance of a neural optoelectrode system (developed by Komal Kampasi, a graduate researcher at Yoon Lab, U of M). The optoelectrode design consists of 8 laser diodes (LDs) assembled at the backend of a 4-shank neural probe. Each shank has an integrated waveguide that can deliver light output coupled from 405nm and 635nm wavelength LDs, to activate or silence neurons in deep brain regions, respectively. The optoelectrode performance characterization from our current work reports:

- initial average baseline power output mean and variance of each type of LD.
- reduction in LD light output after pulsing them upto 600,000 pulses.
- difference in epi-side up and epi-side down eutectic bonding techniques for assembling LDs.
- temperature as a means to validate Comsol model and as a potential predictor of noise and early failure
- a LabVIEW GUI, interfaced with a DAC, to control the LDs.

Application of Engineered Cementitious Composites as an Enhanced Cement Sealant in CO_2 Sequestration Wells

Cameron Beversluis[1], Jubilee Adeoye[2], Alessandra Murphy[3]

[1]*Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI*

[2]*Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI*

[3]*Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI*

One of the most critical solutions for the reduction of CO_2 concentrations in our atmosphere is carbon capture and storage, or sequestration. The ongoing environmental concern of carbon storage is the debated security of CO_2 reservoirs and the timescale of leakage back into the atmosphere. Many studies have been conducted to estimate the rate of CO_2-acidified brine and supercritical CO_2 attack on wellbore cement along fractures and the cement-cap rock interface in wellbores, where leakage is most at risk. Many of these studies have shown conflicting conclusions in both penetration rates and likelihood of CO_2 leakage on a significant timescale, resulting in a remaining uncertainty. The purpose of this study is to test the application of self-healing cements, such as Engineered Cementitious Composite (ECC), as an improved wellbore sealant material for long-term CO_2 storage. Initial experiments involved the exposure of fractured ECC samples to scCO2 and CO_2-acidified brine in a batch reactor under in-situ wellbore conditions. SEM/EDS analyses of samples were performed to monitor self-healing properties and reaction zones in ECC samples. The data and observations from these experiments will serve as a baseline for future flow-through experiments, where dynamic factors and improved experimental parameters will allow for more accurate and significant results. The micro-crack-forming abilities of ECC, as well as its proven self-healing nature, result in the potential for self-healing cements to be an enhanced carbon storage wellbore sealant.

Nutrient Recovery through Urine Separation

Ishi Keenum[1], Heather Goetsch[1], Nancy Love[1], Krista Wigginton[1]

[1]Civil and Environmental Engineering, University of Michigan, Ann Arbor, Michigan

Urine has been identified as an alternate nutrient fertilizer to conventional mined phosphorus fertilizers. Source-separated urine can reduce loads on wastewater treatment plants and provide a renewable source of nutrients. This research assesses lettuce and carrot crops when fertilized with source-separated urine applied as a pasteurized liquid product, a solid fertilizer (struvite, $NH_4MgPO_4 \cdot 6H_2O$), synthetic fertilizer, and two non-fertilized controls with and without plants. Experiments for this SURE project were conducted in the Environmental Biotechnology group under Drs. Love, Wigginton and PhD candidate Heather Goetsch. The content of urine applied to the field, urine used to make struvite, effluent from the struvite reactor, and runoff water collected from each plot were analyzed for total nitrogen, magnesium, potassium, total ammonia nitrogen and total phosphorus. Total nitrogen concentrations in urine were 4000 mg/L and in runoff water were 20.5 mg/L. Total phosphorus urine concentrations were 380 mg/L and .05 mg/L in runoff water. No difference was observed ($p < 0.05$, ANOVA) in runoff water masses of total phosphorus and most total nitrogen plots treated with different fertilizers. Nitrogen masses in runoff had one case where runoff from fertilized plots differed significantly from the control plot with no plants. This research shows that urine derived fertilizers result in similar nutrient runoffs compared to commercial fertilizers and unfertilized plots. The use of pasteurized urine and urine derived struvite could provide the United States and the world with a renewable fertilizer at no additional risk for downstream algal blooms.

Incorporating Non-Traditional Materials in Structures for Earthquake Response Reduction

Carolyn McCann[1]

[1]*Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, Michigan*

Hollow structural sections (HSS) can be used in a variety of structures such as buildings, bridges and cranes. ASTM A1085 HSS is a new specification that can be used to improve performance in these structures while being more cost effective compared to the previously used A500 Grade B. For the HSS beam members used in the research, tension and charpy v-notch tests were required to ensure the HSS complied with the ASTM A1085 specifications. For the tension testing, specimens were cut out of flats, corners and welds of 6 different sized HSS members. Using the MTS 22kips machine, the specimens were all displaced at a constant rate and the corresponding force and strain were recorded using an extensometer. These values and the cross sectional area were then used to graph stress vs. strain. With further analyzing, the ultimate stress and strain, yielding stress and strain and elastic modulus were found. These values were all compared to each other along with the ASTM A1085 requirements. For the charpy v-notch tests, 6 specimens were cut out of each of the 6 different sized beams. A pendulum was held at a designated height with a certain amount of energy. When it was dropped, the head swung and broke the steel specimen; the amount of energy the steel absorbed was recorded. The values of all the specimens were then averaged and again compared to the ASTM A1085 requirements. Once all of the tests are completed, ASTM A1085 HSS can be tested as full size beams.

Formation of MHC Class II Multimers

Lester Lee[1], Mason Smith[1], Andrew Zak[1], Prof. Fei Wen, PhD[1]

[1]Department of Chemical Engineering, University of Michigan, Ann Arbor, MI

In the field of immunology, groundbreaking research is being done to improve the method of using a patient's own T-cells to suppress malignant tumor growth. Research in cancer immunotherapy so far however has been hindered by the relative rarity of functional cancer specific $CD4^+$ Helper T-cells. These cells play fundamental roles in regulating immune responses and producing antibodies. Their receptors have weakly bound interactions with antigens from Class II peptide-Major Histocompatibility complexes (pMHCs).

Practices that have emerged to detect $CD4^+$ T-cells involve the use of tetramers, four-sided constructs capable of presenting four pMHCs. In an effort to improve our ability to capture rare and weakly interacting T cells, we are constructing a variation of tetramers by incorporating a system of multimeric complexes. We are hoping that these newly generated multimers will make improvements on many methods in which tetramers are being used for today. With the engineered multimers that can present many different peptides, we will be able to capture many different varieties of T-cells which, once captured, can have many uses in cancer immunotherapy.

Using Visible Light to Enhance the Activity of Ethylene Epoxidation on Bimetallic Silver-Palladium Catalysts

Alexander Marmorale[1], Umar Aslam[1], Suljo Linic[1]

[1]Department of Chemical Engineering, University of Michigan, Ann Arbor, MI 48109

The primary function of a catalyst is to reduce the activation barrier between the reactants and products of a chemical reaction. Catalysts are commonly used for large scale industrial reactions such as ethylene epoxidation, to produce high-value chemicals and intermediates. Traditionally, a silver catalyst is used to promote the partial oxidation of ethylene to ethylene oxide. Carbon dioxide, an undesired product, is also produced by the complete oxidation of ethylene. In a system in which multiple reactions are present, selectivity and activity are the two performance measurements of a catalyst. Shining visible light on silver nanoparticle catalysts has been shown to increase the activity by transferring the energy of an excited electron from the catalyst to the adsorbate, activating a chemical transformation. The addition of palladium to silver catalysts is a method used to increase the selectivity to ethylene oxide for the reaction. The pairing of the palladium promoter and the photo-catalytic properties of silver nanospheres was used to create a more selective catalyst than monometallic silver that can be actively enhanced by visible light. The hypothesis was validated by plotting the selectivities of the various palladium loaded and monometallic silver catalysts against their respective reaction rates. From the data collected, it was observed that the silver-palladium nanospheres retained the photo-enhancement properties of silver and showed an increase in selectivity of up to 30% compared to monometallic silver. The most selective catalyst was found to contain about 2% palladium. However, as the loading of palladium in each catalyst increased, the overall activity decreased.

Hard-Particle Monte-Carlo Self-Assembly Simulation of Binary Systems of Convex Polyhedra

Kyle Pettibone[1], Carl Simon Adorf[1], Sharon C. Glotzer[1,2,3]

[1]Department of Chemical Engineering, University of Michigan, Ann Arbor, MI 48109
[2]Department of Materials Science and Engineering, University of Michigan, Ann Arbor, MI 48109 [3]Biointerfaces Institute, University of Michigan, Ann Arbor, MI 48109

From nanoparticle crystals to fire ant rafts, self-assembly is a ubiquitous and naturally occurring phenomenon. This study defines self-assembly as the ordering of hard convex polyhedra due solely to entropic interactions. Computational models aid investigating into the basic physics underlying self-assembly behavior. Simulated self-assembly of different polyhedra into complex structures motivated my SURE 2016 research project: Does a system of two distinct, but similarly shaped, polyhedra still self-assemble into the known unary structure? To answer this question I computationally compressed simple-cubic lattices equally distributed with 50/50 mixtures of 4,096 hard polyhedra to packing fractions within the self-assembly regime. Next, I performed 10 million Monte Carlo sweeps on the compressed systems. Bond order diagrams indicate that some, but not all, binary systems self-assemble into the same structure as their constituents do individually. All simulation scripts were written in Python for utilized software packages, including the general-purpose particle simulation toolkit HOOMD-blue developed in the Glotzer group at the University of Michigan. Each simulation was performed in parallel on 8
CPUs on the University of Michigan's high-performance compute cluster, Flux.

Dental Caries diagnosis and treatment with multi-compartmental starch nanoparticles

William J. Troske[1], Nathan Jones[2], Brian Clarkson[3], Joerg Lahann[1,2]

[1]Department of Chemical Engineering, University of Michigan, Ann Arbor, Michigan

[2]Department of Macromolecular Science and Engineering, University of Michigan, Ann Arbor, Michigan

[3]Department of Cariology and Endodontics, The Dental School, University of Michigan, Ann Arbor, Michigan

Dental caries is a significant medical issue that will affects almost everyone during their life. Early caries are reversible, but without proper treatment they become cavities that need filling. The current dentist-recommended methods of caries diagnosis are unchanged in almost a century, struggle in identifying early active caries, and risk damaging the patient's teeth. Our research is developing a targeted nanoparticle for identifying early active caries in combination with a fluoride remineralization treatment. In previous work, we found that fluorescently-labelled starch nanoparticles chemically altered with positive charges can target and illuminate active caries for easy visualization with use of a standard dental composite curing lamp. Research this summer focused on verifying the specific targeting of active caries and validating the non-permanence of the dye after washing. We also explored the potential for loading fluoride in particles for targeted caries treatment, and a release study was performed to determine a fluoride release profile. Additionally, particle preparation by electrohydrodynamic co-jetting was tested as a means of preparing bicompartmental particles for combined fluorescent imaging and fluoride release.

Our results validated that cationic starch nanoparticles consistently target active caries while leaving healed caries and healthy teeth particle-free. The fluoride release study showed only a slightly delayed release that we plan to extend by jetting larger, cross-linked particles. The jetting process is being optimized to achieve properly sized particles stabilized by cross-linking. With continued research these particles have potential for earlier diagnosis, and targeted treatment changing the way dentists manage caries worldwide.

Engineering an Efficient Oxidoreductase Pathway on a Synthetic Metabolic Scaffold in *Saccharomyces Cerevisiae*

Mingcheng Yi[1], Hui Gao[1], Fei Wen[1]

[1]*Department of Chemical Engineering, University of Michigan, Ann Arbor, Michigan*

As an important alternative of fossil fuels, biofuels have been considered a sustainable solution with various economical and environmental advantages. To produce biofuels from biomass such as starch or sugarcane, the traditional ethanologenic yeast, *Saccharomyces cerevisiae*, has become a common choice as the production host. This is mainly because yeast has a short doubling time, ease of genetic manipulation and high tolerance of ethanol. Despite of these advantages, the yeast cannot metabolize xylose, which is a pentose from hemicellulose and is abundant in many types of plant biomass. In order to produce ethanol more efficiently and economically, the yeast needs to be engineered to utilize xylose.

We integrated three types of enzymes into the yeast genome to enable xylose utilization. Xylose is converted to D-Xylitol by xylose reductase (XR) and then into D-Xylulose by Xylitol dehydrogenase (XDH) and finally into Xylulose 5-phosphate by Xylulokinase (XK). The Xylulose 5-phosphate can be metabolized by pentose phosphate pathway and finally converted into ethanol. In order to increase the efficiency, we created a novel synthetic metabolic scaffold that contains the three enzymes. Although the efficiency of ethanol production can be improved with the scaffold, the main bottleneck of the process is the low expression level of the XDH protein. In order to overcome this bottleneck, we've applied the CRISPR gene editing method to integrate more copies of XDH into the yeast genome.

Enabling diverse and robust microbial co-cultures through temperature regulation

Jeff Jiahao Zhang[1], Adam Krieger[2], Xiaoxia Nina Lin[1]

[1]Department of Chemical Engineering, University of Michigan, Ann Arbor, MI [2]Cellular and Molecular Biology PhD Program, University of Michigan, Ann Arbor, MI

Microorganism mediated conversion of biomass to bioproducts is a highly promising environmentally friendly alternative to petro-based processes. In contrast to conventional "superbug" approach that incorporates all of the components of a process into a single organism, multi-species communities can be more versatile and efficient. However, challenges in maintaining multi-species systems remain. To address this, we are developing a new method for enabling diverse and robust microbial co-cultures through temperature regulation. Our initial proof-of-concept co-culture consists of two species, *Escherichia coli* and *Pseudomonas putida,* each of which can be specialized for certain biochemical functionalities. We have used temporal alternation between optimal growth temperatures of the two species to enable their coexistence and regulate the composition of the system. With this method, which has never before been used in a biotechnological context, we have been able to maintain coexistence of both species for an extended period of time. We have also developed a mathematical model to explore stable coexistence in the design space of the system. Three parameters, growth rate difference of the two species at alternating temperatures, time interval ratio, and dilution factor of passage, were identified as the key factors that determine the behavior of the system. We further identified conditions that would lead to coexistence according to an analytically deduced phase diagram. Experimental work to test these model predictions are currently underway and future work will include establishing systematic design principles for enabling and tuning microbial co-cultures using this new technology platform.

Aramid Nanofiber Film Fabrication through Microfluidics

Yu Tao Zhang[1], Ahmet Emre[2], Priyan Weerappuli[2], Shuichi Takayama[2,4,5], Nicholas Kotov[1-5]

[1]Department of Chemical Engineering, University of Michigan, Ann Arbor, MI 48109, USA
[2]Department of Biomedical Engineering, University of Michigan, Ann Arbor, MI 48109, USA [3]Department of Materials Science and Engineering, University of Michigan, Ann Arbor, MI 48109, USA
[4]Department of Macromolecular Science and Engineering, University of Michigan, Ann Arbor, MI 48109, USA
[5]Biointerfaces Institute, University of Michigan, Ann Arbor, MI 48109, USA

This research aims to produce thin films from aramid nanofibers (ANFs) through microfluidic technique. ANFs are made from Kevlar with high strength, modulus, and toughness. Dispersed ANF has a diameter typically at 3 to 100 nanometers, while its length is around 5 to 20 times greater than its diameter. Dispersed ANF is passed through microfluidic device for polymerization to happen. Each uniquely designed microfluidic devices to investigate the effects of flow rates, concentration, print thickness and channel width on the properties of ANF. The fabrication of the microfluidic devices is based primarily on the techniques of soft lithography, which includes rapid prototyping and replica molding. The anticipated outcome of this research is to produce repeatedly coated layers of ANF films using the LBL technique in microfluidics, which may be developed into ANF thin film battery. This will be particularly useful as a battery for biomedical devices, because of its high flexibility, strength, and toughness, and its high reliability and safety.

AGARSoC: Automated Test and Coverage-Model Generation for Verification of Accelerator-Rich SoCs

Harrison Davis[1], Yijun Hou[1], Biruk Wendimagegn Mammo[1], Doowon Lee[1], Valeria Bertacco[1]

[1]Electrical and Computer Engineering, University of Michigan, Ann Arbor, Michigan

AGARSoC is a proposed solution to the problem of verifying the complex interactions between accelerators in an accelerator-rich SoC (system on chip). It aims to observe the interaction scenarios commonly used by the SoC's software, so that it can generate a complete accelerator usage coverage-model and generate tests for the SoC while it's in the RTL (register-transfer level) verification stage. Our build analyzes software on high-level simulation models and gathers these common accelerator interaction scenarios into an abstract representation that can be used in generating the desired coverage model and tests. Two differing SoC designs were used to validate our solution: a SoCLib ARM platform in SystemC and a MicroBlaze platform in RTL. Yijun and I were tasked with generating unique accelerator usage patterns in software for the ARM platform. We learned to work with the SoCLib platform and were able to create a layer of abstraction that allowed us to write software with unique accelerator interactions by simply change a few arrays. By comparing our software's known accelerator usage to that of AGARSoC's coverage model and generated tests, we were able to quickly and efficiently debug our solution and simultaneously generate results for the paper. Our experiments show that AGARSoC is able to identify frequently exercised scenarios, extract coverage models, and generate compact, high-quality tests for these two completely different SoC designs.

Sniffer: A High-Accuracy Malware Detector for Enterprise-Based Systems

Yijun Hou[1], Harrison Davis[2], Evan Chavis[3], Salessawi Ferede Yitbarek[4]

[1]Electrical and Computer Engineering, University of Michigan, Ann Arbor, Michigan
[2]Electrical and Computer Engineering, University of Michigan, Ann Arbor, Michigan
[3]Electrical and Computer Engineering, University of Michigan, Ann Arbor, Michigan
[4]Electrical and Computer Engineering, University of Michigan, Ann Arbor, Michigan

Nowadays, both malware and antivirus technologies are trying hard to leverage ever lower layers of the software system stack in order to control upper layers in the system. Therefore, several recent papers discuss the possibility of enlisting hardware support for security. While the ideas show promise, these hardware-assisted approaches still rely on software-only feature monitoring, which are vulnerable to attack. In this project, we present SNIFFER, a malware detection solution that identifies malware by tracking its system-level behavior. It has three steps. First, SNIFFER leverages in-hardware feature monitoring to get feature data, such as user time and the number of page faults, below all malware. Then it transmits measurement to a set of trusted servers on the network operations center in a timely and secure manner. Finally, SNIFFER uses machine learning to analyze whether there exists malware. We run experiments with a simulated SNIFFER that supports 13 features and tests against five common malicious behaviors under different uses. Our results show that SNIFFER misses malware at a rate of 0% except when attack rates are very low. It has a low false alarm rate. Besides, we change malware's rate of attack and find out that SNIFFER can detect the malware at an attack rate in all but two cases. Furthermore, we list the minimal combination of features for machine learning classifiers, which seems to be multiple unrelated features for most of the malware.

Application of Deep Generative Models on car/MNIST/LFW image generation and 3D object reconstruction

Yijie Guo[1]

[1]*Computer Science & Engineering Department, University of Michigan, Ann Arbor*

Deep generative models is a branch of unsupervised learning techniques in machine learning. This research project mainly focuses on using recent generative models to generate 2D images or 3D volumes.

Our project explores using Variational Autoencoder (VAE) approach, Generative Adversarial Network (GAN) approach, and the combination of these two (VAEGAN) on a new car dataset. Our architecture of VAE performs well to reconstruct input images, and generates reasonable but blurry car images from random noise. Our GAN net shows more clear generation but lacks inference net to study latent representation. VAEGAN model works better and contains more details in the reconstruction and generation images.

We also builds recurrent neural network to make sequential (conditional) variational autoencoder, which improves the generation on MNIST and LFW dataset. Although the performance of our experiment does not beat that of published paper work, we notice the power of sequential VAE to refine the blurry images of generated hand-written digit step by step. For sequential conditional variational autoencoder (CVAE), the human face images are iteratively constructed through an accumulation of modification.

What's more, for single-view 3D object reconstruction project, we implement both the orthogonal projection and the perspective projection, so that projection loss can be used as a part of the objective function to train the 3D volume reconstruction network. In this way with projection loss, the encoder-decoder network can be trained only from 2D observations, without accessing the 3D volume of target objects.

Computational Strategic Reasoning

Ashley Hou[1]

[1]*Computer Science and Engineering, University of Michigan, Ann Arbor, MI*

Empirical game theoretic analysis (EGTA) is an approach for building and analyzing game models using empirical data. It can be used to make policy recommendations in fields like finance, computer security, and automotive regulatory compliance. The quality of predictions from EGTA rest on computing accurate Nash equilibria, however computing Nash equilibria in games with unplayed strategy combinations remains an open problem. EGTA uses deviation-preserving reduction (DPR), a player reduction method for computing Nash equilibria. A proposed alternative method is performing Gaussian process regression on simulation data to learn strategy payoff functions.

We developed an experimental framework to evaluate the accuracy of Nash equilibria identified. Accuracy is measured by regret, the maximum utility a player could gain through a unilateral strategy deviation. Because we can only observe random draws from an unknown regret distribution, we want to be able to report 95% upper confidence bounds on regret. We sample the payoff distribution of each deviation, such that we can construct a confidence interval around the mean of the greatest deviation gain. However, sampling every deviation results in generating unnecessary samples from strategies that are unlikely to provide more information about regret. Therefore, we employ a sequential sampling method characterized by two stopping conditions: when the 95% confidence interval on the greatest payoff distribution is below a threshold and when to stop sampling unnecessary deviations early. Preliminary results indicate that this sequential method saves a significant amount of time and that equilibria obtained using regression appear competitive with those from DPR.

AGARSoC: Automated Test and Coverage-Model Generation for Verification of Accelerator-Rich SoCs

Harrison Davis[1], Yijun Hou[1], Biruk Wendimagegn Mammo[1], Doowon Lee[1], Valeria Bertacco[1]

[1]Electrical and Computer Engineering, University of Michigan, Ann Arbor, Michigan

AGARSoC is a proposed solution to the problem of verifying the complex interactions between accelerators in an accelerator-rich SoC (system on chip). It aims to observe the interaction scenarios commonly used by the SoC's software, so that it can generate a complete accelerator usage coverage-model and generate tests for the SoC while it's in the RTL (register-transfer level) verification stage. Our build analyzes software on high-level simulation models and gathers these common accelerator interaction scenarios into an abstract representation that can be used in generating the desired coverage model and tests. Two differing SoC designs were used to validate our solution: a SoCLib ARM platform in SystemC and a MicroBlaze platform in RTL. Yijun and I were tasked with generating unique accelerator usage patterns in software for the ARM platform. We learned to work with the SoCLib platform and were able to create a layer of abstraction that allowed us to write software with unique accelerator interactions by simply change a few arrays. By comparing our software's known accelerator usage to that of AGARSoC's coverage model and generated tests, we were able to quickly and efficiently debug our solution and simultaneously generate results for the paper. Our experiments show that AGARSoC is able to identify frequently exercised scenarios, extract coverage models, and generate compact, high-quality tests for these two completely different SoC designs.

A Glance of Quantum Algorithms and Quantum Machine Learning

Xuefeng Hu[1]

[1]*Computer Science Engineering, University of Michigan, Ann Arbor, Michigan*

The objective of this project is to be familiar with the foundation of quantum information, to understand and master the basic knowledge of quantum algorithms, and to master one or some of the fields or problems that are related to quantum algorithms or quantum machine learning. In this project, I have studied the basic knowledge and the foundation of quantum information, and get to learn and master the important theorems, methods and frameworks of quantum algorithms such as Grover Search Algorithm, Quantum Fourier Transformation, Phase Estimation, Shor's Algorithm, Amplitude Amplification, Discrete and Continuous Quantum Random Walk and some proof tricks of the Query and Gate complexity. Then, I have researched about the existing results of quantum machine learning algorithms such as Quantum Support Vector Machine and Quantum Kernel Method. Finally, I spend some substantial time to learn and master the quantum algorithms and complexity lower bound of solving linear systems and Hamiltonian Simulation problem, since efficiency of many quantum Machine Learning algorithms is guaranteed by the efficiency of those problems. Now I am working on the possibility to make some original work on the Hamiltonian Simulation problem, and I may continue working on this project in the following Fall semester.

Opacity Verification for UMDES

Dylan Lawton[1]

[1]*Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan*

The work completed this summer involves an extension of DESUMA, a graphical interface for modeling of discrete event systems, and UMDES, the library of routines used for manipulation of these systems. These systems are modeled as finite state automata. DESUMA and UMDES work in tandem to provide the user with a tool to create, analyze, model, and manipulate discrete event systems in their many applications. Specifically, extensions were made in the form of new algorithms for verification of different types of opacity. Opacity is a characteristic of a discrete event system, namely, a system is opaque if it is able to protect its secrets from an outside intruder. A system achieves opacity if it is able to confuse the intruder by making certain that the intruder is unable to deduce the secrets of the system by observation. Algorithms were designed to test for current state, initial state, and K-step opacity. Work has been completed in integrating these new features into the current software package, DESUMA. The new algorithms intend on maintaining the integrity of DESUMA as a complex piece of software and seek to improve the research and studies of others in the field of discrete event systems. Those who use DESUMA will be pleased by the additions, for security and safety of our systems is becoming a heightened study. Work to integrate new functionality will be conducted into the fall. Work on UMDES was done under the supervision of Dr. Stéphane Lafortune and in collaboration with Janice Richards.

Automatic Speech Recognition Model Training

Yuxin Liu[1]

[1]*College of Engineering, University of Michigan, Ann Arbor, Michigan*

I worked for the Sapphire advising system, a student advising system based on artificial intelligence techniques. It is designed to enable students to get advised on topics such as course selection, when faculty advisors are not available. My work focused on two components: automatic speech recognition (ASR) and data annotation. ASR: I used the open-source toolkits Kaldi, OpenFST and SRILM to build and train language models. Kaldi is a toolkit for building ASR systems. OpenFST is used to build finite state transducers for speech recognition. SRILM is used to train (n-gram) grammar language models. I implemented an ASR system and created a detailed documentation for the training and decoding processes, including: training with specified small grammars, training with larger n-gram grammars, and methods to add new words to the language model that are not contained in training utterances. Data annotation: I annotated speech data collected in student advising sessions, to describe various properties (e.g., the level of energy in the dialog). These annotations will be used to guide the development of automatic behavior recognition algorithms. Further, the results can be used to enhancethe accuracy of speech recognition. I learned a lot from this research experience, and thank Professor Emily Mower Provost for the great help she gave me throughout the summer.

Learning to Classify Normal/Abnormal Phonocardiograms

Cheng Perng Phoo, Jenna Wiens

Department of Computer Science and Engineering (CSE), University of Michigan, Ann Arbor

Algorithms for the robust detection of cardiac abnormalities in phonocardiograms (PCGs) or heart sound recordings have the potential to induce a more rapid and effective treatment procedure for patients. Despite decades of research on the problem, key technical challenges remain. In particular, PCGs are subject to temporal variations due to heart rate and the signal collection environment, which in turn can lead to inter-subject and inter-population variability. To address these issues, we explore Dynamic Time Warping (DTW) – an algorithm extensively used in the field of speech recognition to align speech signals spoken at different rates. Applied to PCGs, we use DTW to find a *medoid* heartbeat for each record (i.e., a heartbeat that is most similar to all other beats in the recording). Using this medoid heartbeat, we extract statistical features that capture variability within a recording. We also generate templates of heartbeats from normal and abnormal PCGs and measure the DTW distance from each template to each beat in a record. Statistical features based on these DTW measurements are then used as input to a supervised learning algorithm to learn a support vector machine classifier. Applied to held-out test set, our classifier generalizes well, detecting normal/abnormal records with a sensitivity of 0.830 and a specificity of 0.817.

Private Information Retrieval

Jessica Thompson[1], Yaoyun Shi[2]

[1]Department of Mathematics , University of Michigan, Ann Arbor, MI

[2]Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI

This project focused on studying and improving quantum private information retrieval (QPIR) protocols. In a classical private information retrieval (PIR) protocol, a user retrieves data from a database without disclosing what data was retrieved. The trivial solution is the only information theoretic secure solution using only one server. However, the use of multiple servers provides better results. In a QPIR protocol, communication between the user and the server is done using quantum channels, which leads to a reduction of communication costs. We also studied the relationship between PIR protocols and locally decodable codes (LDC). An smoothly decodable LCD can be used as a PIR protocol by using the code to encode the database.

Active Learning and Crowdsourcing Interface

Yanqi Wang[1]

[1]*Computer Science and Engineering, University of Michigan, Ann Arbor, MI 48109*

Crowd-sourcing is a useful means of obtaining labeled data for some tasks whose requirement cannot be reached by current artificial intelligence technique. Crowd-sourcing is defined as the process of completing such tasks by a large group of people. We sometimes call the process “artificial” artificial intelligence. The crowd-sourcing service is helpful, while the cost for a large project could be unaffordable if the dataset is too large. That’s how the Active Learning algorithm comes. An effective active learning algorithm could help the user decide which questions to ask and when to ask the crowd.

Our job is to implement a web interface to achieve the interaction between the Active Learning framework and Amazon Turk (a crowd-sourcing platform). Active Learning algorithm decides the specific questions to ask to the crowd, and through our interface, those questions can then be posted to Amazon Turk to wait for completion by Amazon Turk Workers. The interface allows the user to upload the dataset and set specific project parameters for the crowd-sourcing process. At the same time, Active Learning algorithm runs, and those algorithm-selected questions are then posted to Amazon Turk for further labelling, and the status of each posted assignments are kept updated by a user-specified time interval and returned to the interface for review. Currently, we work on the web interface and the interaction with Amazon Turk. The next step of our work will be coordinating with the Active Learning framework to achieve the full function of our web interface.

Image and Text Embedding with Deep Learning

Luyao Yuan[1]

[1]*Computer Science, University of Michigan, Ann Arbor, Michigan*

Matching images with their text descriptions is a challenging machine learning problem for both computer vision and natural language processing. In this project, we explored approaches for embedding images and their descriptions in the same feature space. More specifically, if an image patch and a sentence express similar meanings, we would make them have alike or compatible features in the embedded space. The embedding is learnt with recent deep learning techniques, and it is applicable to real-world applications, such as object detection and image retrieval.

In particular, our work started with extracting features with deep neural networks from images and text separately. We adapted state-of-the-art deep neural networks for text classification and image classification for effective feature extraction. The models that we end up with in both text and image domain are convolutional neural networks (CNNs). We transferred knowledge from pre-trained models and fine-tuning them with our datasets. After training models in each domain independently, our next goal is to match related images and text descriptions together, with their features provided. To this end, we trained a Siamese network on top of the domain-specific CNNs. We generated training and testing data in various difficulty levels, explored the effectiveness of our models with multiple datasets (e.g., VisualGenome, MS COCO) and compared their performance with existing baselines.

Ultra-low Power Circuit Design for Millimeter Sized Sensor Nodes

Junjie Dong[1]

[1]*Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan*

This summer I worked in Professor Blaauw's group and completed a circuit design project. The objective of the project is to design and verify a deep-sleep circuit for a stacked deep-sleep system. The deep-sleep system includes several layers such as processor layer, flash layer, sensor layer, etc. The circuit was integrated with a power management unit and taped out in TSMC 180nm technology.

The deep-sleep circuit that I worked on includes a deep-sleep timer, a state machine, a register file, level converters, power switches, reset detectors, power on reset, etc. The deep-sleep circuit disconnects the entire stacked system from the battery when in deep-sleep mode, and resets the power management unit during the system wake-up process. The circuit especially the timer targets low power operation at high temperature. The timer was designed for up to 140 degree, and achieves low frequency variation across different temperature and supply voltages.

Underlying Models of HVAC Systems and Buildings in Energy Plus

Chen Fu[1]

[1]*Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI*

EnergyPlus is a software developed by NREL, which produces realistic simulations of heating, cooling and ventilation systems in buildings. It allows the user to import a designed building structure, set the HVAC or radiant system parameters from wide variety of options, and choose the weather data for the region that building is located in. Based on these parameters, it simulates the behavior of the building with associated parameters in a realistic manner. The underlying models that are employed in Energy Plus are complicated and mostly nonlinear state space models.

The main objective of this project is to identify the underlying model of EnergyPlus by analyzing basic physical equations and relationship of parameters within HVAC systems. Based on the model, we expect to build a similar model with simpler representation while maintaining the accuracy and several characteristics of the original model. After obtaining the model, we check the feasibility of the model by doing validation. When we guarantee the correctness of the model, we will further impose some faults on the model and apply the fault detection approach developed in our group recently.

Near-Optimal Online State Estimation with Persistent Sensor Faults

Lingyun Gao [1], Sze Zheng Yong [2], Necmiye Ozay [3]

[1] *EECS, University of Michigan, Ann Arbor, MI*

[2] *EECS, University of Michigan, Ann Arbor, MI*

[3] *EECS, University of Michigan, Ann Arbor, MI*

The purpose of this research is to estimate the state of an aircraft electric system with persistent sensor faults through active sensing. By selecting a set of controllable contactors and observing the potentially faulty sensor readings, we aim to reduce the uncertainty about the unknown state. We develop a greedy strategy that maximizes the one-step gain in uncertainty reduction. By showing that the conditional expected marginal benefit is adaptive monotonone and approximately adaptive submodular, we derive a worst case performance guarantee for the greedy strategy. In our simulations with different circuits, we observe that our greedy strategy performs just as well as a brute-force strategy.

Local Radius Index Metrics for Texture-Based Identification of Tree Bark

Abhinav Reddy[1], Shen Jin[2]

[1]*Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan*

[2]*Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan*

The goal of this project was to identify the species of a tree from a photo of its bark using a metric based on Local Radius Index (LRI). LRI is a texture analyzing feature that uses a histogram-based method to classify an image by its inter-edge distances. Our project applied a metric based on LRI and two other features, Local Binary Patterns (LBP), and Subband Contrast Distribution (SCD) to characterize differences between images. Our focus lay mainly on methods to combine these features together to determine the species of an input, or to output several possible species. With an initial database of 190 pictures comprised of 19 species, our metric delivered promising results. For a test that output one species per image, our method was 78% accurate. After removing species determined to be too difficult to identify, lowering the database size to 140 pictures of 14 species, the accuracy of a the same experiment rose to 91%, and the accuracy of a multiple species output experiment was 94%.

Expanding to a database of 600 pictures comprised of 20 species, the metric's success did not retain a satisfactory level. For single species output the accuracy was 54%, for multiple species, the accuracy was 69%. After identifying difficult pictures in this database, lowering the size to 560 images, the accuracy rose to 76% for multiple output experiments. The results likely deteriorated due to the increase in database variance. This project, despite the final results, shows the value of LRI+ for texture identification.

Long-Term Impact of Faculty Development Program on Student Evaluations of Teaching

Julia Kerst[1]

[1]*Department of Electrical and Computer Engineering, University of Michigan, Ann Arbor, MI*

Despite the vast amounts of research about active learning pedagogies and their benefits in the classroom, many engineering faculty still have not implemented them. There are many factors for this lack of adoption, and at the University of Michigan, we have developed a faculty learning community program to address some common barriers. Faculty participants in the program meet monthly during one semester to discuss active learning pedagogies and strategies for successfully adopting them.

As one way to assess the impact of the program, we studied student evaluation data for faculty who participated in the program and for a control group of faculty who did not. Student evaluations have been shown to be an especially influential motivator in faculty decisions to adopt active learning pedagogies, and they can provide substantial feedback on how students view these practices.

Our study consisted of 81 engineering faculty members of differing departments, genders, and ranks. Of these, 40 faculty had participated in the faculty learning community program (the “intervention” group), and the other 41 had applied to participate but, due to budgetary limitations, were not accepted (the “control” group). As is standard practice in our university, students in every course were invited to complete an end-of-semester student evaluations of teaching form. The online form included four standard items and other items selected by the college, department, or individual instructor.

For the 81 faculty in this study, we analyzed student evaluations data for al academic terms from Fall 2008 through Winter 2016. We excluded courses that were graduate level, that had fewer than five responses, or that were independent studies. We then identified 12 items from the student evaluations data that had both an adequate number of student responses and that were particularly relevant to our study. Next, for every academic term in which the instructor taught, we computed an item-by-item average response for each instructor, and then we compared those term-by-term responses to identify the impact participating in the program In particular, for every instructor we studied the linear trend for each of the 12 items for the terms before the instructor applied to participate in the faculty learning community and for the terms after the instructor applied (Note that, for instructors in the intervention group, the term the instructor applied is the term they participated in the faculty learning community, an on average, we have student evaluation data for 10 terms before the instructors applied and 8 terms after).

Overall, we found no significant differences between the mean evaluation scores of the two groups, both before and after participation in the program. However, when comparing the linear models of the control and intervention groups, we did find a significant difference. In other words, whereas the slopes for our control group in the pre- and post-application periods remained stagnant or slightly declined, the slopes for the intervention groups steadily increased. This shows that the faculty learning community does foster improvement over time, whereas growth for those faculty who did not participate in the program remained steady.

Layer By Layer Dip Coater

Zidong Li[1]

[1]*EECS, University of Michigan, Ann Arbor, Michigan*

Dip coating refers to the immersing of a substrate into a tank containing coating material, removing the piece from the tank, and allowing it to drain. My job is to design and build a Layer By Layer Dip Coater that can automatically finish these complicated processes. The design could be divided into four parts. Firstly, I designed the robot arm controlled by Raspberry Pi. Instead of using DC motors and stepper motors, I used three much more precise servo motors to build this robot arm which can rotate and extend in the XoY plane. Then I drilled 19 holes on a 36''×36'' wooden board in order to hold 18 beakers that contain chemical reagents. Place the robot arm in the central hole and place all 18 beakers around it. Next, I bought a 7 inch touchscreen and used a 3D printer to print a case for the touchscreen which can contain the Raspberry Pi, the power adapter, the motor driver board, etc. After connecting the machine and the control box, I began the software part. Since the Raspberry Pi has GPIO interface, it can easily control the servo motors. So I designed a Graphical User Interface including Auto Mode, Manual Mode and Calibration Mode. In the Auto Mode, the users need to select the beakers and input the dip coating time then the machine can handle the rest of the work while users can also manually control the robot arm in the Manual Mode.

Extremely Tight Focusing for Super High Intensity

Mark Mathis[1], Anthony Dostine[2], Cynthia Kaullen[3], Zhaohan He[4], John Nees[4]

[1]Department of Electrical Engineering, University of Michigan, Ann Arbor, Michigan
[2]Department of Aerospace Engineering, University of Michigan, Ann Arbor, Michigan [3]Department, Polytech Paris-Sud, Orsay, France
[4]Center for Ultrafast Optical Science, University of Michigan, Ann Arbor, Michigan

Medical procedures like eye surgery use lasers at high intensities to perform precise tasks. For lasers with a given energy, a smaller focus and shorter pulse duration produce higher intensity. Obtaining a minimal focal size may be expected when introducing dipole-like radiation to a focal region because atoms are typically modelled as dipoles and atomic emission is the smallest source of light. Previous analytical work shows that radially polarized light focused by a parabolic mirror resembles the dipole electric field pattern, but reversed. This experiment uses a parabolic mirror that covers a 2π steradian solid angle to focus radially polarized light. However, the mirror has minor optical aberrations, so the focus is imperfect. Furthermore, the focal geometry precludes inserting an optic to view and correct the light at focus. Though the focus is flawed, it reaches intensities strong enough to break down air and generate a small plasma. We seek to improve the focus by optimizing a spatial light modulator (SLM) using a gradient ascent algorithm in which the intensity of the breakdown plasma emission ranks various SLM figures. This approach improves the wavefront of our system, allowing breakdown of air to be driven by an order of magnitude less energy. Ongoing research seeks to reduce this energy further. This data suggests that the breakdown of air could be used to obtain a better focus. Since the dipole focus generated mimics atomic emission in reverse, this might be of interest in studying the nature of atoms in strong fields.

Local Radius Index Metrics for Texture-Based Identification of Tree Bark

Abhinav Reddy[1], Shen Jin[2]

[1]*Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan*

[2]*Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan*

The goal of this project was to identify the species of a tree from a photo of its bark using a metric based on Local Radius Index (LRI). LRI is a texture analyzing feature that uses a histogram-based method to classify an image by its inter-edge distances. Our project applied a metric based on LRI and two other features, Local Binary Patterns (LBP), and Subband Contrast Distribution (SCD) to characterize differences between images. Our focus lay mainly on methods to combine these features together to determine the species of an input, or to output several possible species. With an initial database of 190 pictures comprised of 19 species, our metric delivered promising results. For a test that output one species per image, our method was 78% accurate. After removing species determined to be too difficult to identify, lowering the database size to 140 pictures of 14 species, the accuracy of a the same experiment rose to 91%, and the accuracy of a multiple species output experiment was 94%.

Expanding to a database of 600 pictures comprised of 20 species, the metric's success did not retain a satisfactory level. For single species output the accuracy was 54%, for multiple species, the accuracy was 69%. After identifying difficult pictures in this database, lowering the size to 560 images, the accuracy rose to 76% for multiple output experiments. The results likely deteriorated due to the increase in database variance. This project, despite the final results, shows the value of LRI+ for texture identification.

Using LabVIEW to take Hall Measurements of Semiconductor Samples

Jason VandenBerg[1,2], Vishal Subrahmanyam[1,2], Prof. Rebecca L. (Becky) Peterson[1]

[1]Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan [2]These authors contributed equally to this SURE project

The HL5500PC is a device used to measure the resistivity and the Hall voltage of semiconductor samples at varying currents. In this project, we use LabVIEW, a low-level graphical programming language, to create a new user interface in order to automate commands issued to the device. The motivation for this project is to create a hands-off way to send commands so time can be spent doing other tasks. Automation of the machine began by first analyzing how the machine operated and communicated when sending commands in the original user interface. By utilizing a GPIB analyzer and serial sniffer we were able to analyze the commands sent between the PC and device via a General Purpose Interface Bus (GPIB) and RS-232 bus. Once we figured out the functionality of the original user interface, we needed to write code to mimic the commands that were being sent on the bus lines. We chose LabVIEW to rewrite the original program due to its simplicity in device communication and ease of program development. In our program, users are able to type code in our predefined syntax to take measurements of their choice and the program will take those measurements without supervision. Add-ons, such as a repeat function and timestamp data, are improvements on the original program which merely displayed data. After creating the new user interface, we tested to make sure the program produces results similar to those of the original user interface. We found that the results vary only slightly, making it usable for further experiments.

Using LabVIEW to take Hall Measurements of Semiconductor Samples

Jason VandenBerg[1,2], Vishal Subrahmanyam[1,2], Prof. Rebecca L. (Becky) Peterson[1]

[1]Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan

[2]These authors contributed equally to this SURE project

The HL5500PC is a device used to measure the resistivity and the Hall voltage of semiconductor samples at varying currents. In this project, we use LabVIEW, a low-level graphical programming language, to create a new user interface in order to automate commands issued to the device. The motivation for this project is to create a hands-off way to send commands so time can be spent doing other tasks. Automation of the machine began by first analyzing how the machine operated and communicated when sending commands in the original user interface. By utilizing a GPIB analyzer and serial sniffer we were able to analyze the commands sent between the PC and device via a General Purpose Interface Bus (GPIB) and RS-232 bus. Once we figured out the functionality of the original user interface, we needed to write code to mimic the commands that were being sent on the bus lines. We chose LabVIEW to rewrite the original program due to its simplicity in device communication and ease of program development. In our program, users are able to type code in our predefined syntax to take measurements of their choice and the program will take those measurements without supervision. Add-ons, such as a repeat function and timestamp data, are improvements on the original program which merely displayed data. After creating the new user interface, we tested to make sure the program produces results similar to those of the original user interface. We found that the results vary only slightly, making it usable for further experiments.

A Bisimulation-like Algorithm for Abstracting Control Systems

Andrew Wagenmaker[1], Necmiye Ozay[1]

[1]*Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI*

Motivated by the recent interest in abstraction-based correct-by-construction control synthesis, in this paper we propose a new algorithm to construct finite abstractions for “large”, possibly infinite, transition systems. As opposed to the standard bisimulation algorithms that create a partition of the state space, the new algorithm uses overlapping subsets of the state space as the states of the abstraction. We show that the output of the new bisimulation-like algorithm preserves realizability of linear-time properties. Several interesting prop- erties of the algorithm are analyzed. In particular, when a finite bisimulation of the original system exists, the new algorithm is shown to always terminate in a finite number of steps. Moreover, we show with an example that even when the original system does not have a finite bisimulation, the new algorithm can result in a finite transition system whose infinite traces are equivalent to those of the original system. In the second part of the paper, we focus on the application of this algorithm to construct finite abstractions for discrete-time linear control systems and discuss several of its advantages over the standard bisimulation algorithm. Finally, the new algorithm is compared to the existing algorithms with some numerical examples.

Automated Cell-Laser Lysis

Henry Wang[1], Yu-Heng Cheng[2]

[1]*Department of Electrical and Computer Engineering, University of Michigan, Ann Arbor, MI*
[2]*Department of Electrical and Computer Engineering, University of Michigan, Ann Arbor, MI*

Our goal is to be able to easily sequence and analyze circulating tumor cell samples. These cells are unique between each other, so individual cell analysis is preferred; however, the samples these cells come in typically have moderate contamination—the samples usually include other cells such as white blood cells. Because of the nature of these samples, in order to properly analyze these cells, we required a system that could separate cells for individual analysis and could discriminate between different types of cells. The separation of cells could be done by using a pre-existing device that takes in a sample and separates cells into individual chambers using microfluidic properties. For discrimination between types of cells, this could be done using a program that utilizes computer vision functions. In order to analyze the cells after they've been automatically identified, we will lyse them for RNA analysis via automated laser fire. The system we created to analyze the samples works by first using a device to filter the sample of cells into individual chambers so that each chamber contains only a small amount of cells. Next, an image of the cell-loaded device is processed in order to find all chambers that contain a single tumor cell. The system then goes to these chambers and lyses the proper cells via laser fire. With the system we have created, we are able to take in a sample of circulating tumor cells and, once loaded into our device, automatically lyse them for analysis.

Investigating Efficiencies of Demand Response Events in Large Commercial Buildings

John R. Wolfe[1], Dr. Johanna Mathieu[2]

[1]*Electrical Engineering, University of Michigan, Ann Arbor, Michigan*

[2]*Electrical and Computer Engineering, University of Michigan, Ann Arbor, Michigan*

This summer I worked with Dr. Johanna Mathieu and her colleagues. I contributed to their research on HVAC system performance and efficiency during demand response events. Demand response describes the process in which consumers reduce or shift their electrical consumption during peak periods when the reliability of the grid is at stake.

We worked with a lab located in New Mexico which subjected its building to signals to induce demand response events; we were provided with their system's data so that we could analyze it in order to see the effects these events had. I developed programs to process the data into a useable form where I could then generate plots of data sets, calculate metrics, and relate different measurements to each other to determine correlations and relationships to ultimately understand the dynamics of the system.

The most important program I developed was one that found baseline estimations for power data which was collected from days containing demand response events – the purpose of this was to find accurate estimations of what the power demand would have been if there had not been an event. From there I was able to calculate efficiencies for these events based on the power data and the baseline.

Based on the knowledge we gained through the summer, we designed a new set of experiments for the lab to perform on their system which will allow us to further investigate the efficiency of buildings during demand response events.

Thin film transistor modeling and circuit implementations

Chengpei Xi[1]

[1]*Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI*

PetersonLab is developing new thin film technologies and devices to enable “Electronics on Anything”. The group uses liquid inks for 3-D additive deposition of high-quality semiconductors, transparent conducting oxides, and high-k dielectrics, to build high-performance electronic and optoelectronic devices.

The aim of my SURE project was to build an electrical model for the thin film transistors fabricated, and to design circuits based on the model. During the project, I built a VerilogA model for the thin film transistors, and designed circuits with the model.

The VerilogA model is based on the BSIM3 MOSFET model, with changes applied to characterize some particular properties of our own transistors, including the “super-linear” I-V property in the linear region. The model can reflect the transistors’ key physical properties measured, and is reliable for circuit simulation.

Basic circuit elements are designed using the model derived. Inverters, level converters and operational amplifiers are fundamental circuit elements, and are important to any further applications for thin film transistors. For circuit fabrication, layouts were drawn.

I really appreciate the support of the SURE program, for the great research opportunity and experience it provides. And I am grateful for Professor Peterson’s instructions, it’s a pleasure to work in PetersonLab.

Wavefront Engineering using a Spatial Light Modulator

Colin Yule[1] and Anthony Grbic[1]

[1]*Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan*

Phase retrieval techniques are implemented using a reflective phase-only spatial light modulator (SLM) to shape the intensity of optical wavefronts. The relative phase of incident light depends on the orientation of liquid crystals in the SLM, which is controlled by an applied voltage. The required SLM phase pattern is found using a modified Gerchberg-Saxton algorithm: an iterative algorithm which relates the wavefront in the SLM plane and the observation plane through a Fourier transform. A fast Fourier transform of the SLM phase pattern and amplitude of the illumination at the SLM is computed to find the observation plane field. The amplitude at the observation plane is then replaced by the desired amplitude. An inverse fast Fourier transform of this modified observation plane field is then computed to find the field at the SLM. This process is repeated until the phase pattern of the SLM converges from a random initial pattern to the pattern needed to form the desired amplitude profile at the observation plane. A theoretical method to independently control both the amplitude and phase of a wavefront with a single phase-only SLM involves displaying two different phase patterns side by side on the SLM and reflecting the wavefront so that it is incident once on each phase pattern. The first pattern creates the desired intensity in the plane of the second pattern, which imparts the specified phase. This has applications in optical tweezing and trapping, creating three dimensional holographic images, and light transmission through random media.

AGARSoC: Automated Test and Coverage-Model Generation for Verification of Accelerator-Rich SoCs

Harrison Davis[1], Yijun Hou[1], Biruk Wendimagegn Mammo[1], Doowon Lee[1], Valeria Bertacco[1]

[1]Electrical and Computer Engineering, University of Michigan, Ann Arbor, Michigan

AGARSoC is a proposed solution to the problem of verifying the complex interactions between accelerators in an accelerator-rich SoC (system on chip). It aims to observe the interaction scenarios commonly used by the SoC's software, so that it can generate a complete accelerator usage coverage-model and generate tests for the SoC while it's in the RTL (register-transfer level) verification stage. Our build analyzes software on high-level simulation models and gathers these common accelerator interaction scenarios into an abstract representation that can be used in generating the desired coverage model and tests. Two differing SoC designs were used to validate our solution: a SoCLib ARM platform in SystemC and a MicroBlaze platform in RTL. Yijun and I were tasked with generating unique accelerator usage patterns in software for the ARM platform. We learned to work with the SoCLib platform and were able to create a layer of abstraction that allowed us to write software with unique accelerator interactions by simply change a few arrays. By comparing our software's known accelerator usage to that of AGARSoC's coverage model and generated tests, we were able to quickly and efficiently debug our solution and simultaneously generate results for the paper. Our experiments show that AGARSoC is able to identify frequently exercised scenarios, extract coverage models, and generate compact, high-quality tests for these two completely different SoC designs.

AGARSoC: Automated Test and Coverage-Model Generation for Verification of Accelerator-Rich SoCs

Harrison Davis[1], Yijun Hou[1], Biruk Wendimagegn Mammo[1], Doowon Lee[1], Valeria Bertacco[1]

[1]Electrical and Computer Engineering, University of Michigan, Ann Arbor, Michigan

AGARSoC is a proposed solution to the problem of verifying the complex interactions between accelerators in an accelerator-rich SoC (system on chip). It aims to observe the interaction scenarios commonly used by the SoC's software, so that it can generate a complete accelerator usage coverage-model and generate tests for the SoC while it's in the RTL (register-transfer level) verification stage. Our build analyzes software on high-level simulation models and gathers these common accelerator interaction scenarios into an abstract representation that can be used in generating the desired coverage model and tests. Two differing SoC designs were used to validate our solution: a SoCLib ARM platform in SystemC and a MicroBlaze platform in RTL. Yijun and I were tasked with generating unique accelerator usage patterns in software for the ARM platform. We learned to work with the SoCLib platform and were able to create a layer of abstraction that allowed us to write software with unique accelerator interactions by simply change a few arrays. By comparing our software's known accelerator usage to that of AGARSoC's coverage model and generated tests, we were able to quickly and efficiently debug our solution and simultaneously generate results for the paper. Our experiments show that AGARSoC is able to identify frequently exercised scenarios, extract coverage models, and generate compact, high-quality tests for these two completely different SoC designs.

Using LabVIEW to take Hall Measurements of Semiconductor Samples

Jason VandenBerg[1,2], Vishal Subrahmanyam[1,2], Prof. Rebecca L. (Becky) Peterson[1]

[1]Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan [2]These authors contributed equally to this SURE project

The HL5500PC is a device used to measure the resistivity and the Hall voltage of semiconductor samples at varying currents. In this project, we use LabVIEW, a low-level graphical programming language, to create a new user interface in order to automate commands issued to the device. The motivation for this project is to create a hands-off way to send commands so time can be spent doing other tasks. Automation of the machine began by first analyzing how the machine operated and communicated when sending commands in the original user interface. By utilizing a GPIB analyzer and serial sniffer we were able to analyze the commands sent between the PC and device via a General Purpose Interface Bus (GPIB) and RS-232 bus. Once we figured out the functionality of the original user interface, we needed to write code to mimic the commands that were being sent on the bus lines. We chose LabVIEW to rewrite the original program due to its simplicity in device communication and ease of program development. In our program, users are able to type code in our predefined syntax to take measurements of their choice and the program will take those measurements without supervision. Add-ons, such as a repeat function and timestamp data, are improvements on the original program which merely displayed data. After creating the new user interface, we tested to make sure the program produces results similar to those of the original user interface. We found that the results vary only slightly, making it usable for further experiments.

Influence of Gender and the Teaching Circle Participation on Student Evaluations of Teaching

Hanna Pfershy[1]

[1]*SURE student, University of Michigan, Ann Arbor, Michigan*

Though many engineering faculty would like to introduce more active learning practices in their classroom, many feel ill-equipped to do so. Even though these practices are shown to improve student performance, many cite student resistance as a major barrier. At the University of Michigan, Professor Cynthia Finelli has introduced a faculty professional development program, called the Teaching Circle, which allows faculty to discuss implementing active learning practices. We gathered data from student evaluation of teaching surveys, shown to be effective in representing the opinions of the students, to determine if the Teaching Circle helped faculty successfully implement active learning practices with positive feedback from students.

We studied 81 engineering faculty, all of whom applied to participate in the Teaching Circle. Of those, 41 were selected to take part in the Teaching Circle (intervention group), and because of limitations in program space, 40 were not selected to participate (control group). As is true for every student at University of Michigan, students in all courses in this study were invited to complete an end-of-semester student evaluation of teaching form, which includes four standard items and additional items selected by the individual instructor, department, and college. We analyzed student evaluation data for all 81 instructors in this study for all academic terms beginning in Fall 2008.***

There were no differences in ratings between the intervention and control groups, but we observed that women in the intervention group had significantly lower scores than males in the group and females in the control group before the intervention. After intervention, there was only one survey item from one semester in which the intervention female group was significantly lower than any other. This suggests that The Teaching Circle especially benefits women, and it has long lasting effects up to the 6 semesters after the program we observed.

Optimizing Marker Placement for Body Postural Angle Analysis

Maggie Hafers[1], Sol Lim

[1]*Industrial and Operations Engineering, University of Michigan, Ann Arbor, MI*

[2]*Industrial and Operations Engineering, University of Michigan, Ann Arbor, MI*

Currently, motion capture systems are used as the primary tool for evaluating ergonomic posture assessment. When large amounts of markers are placed on the body during dynamic work tasks, it becomes increasingly difficult for the video cameras to pick up these markers and provide valuable data. The capture system can also confuse closely located markers and swap their marker labels.

Optimizing marker placement on the body is crucial to collecting clean data that is used for analyzing body posture angles. Six participant trials were conducted using small, triangular marker triads on the subject's upper and lower arms and legs along with 39 additional passive markers placed on major body landmarks. After the participant trials ended, triads of both active and passive markers were tested on the larger rectangular triads. The motion capture data from both triad sizes was analyzed using QTM software.

QTM software showed a larger number of gaps and marker swaps in between motion capture camera data when the triad markers were placed closer together on the triangular triads during the participant trials. When the markers were spread out on larger rectangular pieces and then strapped to the body, the video camera coverage of the markers increased by 20-30%. Minimizing the number of gaps in between motion capture data by determining the best available marker placement on the body is crucial for gathering important posture assessment data. By increasing the distance between markers, video camera systems can more easily identify and collect data, which yields more conclusive results.

Improvements to a Driving Simulator for Human Factors Testing

Kevin Li[1]

[1]*Industrial and Operations Engineering, University of Michigan, Ann Arbor, MI*

Within the University of Michigan's Transportation Research Institute is a large-scale driving simulator with a full-size vehicle cab and highly accurate eye tracking system. The simulator gets the most attention because it is the most visually impressive. However, there is a second driving simulator at UMTRI (in Dr. Paul Green's) lab which was designed for easier access and modifications, and cost 1/15 as much to build. The operating cost is much lower as well.

This summer I participated in a number of activities to improve the low-cost simulator. Previous research suggests motion sickness is due to subjects having a visual and physical disconnect with using the simulator. Initially, we added sub-acoustic vibrators to simulate road vibration the driver could experience. Specifically, we added four sub-acoustic vibrators, three to the seat and one below the steering wheel.

I also spent time exploring the availability and merits of motion platforms most commonly used by racing game simulator hobbyists. Because these systems are intended to be used at home, these motion bases tend to be compact, cost less, require less power, and have fewer degrees of freedom of motion. We recently purchase a motion base and installation is in process.

To support future research proposals, I examined the literature on vehicle warning algorithms for distraction, with the intent of implement one or more in the driving simulator for demonstration purposes. Opposed to simple thresholds, modern vehicles use machine learning to detect variations in the driver's state to determine driver distraction. Due to the difficult nature of programming machine-learning software, we chose to explore alternative algorithms like AttenD.

Summer 2016 SURE Program Experience at CHEPS

Meng Sang

[1]*Industrial and Operations Engineering, University of Michigan, Ann Arbor, MI*

In summer of 2016, I worked on three projects at the Center for Healthcare Engineering and Patient Safety (CHEPS) under Professor Amy Cohn. One of the projects is called Provider Scheduling, which involves writing C++ code to incorporate restrictions such as resident programs, levels, clinic days, maximum shifts, bad sleep patterns and build optimal schedules for residents at UM Hospital using linear programming. In the second project, Aviation, data from Bureau of Transportation Statistics were analyzed using Python and SQL to look at delays, cancellation, and network structures of airports and assess their relationship with capacity reduction and possibly with weather with R. The third project, SCOPES, which stands for Systems Concepts for the Optimization and Personalization of Endoscopy Scheduling, which aims to schedule patients based on multiple factors in order to maximize the utilization of resources in the endoscopy unit, such as reducing waiting time of the patients, idle time and overtime of the nurses and providers in all three process: intake, procedure, and recovery. Multiple metrics we came up with were used to evaluate the quality of a schedule with multiple scheduling heuristics we came up with.

Working at CHEPS has been a precious experience for me. One of the biggest reasons would be that I am able to find people with different backgrounds such as IOE, CS, pre-med, med, and nursing. There were many things I was able to learn from my peers when working on projects. At the same time, I was also able to teach them something that I know from my previous experience. Everybody was so friendly to work with!

Simulating Human Motion in Lightweight Flexible Material Handling

Tianke Wang[1], Justin Haney[1]

[1]Department of Industrial and Operations Engineering, University of Michigan, Ann Arbor, Michigan

Digital human modeling (DHM) software allows workstation designers to estimate the physical demands of a task such as, body postures, reach capability, and clearance. Currently, DHM software lacks the ability to simulate tasks that involve the handling of flexible continuous material such as threads and films. The overall objective of this study is to develop algorithms to predict postures associated with handling of these materials that can be implemented in DHM software. An experiment was conducted that required subjects to thread string though a sequence of pulleys in order to determine the influence of pulley design parameters, pulley locations, and threading direction on hand motion trajectory and threading time. Three motion capture markers were placed onto the back of the hand to track hand position throughout the experiment. The objective of this summer research was to develop a Graphical User Interface (GUI) to process the raw motion capture data files to estimate the fingertip-thread grasp position and to segment the files based on task conditions. The GUI loads in raw data files for each threading trial and plots each marker trajectory. The program is able to: (1) remove errant data, (2) interpolate missing data, (3) filter the data through a low-pass filter, (4) separate each sequence into the five trials corresponding to each individual pulley, and (5) saves each pulley location condition as a separate data file. These files will then be inputted into another program to calculate relevant kinematic variables and task threading times.

Coronary Vessel Segmentation and Stenosis Detection Using Image Processing Techniques

Yuxuan Chen[1, 2], Reza Soroushmehr[2], Kayvan Najarian[2, 3]

[1]School of Information, University of Michigan, Ann Arbor, MI, USA

[2]Department of Emergency Medicine, University of Michigan, Ann Arbor, MI, USA

[3]Department of Computational Medicine and Bioinformatics, University of Michigan, Ann Arbor, MI, USA

Coronary artery disease (CAD) is one of the leading causes of death. Atherosclerosis is a type of CAD which can be detected in coronary angiograms. However, current diagnosis of this disease relies on human visual examination of angiograms which could result in errors such as the under- and over-calling of lesions. This project consists of developing algorithms to help cardiologists in the diagnostic process by using various image processing techniques to better find and determine the level of stenosis present in X-ray angiogram videos of a patient. Our proposed method determines the existence of stenosis by taking an X-ray angiogram video as input, choosing specific frames that show the vasculature better, and applying various image processing techniques such as Gaussian filtering, Hessian filtering, and contrast enhancing to the frames in a way that compensates for noise, video quality, and moving objects. The proposed method maps out the major blood vessels, calculates the widths of those blood vessels, and determines whether or not there is stenosis based on the width calculations. Calculation of the width of a vessel is performed by extracting the skeleton of the segmented images and finding the perpendicular line to each pixel on the skeleton. If there is stenosis present, the proposed method calculates its severity and marks it on the output result. The goal of this project is to assist healthcare professionals in their decision on patients' needs for stent placement in a major blood vessel for the treatment of atherosclerosis.

Compressive stress suppresses proliferation of human epithelium

Ashley Bonnoitt[1], Kenneth Ho[1], Allen Liu[1,2]

[1]Department of Mechanical Engineering, University of Michigan, Ann Arbor, Michigan

[2]Department of Biomedical Engineering, University of Michigan, Ann Arbor, Michigan

During unrestricted tumor growth, compressive mechanical pressure is exerted onto non-tumorous adjacent epithelium. The subsequent signal transduction pathway in healthy epithelial cells surrounding the tumor remains poorly understood. We investigated the mechanotransduction pathway that controls transcriptional regulation of cell fate via conversion of mechanical properties of the microenvironment into biochemical signals. We directly applied mechanical compression over varied timescales on human epithelial (MCF 10A) cell monolayers seeded on a transwell via an agarose cushion and plastic cap filled with different weights. We immunostained Ki67, a marker for proliferation, and YAP, a proliferation activator via the Hippo pathway. After imaging by confocal microscopy, we discerned a negative correlation between compressional stress and YAP or Ki67 positive cells, insinuating decreased proliferation with compression. To investigate the progression of different cellular responses we conducted Western blots at varying timescales. This method permitted us to identify the expression level of proteins p27, cleaved caspase 3, and PI; a proliferation inhibitor, marker for apoptosis, and necrosis indicator, respectively. While still preliminary in nature, our methods and findings set the basis for continued work to understand the specifics behind cellular responses to compressive stress. With applications to tumor growth and metastasis, future experiments could look into a cell's elastic volume response to mechanical compression. Other possible avenues include investigating any differences in cellular response to compressional stress when using cancer cells or multicellular spheroids rather than epithelial monolayers.

Exhaust Gas Water Collection Techniques and Estimating Time Spent in Knock-Limited Zones for Use in Water Injection

Andrew Braun[1], John Hoard[2]

[1]*Department of Mechanical Engineering, University of Michigan, Ann Arbor, Michigan*

[2]*Department of Mechanical Engineering, University of Michigan, Ann Arbor, Michigan*

Water injection is a method for suppressing engine knock, as well as increasing power and efficiency. Because of the benefits of this technology, it will be implemented in commercial vehicles, and therefore it is important to develop a self-sustaining way to collect and store water for injection.

Collecting water for injection by condensing water out from the exhaust gas is one method, found by researching academic papers. Exhaust gas is constantly produced, making this a very reliable method. For a significant amount of water to condense out, the exhaust needs to be cooled to 50^{o}C. This requires a two part cooling system. A filter before the coolers will catch particulate matter. The coolers also need an acid resistant coating, as the liquid condensed out will be very acidic.

The condensed water needs a storage system so that it is available when the engine enters knock conditions. The system should only be big enough to carry as much water as needed. To predict the size needed, real-world drive cycles from NREL were analyzed using GTSuite and MATLAB. GTSuite used the speed vs. time data from NREL to back-calculate torque and engine speed. MATLAB determined the percentage of time the vehicle spent in certain intervals for each variable. These percentages, when compared to each vehicles' knock-limited zone, give an indication of how much time a vehicle operates in knock conditions, thus how often water is injected and the size needed of the storage tank.

Identification of the anisotropic behavior of A7075-O

Zhiyi Chen[1], Prof. Mihaela Banu[2]

[1]Mechanical Engineering, University of Michigan, Ann Arbor, MI

[2]Mechanical Engineering, University of Michigan, Ann Arbor, MI

Aluminum A7075-O is a new type of aluminum alloy with higher tensile strength comparing with the existing aluminum alloys. To predict the performance of A7075-O under forming processes, its anisotropy need to be tested. Anisotropy may greatly influence the dimension and shape accuracy of formed components. My SURE project was to experimentally identify anisotropic behavior of A7075-O for its use in finite element simulation of incremental forming. Hill's 48 and Hill's 79 criteria were used to describe the yield surface of the material. The basic methodology was to apply tensile tests on ASTM standard specimens. Specimens were cut in seven different directions, with respect to the rolling direction of the sheet, e.g. 0^{o}, 15^{o}, 30^{o}, 45^{o}, 60^{o}, 75^{o}, 90^{o}. A strain gauge was used to measure the width and thickness strains of the specimens at 8% elongation. Then Lankford coefficients were calculated as the natural logarithm ratio of the width and thickness strains. Based on the Lankford coefficients, parameters for the two selected criteria were identified, and two yield surface models were plotted. Swift and Voce Law were considered to fit the stress strain behavior of A7075-O. Voce law, which indicates an isotropic behavior with hardening provided a better fit. The results show that A7075-O has a weak anisotropy in the strains and stresses. The identifications were implemented in finite element modeling of incremental forming of a pyramid shape. The experimental and simulation results of this forming process were in good agreement, showing that the material behavior was correctly identified.

Analysis and Experimental Investigations of Origami-Based Metamaterials

Shih-Cheng Andrew Chu [1], Hongbin Fang[1], K.W. Wang [1]

[1]Mechanical Engineering, University of Michigan, Ann Arbor, Michigan

Origami structure is currently a growing field of interest. These structures are promising to be used in numerous applications, from large-scaled deployable solar panels to small-scaled biomedical devices. To date, many interesting origami properties have been discovered, which are mainly based on idealistic models of rigid folding. This research will explore the effect of realistic material on these origami properties. Two origami structures are focused here: one is a single-collinear structure with self-locking ability, and the other is a Miura-ori structure with bistability. Locking is induced by a kinematic phenomenon: facet binding. When facet binding happens, the structure cannot be further folded and the structure stiffness will jump significantly. Bistability is a property showing that the Miura-ori structure has two different stable configurations.

The following tasks have been pursued in this project:

(a) Two types of finite element models were developed to simulate a single-collinear origami structure and a Miura-ori structure as they undergo compression tests.

(b) Models with different crease stiffness were built to show the possibility of a locking-induced piece-wise stiffness jump and multi-stability.

The models were built with realistic material constants and geometry constraints. Simulation results show that such models behave significantly different with the rigid-folding models, which need further consideration. In the future, the origami structures will be 3-D printed for testing to verify the finite element method results. This research can lead insights on passive and active meta-materials based on origami structures.

Medium Duty Diesel Engine Research

Daniel Knister[1]

[1]*Mechanical Engineering, University of Michigan, Ann Arbor, MI*

With emissions regulations growing more stringent, automakers are placing increasing emphasis on improving engine performance while reducing fuel consumption and emissions. Critical to this effort is having the capacity to reliably test potential technologies for engine improvement. The focus of this project has been on preparing and testing a medium duty diesel engine for future experimentation.

The engine has been connected to a dynamometer to measure the torque and speed output of the engine to understand what conditions the engine is operating at. The dynamometer also allows a transient operation, varying the operating point through time, which means EPA test cycles can be run and real world driving conditions can be simulated. While the engine is controlled through the dynamometer, the focus of engine research is on improving fuel economy and reducing emissions. This means that much additional instrumentation is needed; temperature, pressure, mass flow rates and other data are measured throughout the engine and the exhaust is sampled for emissions testing. This data first allows the researcher to verify that the engine is operating as expected, then to understand the effect of various changes to the engine. This data will thus be critical to future experimentation, from understanding changes in turbocharger efficiency at varied conditions to the effects of Exhaust Gas Recirculation on nitrogen oxide emissions.

After engine installation was completed, the engine was tested and the instrumentation was shown to be operating as expected. Research work can now proceed on the engine.

Plasma Assisted Automotive Catalysis

Weilun Peng[1], John Hoard[1]

[1]*Department of Mechanical Engineering, University of Michigan, Ann Arbor*

With the development of science and technology, automotive has been a major and necessary transportation for our daily life. People also start to research on better fuel for automotive, which can improve the efficiency of energy. However, with increasing environmental pollution, the automotive emission has become a new concerned topic. Plasma-Catalyst laboratory is attempting to generate complex mixtures of gases to simulate automotive emissions by observing chemical reactions under different conditions (flowrate, gas concentrations). In addition, we test the plasma and catalyst to see whether the gas concentrations will be changed before and after adding plasma and catalyst. The major components of the bench are Multi-Gas FTIR and Hiden Mass Spectrometer, which can obtain the specific gas composition for each experiments. According to the plasma data of voltage and current collected and saved as waveforms, the information of each gas production, such as concentrations and flowrates, can be calculated. The whole bench is accomplished by manual commands to the Labview control computer and the whole system is followed by an experiment script. The anticipated outcome of this lab is to obtain better plasma and catalyst by analyzing the gas composition after the chemical reactions, which can be adapted to automotive emissions and then reduce the environmental pollution.

Design of a femoral artery simulator to determine to the minimum amount of contrast required in digital subtraction angiography and standard fluoroscopy

Albert Shih[1], Hitinder Gurm[2], Connor Yako[3]

[1]*Mechanical Engineering, University of Michigan, Ann Arbor, Michigan*
[2]*Cardiology, University of Michigan, Ann Arbor, Michigan*
[3]*Mechanical Engineering, University of Michigan, Ann Arbor, Michigan*

The purpose of this research was to create a viable femoral artery simulator in order to determine the minimum amount of contrast needed during fluoroscopy techniques, which are used to visualize blood vessels. Contrast is a substance used to distinguish the flow in blood vessels from the surrounding tissue. Two unique simulators were created for this research. One simulator consisted of a stenosis, or narrowing of the blood vessel. The second simulator included a curved artery, since the femoral artery does not follow a completely straight path. Both devices were constructed out of silicone to simulate the tissue surrounding the artery, acrylic plates to contain the silicone, an 8 mm outer diameter 5 mm inner diameter PVC tube for the artery, and fishing line. The fishing line was used to control the vertical and horizontal position of the artery (tube) at certain points between the two ends of the simulator, without casting a shadow visible in the X-ray images obtained during a fluoroscopy. Each simulator was connected to a peristaltic pump, which was used to replicate the pulsing of the heart. An open circuit was created, with collection bags at one end of the simulator, and the pump, fluid reservoir, and contrast reservoir at the other. With an open circuit, contrast could be added into the flow in controlled amounts. Contrast was added to the flow through the use of a three-way connector and a one-way valve prior to flow entering the simulator.

Magnetic field's influence on *Caenorhabditis elegans* locomotion

Yang Zhang[1]

[1]*Department of Mechanical Engineering, University of Michigan, Ann Arbor,*
MIt[2] *Department, University, City, State etc…*

Caenorhabditis elegans is a nematode worm, broadly used as a model organism. This project focuses on magnetic field's influence on *C. elegans'* locomotion. We hypothesize that the magnetic field affects *C. elegans* locomotion. To test this hypothesis, we compare the locomotion of worms moving in the presence or absence of magnetic field. We are interested in defining specific locomotion parameters indicating a possible magnetic field influence on *C. elegans*. We study the locomotion of four groups of young adult *C. elegans* worms: i) fed on normal food source (*E. coli* OP50), ii) fed on 1 um-diameter superparamagnetic particles, iii) fed on 70nm-diamater iron core particles and fed on 40nm-diameter iron core particles. We hypothesize that internalized nanoparticles can generate secondary magnetic fields, which may further affect *C. elegans* locomotive behavior. Recordings of *C. elegans* locomotion in the presence or absence of magnetic field are shot for further analysis. A worm tracking software developed in our lab is used to collect the motion-related information. We develop metrics to quantify the locomotion, including average velocity, spatial distribution, bending frequency, trajectory, longest distance traveled and area covered for closed trajectories. To date, we have concluded that average velocity and spatial distribution are not affected by magnetic field, for all four groups studied. However, bending frequency analysis shows that this parameter changes significantly when worms fed on normal food source and 40nm-diameter iron core particles are moving under magnetic field. Further experiments will focus on clarifying the phenomenon.

Designing and Testing of Origami-based Earthworm-like Robot

Yetong Zhang, Hongbin Fang, and K.W. Wang

Department of Mechanical Engineering, University of Michigan, Ann Arbor, MI

The body of an earthworm is composed of numerous similar segments; each segment can contract in the axial (radial) direction and extend in the radial (axial) direction. By arranging the sequence of extension and contraction of the body segments, the earthworm can achieve locomotion in various media with certain gaits. Earthworm-like robot has wide application potentials. This project aims to integrate the advantages of origami structures into the design of earthworm-like robots. The origami structure's mechanical properties and the earthworm-like robot's locomotion performance will be evaluated.

In this project, the following tasks have been carried out:

(a) The project uses a "magic-ball" origami structure to simulate the earthworm's body segment. Mathematical analysis is performed on the "magic-ball" origami's geometry. It can well mimic earthworms' body segment, i.e., with converse deformations in radial and axial directions.
(b) The "magic-ball" flat pattern is made of polyester sheets through laser cutting. Then the flat pattern is manually folded into an origami "magic-ball". Each segment is actuated by a four-bar linkage with a servo.
(c) Eight segments are connected together into an earthworm-like robot.
(d) Mechanical properties of the origami "magic-ball" structure are tested in a material test machine.
(e) The robot is tested under different gaits in a tube to evaluate its locomotion performance.

Extraction of the Three-dimensional Three-components Kinetic Energy from Large Eddy Simulation Calculation

David L. Reuss[1], Ziyang Zhong[2]

[1]*Department of Mechanical Engineering, University of Michigan, Ann Arbor, MI*

[2]*Department of Mechanical Engineering, University of Michigan, Ann Arbor, MI*

The Ensight software has been used for extracting the kinetic energy from the post-processed Large Eddy Simulation. With a commercial post processing software, Ensight, we are able to obtain the volume-averaged kinetic energy, the density, the volume and many other physical parameters inside a user-defined volume or plane. The extracted data have been mainly used for two main purposes. One purpose is to estimate the volume-averaged kinetic energy loss in the two-dimensional, two-components PIV measurement plane when compared with the three-dimensional, three-components volume-averaged kinetic energy in the total volume inside the cylinder. The second purpose is to examine the net kinetic-energy change inside the cylinder at different crank angles. The values were calculated by subtracting the total kinetic energy between consecutive crank angles.

Some other sub-tasks were also fulfilled. We successfully created the finite mesh grid in the cutting plane and showed the velocity vector in each grid. This was used to compare the difference in the kinetic energy between a cutting plane and a slab of finite volume. A movie showing the velocity field during the four strokes of the engine has been extracted. Also, anisotropy in the flow field was examined by calculating the kinetic energy with single-component velocity vector. The squared velocity was extracted and compared with the volume-averaged kinetic energy inside the total cylinder volume. The comparison was done in the crank angle between 180 and 360. The extracted data shows the increasing volume-averaged kinetic energy with the decreasing velocity.

A Step into the Development of a Platform for Neural Teratogenicity Assessment

Zhiheng Zhou[1], Zida Li[1], Yue Shao[1], and Jianping Fu[1].

[1]Department of Mechanical Engineering, University of Michigan, Ann Arbor, MI

Congenital disorder, or birth defect is a physical body structural defect caused by abnormal embryonic or fetal development. In the USA, birth defect is present in 3% of newborns and results in 632,000 deaths in 2013. Birth defect is related to genetic predisposition and environmental factors including teratogenic agents like medication. Therefore, it is necessary to investigate the teratogenicity of chemical agents. Though several in vitro models have been developed to evaluate the toxicity of chemical agents on mouse tissue, there is not proper method focused on early neural differentiation of human stem cells. Such specified methods can potentially reduce the incidence of neural defect such as spina bifida. This SURE project aims to contribute to the development of a platform that assesses neural teratogenicity by capturing the spatial and temporal development of neural crest cells on a circular colony. In particular, I differentiated human embryonic stem cells on a circular pattern towards neural cells, and monitored the expression of SOX10, a marker of neural crest cells, on a daily basis. This experiment includes several components: sample preparation based on microcontact printing, cell culture, image acquisition using a fluorescence microscope, and image processing with MATLAB. I observed that SOX10 first appeared on Day 2, and the intensity across the whole colony became brighter over time. The coded MATLAB program is capable of automatically processing hundreds of images and generating quantified intensity data in a few hours, without human intervention.

$SrHfSe_3$ and $BaHfSe_3$ Chalcogenide Needle-like and Distorted Perovskite Synthesis and Characterization

Christopher Bauer[1]

[1]*Material Science Engineering, University of Michigan, Ann Arbor*

In an effort to increase the efficiency of solar cells and other thermoelectric devices many researchers are exploring the uses of inorganic chalcogenide perovskites. In our research we attempted to synthesize six chalcogenide compounds ($CaZrSe_3$, $CaHfSe_3$, $SrZrSe_3$, $SrHfSe_3$, $BaZrSe_3$, and $BaHfSe_3$) with theoretical absorption properties ideal for photovoltaic applications in the distorted perovskite structure. Two solid state synthesis methods were used. The first method consisted of mixing the refined elements under argon gas then sealing and high energy ball-milling the mixtures in stainless steel jars for 30 minutes. After milling the samples were transferred to graphite crucibles which were then sealed in evacuated silica tubes and heated to 800° C for 5 days in temperature controlled furnaces. In the second method the ball-mill time was extended to 100 hours. All except the $SrHfSe_3$ prepared using the first method yielded compounds with significant binary impurities according to powder x-ray diffraction (XRD) characterization. $SrHfSe_3$ synthesized using the same procedure formed pure (>99%) ternary $SrHfSe_3$ in the needle-like phase. Attempts to convert the needle-like structure to the perovskite were unsuccessful. It was found that the thermoelectric properties of needle-like $SrHfSe_3$ could be enhanced through substitutional doping of Sb for Sr. Ternary $BaHfSe_3$ prepared under the second method and after hot pressing exhibited the perovskite phase according to XRD and further Rietveld refinement. After further testing we were able to characterize the thermal conductivity, electronic conductivity, thermopower, and figure of merit for these novel thermoelectric materials.

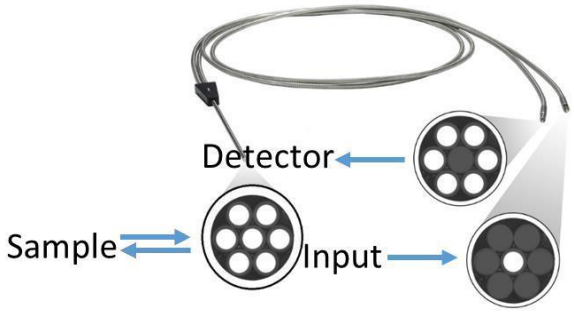
Research on Blue OLED Testing and Ultra-thin Film Absorption Measurement

Xiaoer Hu[1]

[1] *Department of Materials Science and Engineering, University of Michigan, Ann Arbor, Michigan*

The research on blue OLED testing includes: OLED lifetime testing setup and OLED characteristic auto-measurement setup. Both of them require the basic skills of writing LabVIEW programs, designing circuits in Eagle CAD, and soldering wires and pins on circuit boards. The first setup is designed to measure the lifetime of blue OLEDs by tracking the voltage on the OLEDs and their luminance, for extended periods operating on a constant current supply. The second setup focuses on measuring the current-voltage-luminance characteristics of OLEDs automatically. The main goal is to automatically measure four OLEDs on a standardized patterned substrate one by one. The program can also evaluate whether the measurement has acceptable data based on user input. If acceptable, the data will be saved, otherwise the program will measure the OLED again.

The other project is to setup an ultra-sensitive spectroscopic system and measure the absorption spectra of two dimensional organic films from layer-by-layer growth or monolayer transition metal dichalcogenide. The methods such as transmittance measurement through UV-Vis spectrometer cannot be applied due to the limited area of the samples and low signal-to-noise ratio. Therefore, Normal Incidence Differential Reflectance is used, where bifurcated fiber bundles (see the picture below) and proper optical paths are applied to focus the light on the sample and collect the reflected signal. The absorption is proportional to the difference between the reflected signals of the substrates with and without the thin film on it, divided by that for the bare substrate.



Computer Simulation of 2D Material

Guanglong Huang[1], David Montiel[1], Katsuyo Thornton[1]

[1]Material Science and Engineering, University of Michigan, Ann Arbor, Michigan

This SURE project aims to write, run and test a C++ code to simulate atomic structures using a newly developed Phase Field Crystal (PFC) model to study 2D materials. The C++ language was chosen by virtue of its efficiency. The equilibrium atomic structures are found via the minimization of a free energy functional consisting of four contributions: ideal energy, two-point correlation, three-point correlation and four-point correlation. The ideal energy term leads the system to a state of uniform density, which is interpreted as a disordered state. The two-point correlation term drives the system into a periodic state and controls the interatomic distance (i.e. the bond length). A Body-Centered Cubic (BCC) structure can be generated using the ideal energy and two-point correlation terms only. In order to verify our code, some simulations with different parameters were conducted and the parameters that yielded the desired BCC structure were found. More complex structures, however, require the inclusion of a three-point correlation term. This term is used to set the angle between two bonds. Relationships among groups of three atoms are therefore determined. By tailoring three-point correlation to favor specific bond angles and changing the weighting parameters of each term, various kinds of structure can be obtained. For instance, we have managed to get simple cubic (SC) structure if the initial condition resembles SC. We used this result to validate the three-point correlation term. The next goal of our task is to obtain a two-dimensional structure such as graphene. Due to constraint of restricting growth to a plane, the three-point correlation may not be enough to accurately simulate it. A four-point correlation, capable of controlling angles between several bonds rather than only two, is necessary in this case. Although the code for the four-point correlation has been written, it is still being tested. The simulation of a 2D structure, therefore, is still on the way.

Influence of Annealing on Structure and Properties of the Semiconductor Alloy GaAsNBi

E. Rizzi[1], J. Occena[2], T. Jen[3], R. S. Goldman[4]

[1]*Department of Materials Science and Engineering, University of Michigan, Ann Arbor,MI*
[2]*Los Alamos National Laboratory, Los Alamos, NM*

Due to their significant band-gap narrowing with minimal change in lattice parameter, dilute nitride semiconductor alloys are useful for a variety of applications, including long-wavelength lasers and detectors, ultra-high-frequency solar cells, and high performance heterojunction bipolar transistors. For GaAsN and related alloys, a reduction of N interstitial concentration induced by post-growth rapid thermal annealing (RTA) over a range of temperatures has been associated with enhanced photoluminescence (PL) efficiencies. In the case of GaAsNBi, successful RTA-induced PL efficiency enhancements were limited to a specific temperature window. On the other hand, UV irradiation has been used to enhance PL efficiency in GaAsBi films. Therefore, we are exploring strategies to reduce the concentration of N interstitials while retaining Bi incorporation in GaAsNBi films. We examine a series of GaAsNBi films grown by molecular-beam epitaxy, with and without post-growth RTA or UV irradiation. We utilize Atomic force microscopy, high resolution X-ray diffraction, optical microscopy and Raman microscopy to examine film morphology, alloy composition, and phonon modes.

Serial Sectioning of Fatigue Cracked WE43 Magnesium

John Allison[1], Jiawei Zhang[2]

[1]Materials Science and Engineering Department, University of Michigan, Ann Arbor, Michigan
[2]Materials Science and Engineering Department, University of Michigan, Ann Arbor, Michigan

This project focused on studying microstructural evolution and its impact on the fatigue crack in light alloy. The material I analyzed throughout the summer was WE43, a hot-rolled, rare-earth strengthened magnesium alloy which has been solution heated and fatigued to produce large average grain size. Serial sectioning was the repeated sectioning of the sample, which included polishing, etching, indenting and characterization of the microstructure through imaging. The purpose of polishing was to remove 7-8 microns of material as well as all scratches, particles, etc. Before we used the polishing solutions, the material was first grinded with 800g and 1200g sandpapers. Oxidation prevention was crucial during the whole process. Then, etching provided us with clearly-identified grain boundaries and indenting on the sample helped to measure the thickness of each slice removed. Next, we imaged the sample under optical microscope for the exactly same region every time. Finally, this stack of images was later compiled into a three-dimensional representation using Avizo 8.1 software. The reconstruction allowed us to observe how the grains grow or shrink near the crack; therefore, we could investigate the microstructural characteristics in three dimensions as well as how a short fatigued crack may interact with microstructural features. Furthermore, we integrated periodic EBSD scans with optical imaging for identification of crystallographic orientations in software to finally analyze the crystallographic/ non-crystallographic propagation behavior of the fatigue crack.

Development and Testing of a Feedback Controller for Automatic Calibration of Scintillator Detectors

K. Beyer[1], A. Di Fulvio[1], S. Pozzi[1]

[1]*Department of Nuclear Engineering and Radiological Sciences, University of Michigan, Ann Arbor, MI*

Organic scintillators are useful in radiation detection for nuclear non-proliferation due to their fast response, and capability of detecting and discriminating neutrons and photons. Photomultiplier tubes (PMTs) are commonly used to convert light pulses produced by ionizing radiation in a scintillator into an amplified electric signal, with gain dependent on the high Voltage (HV). Compton Edge (CE) gain calibration is performed by matching a detector response voltage to the light output peak in the detector response corresponding to maximum energy deposition due to Compton scattering (487 keVee for 611 keV Cs-137 photons). We developed and validated a user-friendly GUI in LabView that acquires and plots in real-time spectra from an organic scintillator, and adjusts the PMT HV until the voltage corresponding to the CE matches a user defined value. The software can operate in three modes: manual, pre-calibration and calibration mode. In manual, the user has full control over the HV gain. In pre-calibration, a detector response spectrum is generated between pre-set high and low HV bounds; then the HV gain required to match the user-defined detector response voltage at the CE is estimated via linear interpolation. In calibration, the HV gain is initialized to the pre-calibration estimate, and then a proportional controller finely adjusts the HV, while rebuilding the spectrum, until the CE is within a tolerance of the user defined value. Typical calibration times for a 2”x2” EJ-309 detector, irradiated with a 1 µCi Cs-137 source, were ~10 minutes to achieve a ±1% tolerance.

Building a Map for Robot Navigation

Xinyu Chang[1]

[1]*Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI*

Mapping is a rising topic in robotics. For this summer, the objective of my research project was to build a rudimentary 3D mapping system for some existing robot systems in the lab. The purpose of this project was to gain some background and experience in robotics.

To conduct the project, the first step was to understand how the current robot system worked and how to operate on it. Afterwards, the problem naturally divided into two parts – getting data from the robot and displaying the map. Firstly, to get the data from the robot, a subscriber was written to listen to the odometry and laser-scan data. The odometry data kept track of the orientation and position of the robot whereas the laser-scan data stored the range data of the current scan. For each scan, a 4x4 matrix was formed using the odometry data to convert the local range data into world coordinates, which would then be used in map display. Secondly, to display the map, I chose to use modern OpenGL as a drawing tool. By rendering the coordinates to the vertex buffer, the map would be displayed as the robot moved.

Due to the lack of experience in modern OpenGL and the robot system, unfortunately I did not get into 3D map by the end of summer. However, I was able to build a basic planar map for the robot. I really appreciate the learning experience as the knowledge I gained built strong interest of robotics in me.

Random Maze Generation and Traversal with MAEbot

Jon Toto[1]

[1]*EECS, University of Michigan, Ann Arbor, MI*

The goal of the project was to create a structure for virtual maze generation and path traversal by a MAEbot (Miniature APRIL Education RoBot). The first step was to develop odometry and path traversal code to run locally on the MAEbot. The MAEbot publishes its odometry and receives its path over LCM (Lightweight Communications Marshalling). If motion capture is available, the odometry calculations take place on the controlling laptop. The virtual maze is generated in C using vx, an OpenGL wrapper, on the controlling laptop. The maze is generated on program started and uses a modified version of Prim's algorithm. In order to traverse the maze, the native vx event handler is used to allow mouse clicks to choose a goal point; then the A* search algorithm is used to find a safe path to the goal which is published over LCM and received by the MAEbot code, allowing the MAEbot to complete the maze.