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Presenter: **Ada Barach**
Major: **Computer Science & Engineering**
Advisor: **Dr. Krista Kecskemety**

A MATLAB Programming ConceptInventory for Assessing First-Year Engineering Courses: a Replication of the Second Computer Science 1 Assessment

Validated concept inventories are necessary to accurately gauge student understanding and measure classroom teaching methods. However, the First-Year Engineering (FYE) program at The Ohio State University lacks a validated assessment tool to determine student understanding of MATLAB programming concepts for first-year students. It is critical for FYE programs to have these tools available to allow the program and its instructors to determine the impacts of various teaching styles and curricula.

While there are existing concept inventories available for introductory computer science concepts, these concept inventories are programming language independent and have limitations. One such limitation is that the scores of lower-performing students tend to differ for language-independent versus language-dependent assessments more than those of high-performing students. This indicates that language-independent assessments favor high-performing students. In this study, a new MATLAB-specific concept inventory, MCS1, is developed by replicating a previously validated foundational computer science concept inventory, SCS1, for use in the FYE program at Ohio State.

The result of this study is assisting in successfully developing the MCS1 concept inventory by replicating SCS1. Think-aloud interviews were conducted with six first-year students. The MCS1 and SCS1 assessments were given to a combined total of 724 FYE students in autumn 2019. Preliminary data demonstrates a statistically significant difference between SCS1 and MCS1 scores, indicating that MCS1 cannot be validated against SCS1. As a result, a future study is required to validate MCS1 on its own.

MCS1 has the potential to impact thousands of students enrolled in FYE courses at Ohio State, as well as at other universities, by normalizing the assessment process. Further, this assessment can be incorporated into the curriculum as a benchmark which can then be used by faculty and administrators to make informed decisions about the curriculum based on student retention of key concepts.

Presenter: **Anna Debski**
Major: **Materials Science & Engineering**
Advisor: **Dr. Gunjan Agarwal**

Analysis of Collagen Fibril Structure in Abdominal Aortic Aneurysm

Abdominal aortic aneurysms (AAA) are characterized by remodeling of the elastin and collagen components of the extracellular matrix. While both collagen and elastin remodeling dictate aortic function, little is known about microstructural changes regarding collagen remodeling. This study focuses on identifying characteristics of collagen remodeling in AAA which can be applied towards determining new diagnostic and therapeutic approaches. AAA tissue was obtained from mouse and human specimens. The samples were analyzed topographically with atomic force microscopy (AFM) to determine changes in d-periodicity, band depth and visual differences between normal and abnormal collagen. Transmission electron microscopy (TEM) has also been performed on the samples to identify how diameters are altered by the remodeling process. Collagen degradation was analyzed by staining the samples with collagen hybridizing peptide (CHP). Atomic force microscopy was used to determine structural differences in collagen fibrils in regions with or without CHP staining. Understanding the structural features of collagen and its distribution in AAA can provide novel insights into the pathogenesis of the disease.

Presenter: **Haelie Egbert**
Major: **Mechanical Engineering**
Advisors: **Dr. Ahmet Kahraman, Dr. Isaac Hong**

Cyclic Crack Growth Rate of a Spur Gear Tooth

Gear teeth in mesh undergo cyclic forces as the teeth rotate in and out of contact. The resultant contact and bending stresses produce fatigue damage, which can lead to failure through contact surface degradation and tooth breakage through the root fillet. The fatigue process occurs in two distinct phases, crack initiation and propagation. Many proposed diagnostic techniques to detect onset of gear failure rely on changes in mechanical properties due to crack propagation. Moreover, theoretical studies to predict fatigue crack propagation rate rely on limited numbers of experimental measurements for their validation, with little extension to gears. The focus of this study is to develop an optically based system for measuring the crack growth rate in the tooth root of a spur gear at the onset of crack propagation. A gear Single Tooth Bending Machine coupled with a high-speed camera is utilized to demonstrate the new methodology. A digital image correlation technique is developed to compute crack length during each load cycle, in order to obtain cyclic crack growth rate.

Presenter: **Chris Eubel**
Major: **Mechanical Engineering**
Advisor: **Dr. David Hoelzle**

Machine Learning for Autonomous Additive Manufacturing of Acoustic Metamaterials

Our research team's objective is to investigate and develop a set of machine learning algorithms capable of driving the intelligent design of additively manufactured acoustic metamaterials. These metamaterials, described as mini Post-it Note sized, FDM-printed lattice structures, have two discrete degrees of freedom within the geometry of their repetitive design that grants slight control of their acoustic properties. The acoustic property of interest is the acoustic passband characteristics, and the goal is to develop a closed-loop additive manufacturing system that can autonomously achieve any given passband within the constraints of the two mutable parameters of the design. This project requires the hardware and software modification of an off-the-shelf desktop 3D-printer to create an additive manufacturing system capable of narrow autonomous design. These modifications most notably include: repetitive printing capabilities, integration of in-situ acoustic sensing for performance feedback, software to generate custom G-code, system automation software, data post-processing, and machine learning algorithms to drive metamaterial design. The team is currently ready to begin integrating and testing machine learning algorithms on the automatic system with the hopes to gain useful insight and, eventually, increase the number of design parameters that the intelligent system can wield to meet its passband objective. Lastly, it is important to note that this research is a testbed for a much broader goal of developing a general autonomous framework that is portable to many different additive manufacturing systems and unique design objectives.

Presenter: **Peimeng Guan**
Major: **Electrical & Computer Engineering**
Advisor: **Dr. Jiankang Wang**

Optimal Adaptive Coordinated Cyber-Attacks on Power Grids using Epsilon-Greedy Method

The future power grid is supported by Information and Communication Technology, which also exposes it to cyberattacks. In particular, Coordinated Cyber-Attacks (CCAs) are highly threatening and difficult to defend against. We propose a stochastic game model to capture the interaction between attackers and the grid operator. In particular, we consider the most vicious CCAs, which intend to cause cascading power blackouts, through a non-cooperative zero-sum game. The CCA attack vector is derived with the Multi-Armed Bandit Epsilon-Greedy method. Distinct from few existing studies on CCAs, the attack model is more realistic in twofold: (i) it does not assume attackers with prior knowledge of the power grid, and (ii) attackers could adapt their strategies in response to defense actions. The result of this research provides important implications in defense resource allocation and cybersecurity infrastructure reinforcement in the power grid. The proposed model and the attack vector are validated using the New England 39 bus power system model.

Presenter: **Jianshe Guo**
Major: **Mechanical Engineering**
Advisor: **Dr. Jung Hyun Kim**

Development of TiNb2O7 anode for low temperature batteries

With increasing in gasoline price and greenhouse gas emissions, more and more hybrid electrical vehicles (HEV) and pure electric vehicles (EV) appear on the Auto market. Li-ion batteries have become the dominant power source for electric vehicles applications because of many advantages such as high energy densities, less pollution, stable performance and long cycle life. However, the market for HEVs and EVs need to overcome many technical issues. One issue is that energy and power densities are significantly reduced when the Li-ion batteries are at low temperatures. TiNb2O7 (TNO) electrodes can be a good choice in order to solve low-temperature issues of Li-Ion batteries. The original anode-based batteries are Li4Ti5O12 (LTO) anode-based batteries. I have made a comparison between TNO anode and LTO anode in low temperature condition. The energy densities of TNO anode-based batteries in low temperature are around 350Wh/L and the energy densities of LTO anode-based batteries are around 177Wh/L. It means that TNO anode-based batteries have a higher energy density than LTO anode-based batteries. In addition, TNO anode batteries have a longer cycle life and shorter charging time than LTO anode batteries. The purpose of this research is to identify whether the TNO anodes-based batteries have the advantage of high energy and power densities in low temperature conditions. First, I need to identify whether the TNO anode can be run in normal cycling battery by doing half-cell test. I have done the half-cell test which consist of TNO anode and metallic Li as a counter electrode. The voltage profile obtained from half-cell test fits well with TNO electrode. In addition, cycle life tendency corresponding to high-density TNO composite electrode which indicate the TNO electrode can be used in normal cycling battery. In the future research study, I will identify the important parameters that lead to poor performance in the low-temperature condition and demonstrate the performance of TiNb2O7 anodes-based batteries has been improved in the low temperature condition.

Presenter: **Lindsay Isom**
Major: **Chemical Engineering**
Advisors: **Dr. Mandar Kathe, Dr. Liang-Shih Fan**

Data-based models for design of Chemical looping Hydrogen production systems

Hydrogen (H2) gas is an extensively used chemical intermediate that also offers an attractive opportunity for clean energy generation. However, a majority (>90%) of Hydrogen gas is produced from natural gas using a process called steam methane reforming (SMR), which result in carbon dioxide (CO2) emissions. The concept of iron-based chemical looping (CL) technologies developed at The Ohio State University (OSU) has shown promise in reducing cost associated with CO2 capture over SMR processes. This is achieved by intensifying several unit operations into a single reactor system by utilizing iron-oxide as a reacting agent. The design of a CL system requires computationally intensive simultaneous management of several variables like iron-oxide flows, reactor temperatures, operating pressures, etc. This study proposes to use data informed models to reduce computational complexity in order to aid and accelerate a holistic design of OSU CL technology.

This poster will initially present on the rationale on design of a chemical looping (CL) system that simplifies the SMR flowchart. The study will then review existing CL performance parameters that quantify the existing system efficiency as a function of all the system variables. These existing results will be used to develop a data-based model that captures the CL behavior accurately. The data-based model will be used to explore the chemical looping design space and recommendations for efficient operation will be explored. Preliminary results indicate that using data-based models in conjunction with rigorous thermodynamic simulations can allow for a significant reduction in computational loads, while improving the process of developing designs of CL systems.

Presenter: **Amanda Killian**
Major: **Environmental Engineering**
Advisor: **Dr. Natalie Hull**

Longitudinal Comparison of Water and Biofilm Microbial Communities after UV Light versus Chlorine Disinfection

This project seeks to compare microbial communities between water and biofilm in samples disinfected with UV light versus chlorine. The UV reactor in this study is a novel LED that was implemented in a yearlong study in a small water system alongside conventional chlorine disinfection. I hypothesize that if UV disinfection inactivates different microbial communities than chlorine disinfection, it may be a great alternative or supplement to chlorine.

Microbial community comparison will be done through DNA extraction, quantitation, amplicon and long-read metagenomic sequencing, taxonomic classification of sequences, and statistical comparisons with metadata. This study examines how the microbial communities in UV treated water and chlorine treated water differ, possibly due to their different inactivation mechanisms. UV light disinfection works by inactivating bacteria and microorganisms through damaging their nucleic acids, and chlorine works by oxidizing microorganisms.

Water and biofilm sample DNA was extracted and the 16S rRNA gene amplicons were sequenced with Illumina Miseq. I am analyzing fastq files generated from this process to determine and compare the microbial communities present using the Ohio Supercomputer, an R programming environment, and DADA2. I am then assigning the taxonomy of bacteria found in the samples by comparing the sequence information to database information.

In addition to analyzing the professional lab sequence data, I will be sequencing the samples myself using the MinION: a portable, handheld device that sequences long fragments of DNA to enable shotgun metagenomics. I will process shotgun metagenomic fastq files using MetaPhlan for quality control and taxonomy assignment.

For both the amplicon and shotgun metagenomic datasets, I am performing statistical microbial analysis by using PERMANOVA, bar plots, Mantel tests, nonmetric multidimensional scaling, and quantifying changes in alpha and beta diversity using the vegan R package. I am also using another R package, phyloseq, to help visualize the microbial communities.

Presenter: **Eunsung Kim**
Major: **Mechanical Engineering**
Advisor: **Dr. David Talbot**

An Investigation of the Progression of Micropitting during Standard Contact Durability Testing

Micropitting of a gear tooth surface is contact fatigue occurring at a relatively small scale at the surface of a gear tooth. While most times not considered a failure mode itself, many times
micropitting directly proceeds a more catastrophic failure such as macropitting which is sometimes referred to as spalling. This is particularly true in standard contact durability testing of gears on a component level. This study aims to investigate the progression of micropitting during a standard contact durability test. This will involve the measurement and quantification of the amount of micropitting throughout the test. Gear contact simulations will be performed to identify what detrimental effects on the durability test, e.g. contact pressure rise due to surface degradation, the micropitting may have.

Presenter: **Vincent Li**
Major: **Mechanical Engineering**
Advisors: **Dr. Jung Hyun Kim, Junbin Choi**

Reducing Interfacial Resistance in Garnet-Structured Solid-State Lithium-Ion Batteries

Due to the slow development in recent years, conventional lithium-ion batteries are considered to hit the limit of performance. Most battery researchers believe that solid-state batteries can replace the conventional lithium-ion battery status in the future because the solid-electrolyte battery is safer and has higher volumetric energy density. However, the most critical challenge in achieving a high-performance solid-state battery with garnet-structured electrolytes is the high interfacial resistance between the solid-state electrolyte and electrode materials. Several methods have been tried to reduce the interfacial resistance, such as using direct coating and vacuum depositions. This study will focus on the anode/electrolyte interface and investigate the wetting behavior of solid-state electrolytes against lithium metal. Molten Li will be applied to pellets in order to form a smooth interface and reduce the resistance. Meanwhile, sintering temperature and Lithium amount will be the working parameter for the pellet fabrication process. Pellets of different porosities will be produced and its relation to the Li wettability will be investigated. Finally, the interface conductivity between the anode and solid electrolyte will be measured.

Presenter: **Marisa Lovell**
Major: **Mechanical Engineering**
Advisor: **Dr. Rob Siston**

Coupler System Design for Surgical Navigation in Anterior Cruciate Ligament Reconstruction

Anterior cruciate ligament reconstruction (ACLR) surgery is one of the most commonly performed orthopedic surgeries with over a quarter million surgeries done each year in the US alone. The surgery consists of replacing the torn ACL with a tissue graft. The desired outcome for ACLR is to recreate a stable knee, and stability is currently analyzed subjectively before and after surgery. This is done to prevent suboptimal outcomes such as changes in range of motion and instability of the knee. Tools known as surgical navigation (NAV) systems are sometimes utilized in the OR for other surgeries. These systems consist of optical tracking cameras, marker arrays that are attached to the tibia and femur with coupler systems, and computer technology to track certain bones so that surgeons can perform surgical movements such as cutting and drilling more accurately. The more accurate movements can then potentially lead to better patient outcomes and a more stable knee. The reason NAV systems aren’t widely used in ACLR is due to limitations in current coupler system designs. The main challenge with these designs for ACLR attaching the markers to the tibia and femur in a secure fashion without creating additional scarring for the patient. My project is to design a coupler system that is minimally invasive but still provides a secure attachment to enable the cameras to locate the bones in space accurately. Different design concepts were hand sketched and made in SolidWorks. The prototype made by 3D printing was the ball-and-socket design concept. This design was chosen due to its ease of use and ability to fit majority of the design constraints. Overall, this research project can lead to a NAV system to be incorporated into ACLR that tracks the motion of the tibia and femur to assist surgical techniques to improve ACLR outcomes.

Presenter: **Yao Lu**
Major: **Mechanical Engineering**
Advisor: **Dr. Jung Hyun Kim**

Development of advanced coating process on NMC with Li-ionic conductive materials

As the hybrid electric vehicles (HEV) and electric vehicles (EV) occupies more in the automobile market, the battery industry faces enormous challenge since the demands for high performance batteries increases fast by time. The currently used batteries are typically Lithium-ion batteries since it has high energy density but even lithium-ion batteries suffer from short cycle lives and significant degradations when changed and discharged at high rate. And since the expensive price for making the cathode materials, It is impossible to simply add in more materials to prolong the batteries' lives and performance. This research aims to solve this problem by taking actions on another aspect which is coating instead of active materials. The coating material the research focuses on is a compound called LATP which consists with high Lithium ion conductivity. In industry, the price for LATP is far lower than that of NMC which makes the LATP a potential valuable way for achieving higher performance of Lithium-ion batteries. The methods of coating the research focuses on are mixing and plating. For mixing method, the LATP powder will be added to the NMC with two portions:(1). NMC:LATP = 1:1 and (2). NMC:LATP = 3:1 to investigate the more optimum ratio for higher performance. For plating method, the LATP will cover the NMC after NMC cathode is made to investigate whether it improve the performance of the battery. The plating layer of LATP will also be made in different thicknesses to investigate the impact it has on performance of the batteries.

Presenter: **Mikala Malkus**
Major: **Aeronautical & Astronautical Engineering**
Advisor: **Dr. Datta Gaitonde**

An Application of Modal Decomposition to Supersonic Flow Over a Wall-Mounted Turret

Data driven modal decomposition techniques provide a means for extracting physically important features from high-dimensional, time-resolved dynamic systems. While the theoretical bases of these methods are well-developed, the interpretation of the obtained modes to understand complex unsteady flow physics can be difficult. In this research, the Proper Orthogonal Decomposition (POD) and Dynamic Mode Decomposition (DMD) techniques were employed to study the unsteady behavior of supersonic flow over a wall-mounted cylindrical turret. This flow problem contains a variety of time-dependent features including multiple unsteady shock waves and separated shear layers. The multiscale and broadband nature of these features lend themselves well to be examination via the above modal decomposition techniques which extract modes based on characteristics such as energy content and frequency. The POD method was used to objectively rank the dominant features in the system while the DMD method highlighted structures based on their dynamics and their evolution with time. The analysis indicates that unsteady shock waves dominate many aspects of the unsteadiness in this flow, since the top POD mode contained over 40% total energy. Lower ranked POD modes yielded detail about structures in the shear layer and separation regions; however, these were mixed and broadband in character. The DMD modes revealed that the unsteady shock waves were oscillating at a peak nondimensional frequency of $St_L \sim 0.3$, about an order of magnitude lower than the next extracted mode. Since DMD modes contain only a single frequency, other modes extracted coherent oscillation patterns in the shear layers, separation regions, and turbulent boundary layers. Overall, it was found that DMD provided a better characterization of all unsteady features in the flow. Although the application was complex, modal decomposition was shown to be a useful tool for characterization the features dominating the unsteady flows, which is vital for flow control techniques to be developed. Future work should focus on the development of reduced order models for use in flow control analyses.

Presenter: **Tyler Martin**
Major: **Mechanical Engineering**
Advisor: **Dr. Shawn Midlam-Mohler**

Fault Insertions into Hardware-in-the-Loop Simulation

The Ohio State EcoCAR Mobility challenge is an intercollegiate team that designs and integrates an electric automotive vehicle. One of the main goals of this team is to build a hybrid supervisory controls strategy that tests the potential failure mechanisms derived from fault analysis. Currently, Automotive companies are focused on integrating model-based designs enabling simulations for low-cost, rapid experimentation that assess a vehicle's performance. Model-based designs allow engineers to simulate specific tests within controlled environmental conditions. Through the use of model-based design, engineers can test vehicle and component faults inside a simulation model to assess how the vehicle behaves during various failures without incurring the cost of destructive testing.

This thesis, in partner with the EcoCAR Mobility Challenge, aims to incorporate modern industrial fault diagnostics into a hardware-in-the-loop (HIL) simulation and analyze the performance of the model-based design. Fault Tree Analysis (FTA) and Failure Mode and Effect Analysis (FMEA) were used to develop the capability requirements for the vehicle system. Different faults were tested for each major component, including, but not limited to, the energy storage system, rear electric motor, belted alternator starter, DC-DC converter, and the multiplexed vehicle electrical center. The research details how a standard method was constructed for developing and inserting faults in the HIL test environment. The process is used for testing and designing the control algorithm for a hybrid supervisor controller in OSU EcoCAR's retrofit 2019 Chevy Blazer.

Presenter: **Emily McDonel**
Major: **Food, Agricultural & Biological Engineering**
Advisor: **Dr. Andre Palmer**

Development of Hemoglobin-Based Oxygen Carriers (HBOCs)
Through the Process of Co-Precipitation of Nanoparticles

Hemoglobin based oxygen carriers (HBOCs) are potential red blood cell substitutes that present the possibility of being used when blood transfusions are unavailable. Free hemoglobin and smaller HBOCs cause complications including vasoconstriction, hypertension, and short circulation time, prompting research into engineering nanoscale constructs. One such technique involves the formation of hemoglobin particles through the process of co-precipitation, but previous attempts have resulted in large, irregular particles. This study investigates the optimization of hemoglobin entrapment through the variation of hemoglobin and salt concentration. Particle size was also measured to reach an optimal range of 150 to 300 nm.

A particle template was formed by mixing a Manganese Chloride (MnCl2) solution containing dissolved hemoglobin into a solution of Sodium Carbonate (Na2CO3), trapping the hemoglobin during the precipitation reaction. The concentration of hemoglobin and the two salt solutions were then varied. Glutaraldehyde was used to cross-link the hemoglobin molecules. The Manganese Carbonate (MnCO3) template was then dissolved using Ethylenediamine Tetraacetic Acid (EDTA) and the particles quenched using Sodium Cyanoborohydride (NaBH3CN) and washed into PBS. The effect of hemoglobin and salt concentration were determined in this study as well as the feasibility of scale up.

The optimum salt concentration was observed at an equimolar ratio of MnCl2 and Na2CO3 at 0.65M. The highest entrapment was also seen at a hemoglobin concentration of 7.5mg/mL. At these concentrations an entrapment efficiency of 61% was reached.

The average size of the particles achieved were about 250 nm which fell within the desired size range as well as proved viable for scale-up. Further analysis can be conducted on to establish biocompatibility and oxygen carrying efficacy of these particles.

Presenter: **Rob McEwan**
Major: **Mechanical Engineering**
Advisor: **Dr. Ahmet Kahraman**

An Experimental Investigation on the Effect of Journal Bearing
Lubrication on Spin Power Loss in a Planetary Gear Set

Planetary gear sets experience two forms of losses, load-dependent (mechanical) and load-independent (spin) power losses. As pitch line velocities increase, spin losses can become the dominant source of loss in the system and lead to low efficiency and fuel economy as well as high operating temperatures which can affect component life. This research focuses on experimentally measuring various components of spin loss at high pitch line velocities. A test setup to measure spin power losses from lubrication sprayed to the side of a gear at the interface between a planet gear and the supporting journal bearing is designed. A methodology to extract component losses of planetary gearbox spin power loss including loss due to the journal lubrication is adapted and applied to the experimental setup such that these losses are measured across a range of speeds. The measured component losses are utilized to build predictions of total spin power loss for an entire planetary gear set of an arbitrary number of planet gears.

Presenters: **Margaret Miles & Jonathan Dowling**
Major: **Industrial & Systems Engineering**
Advisor: **Dr. Martijn IJtsma**

Work Domain Analysis to Develop Scenarios for Resilient Unmanned Air Traffic Operations

As unmanned vehicles become more commonplace in society, a growing interest with protection and safety for the people interacting with this technology is becoming paramount. Our lab is assisting with a project for the state of Ohio to develop a new visual monitoring system integrated with unmanned aerial vehicles, current air traffic management, ground based detect and avoid systems, and weather. This system will integrate different systems for the airspace in hopes to increase efficiency and decrease safety concerns to revolutionize unmanned air traffic management (UTM). Our lab specifically is focused on how to best design a human-autonomy team system using the principles of cognitive systems engineering and resilience engineering. We will focus on understanding the total systematic human and autonomous vehicle performance through conducting a work domain analysis (Rasmussen, 1983). This analysis develops an abstraction hierarchy describing the system's goals, functions, and physical form Using this system description, we will identify human performance issues, and develop scenarios and edge cases that challenge the system's resilience. Accounting for the brittleness of the system in the edge cases is one of the pillars of resilience engineering, and allows the system to be robust in the phase of varying and uncertain demands. Findings from our abstraction hierarchy, scenarios and edge cases will ultimately support the development of an accurate simulation of the introduction of unmanned vehicles into airspace, and support our efforts to create a safe and efficient UTM system.

Presenter: **Ahmed Mohamed**
Major: **Mechanical Engineering**
Advisor: **Dr. Vishnu Sundaresan**

Structural Health Prognosis of Mechanoluminescent Composites using Machine Learning Algorithms

Smart material particulates impart their multifunctional properties to polymer composites and are referred to as smart particulate polymer composites (SPC). These composites undergo a slow and continuous degradation of its structural strength over millions of cycles due to damage at the interface between the particulate phase and matrix throughout its performance lifetime. As a result of this continuous degradation of mechanical strength, a load much smaller than the design strength of the material leads to abrupt failure. The economic advantages of light-weighting automotive and aircraft component using polymer composites is lost when expensive periodic maintenance becomes mandatory to avoid catastrophic failure. Hence, structural health prognosis (SHP) of SPC is essential in critical load bearing applications structural applications. SHP utilizing machine learning and deep learning techniques, such as Neural Networks (NN), recently emerged as an efficient tool to predict the health state of a structure in real-time. A neural network is a data analytical multivariate mapping tool that are trained to inversely relate measured outputs to given inputs with high accuracies.

In this project, a Neural Network-based health prognosis algorithm is constructed by correlating light intensity data to material deterioration, which are acquired by mechanically testing six samples of mechanoluminescent composites. Mechanoluminescence is the phenomenon of light emission from organic/inorganic materials due to mechanical stimuli. This underlying relationship between light intensity and material degradation is developed in the frequency domain by performing the Fast Fourier Transform (FFT) on the measured light intensity data as the composite progressively ages and classifies the light amplitude spectrum as a function of its frequencies and age. The FFT spectrum at different ages or health state encodes vital information regarding structural degradation in the form of changes in amplitude at various constitutive frequencies. Since SHP is basically a pattern recognition problem at given inputs, the large amount of FFT spectrums at different ages and frequencies is fed as inputs to the NN model to identify the underlying pattern and hence map the inverse relationship between measured light intensity and material deterioration. The NN algorithm was trained and tested yielding high accuracies in predicting material deterioration in real-time.

Presenter: **Matthew Newman**
Major: **Mechanical Engineering**
Advisor: **Dr. Vishnu Sundaresan**

Fabrication of Lithium-Ion Pouch Cells with Reversible Shutdown Membrane Separator

Electric vehicles and the batteries that power them are especially of interest as the thrust for sustainable transportation intensifies. A major safety concern of batteries is thermal runaway which can result in fires or explosions. Power limitations contribute to internal combustion engine vehicles outperforming electric vehicles. The purpose of this research was to transition a reversible shutdown membrane separator (RSMS) from a Swagelok to a Li-ion pouch cell architecture and find a cheaper alternative to gold in RSMS fabrication. The RSMS can function as an ion source or sink through a redox event, which can internally and reversibly prevent thermal runaway or provide a power boost.

A novel fabrication method was developed for a three active electrode Li-ion pouch cell with a RSMS. The RSMS shape was tailored with a built-in current lead and melt tape parameters were optimized for sealing. Capacity cycling and real time testing were performed to validate cell cycling capacities and reversible thermal runaway prevention or power boost capabilities of the RSMS. Cyclic voltammetry on gold alternatives provided filling efficiencies which indicate potential effectiveness in operation.

The cycling capacities of the cell with a RSMS were comparable to baseline cells for a reduced RSMS and lower for an oxidized RSMS. Real time results showed the RSMS could shutdown the battery anode current for ~30-60 seconds or provide a power boost for ~60 seconds. Nickel was determined a potential alternative to gold due to electropolymerization ease and a filling efficiency of 31.9% compared to gold's 42.5%. This is the first technique (to our knowledge) for fabricating three active electrode pouch cells, which could be used with different active membrane separators or third electrodes for expanded battery capabilities. Battery architectures with a RSMS can provide enhanced safety with thermal runaway prevention and improved performance with power boost capabilities.

Presenter: **Andrew Palo**
Major: **Electrical & Computer Engineering**
Advisor: **Dr. Inder Gupta**

Kalman Filter for Noise Reduction in Aerial Vehicles using Echoic Flow

Echolocation is a natural phenomenon observed in bats that allows them to navigate complex, dim environments with enough precision to capture insects in midair. Echolocation is driven by the underlying process of echoic flow, which can be broken down into a ratio of the distance from a target to the velocity towards it. This ratio produces a parameter τ representing the time to collision, and controlling it allows for highly efficient and consistent movement. When a quadcopter uses echoic flow to descend to a target, measurements from the ultrasonic range sensor exhibit noise. Furthermore, the use of first order derivatives to calculate the echoic flow parameters results in an even greater magnitude of noise. The implementation of an optimal Kalman filter to smooth measurements allows for more accurate and precise tracking, ultimately recreating the high efficiency and consistency of echolocation tracking techniques found in nature. Kalman filter parameters were tested in realistic simulations of the quadcopter's descent. These tests determined an optimal Kalman filter for the system. The Kalman filter's effect on an accurate echoic flow descent was then tested against that of other filtering methods. Of the filtering methods tested, Kalman filtering best allowed the quadcopter to control its echoic flow descent in a precise and consistent manner. In this presentation, the test methodology and results of the various tests are presented.

Presenter: **Deja Rush**
Major: **Biomedical Engineering**
Advisor: **Dr. Jennifer Leight**

Development of a MMP-responsive Drug Delivery System for De-differentiated Liposarcoma

De-differentiated liposarcoma (DDLPS) is a malignant soft tissue sarcoma known for its metastatic potential and high rate of local recurrence. Surgical resection remains the standard treatment for DDLPS due to the limited efficacy of systemic chemotherapy and radiation [1]. Chemotherapy is limited by systemic effects that prevent accumulation at the tumor site, thereby requiring higher dosages leading to adverse side effects. We started the development of a targeted drug delivery system that is responsive to specific signals in the tumor and its microenvironment to treat locally recurrent DDLPS. DDLPS is marked by amplification in the chromosomal locus 12q13-15 which is associated with amplifications of the oncoprotein mouse double minute 2 (MDM2) [2]. Mdm2 is found to be upregulated in nearly all cases of DDLPS and is associated with increased local recurrence rates [3]. Given that Mdm2 can serve as a reliable diagnostic marker, we wanted to find a downstream product that could be used to prompt controlled drug delivery. Matrix metalloproteinases (MMPs) are a family of endoproteases that contribute towards the degradation of the extracellular matrix (ECM). MMPs have previously been used in targeted drug delivery systems and are upregulated by increased levels of MDM2 [4]. Therefore, the relationship between MDM2 and MMPs demonstrated the potential to be exploited for a controlled drug delivery system. To make this system transferrable to a clinical setting, we began characterization of the MMPs being released from liposarcoma (LPS) cell lines. We used polymerase chain reaction (PCR) to gain a better understanding of how increased Mdm2 levels impacted MMP expression and found that MMP-1, -2, and -14 mRNA expression was significantly increased in cell lines with higher Mdm2 expression. Based on these results, we designed four peptide substrates that were amenable to degradation by the identified MMPs. Results indicated a trend in the QGIW and RSLS peptides that suggested preferential degradation by LPS cell lines with high levels of MDM2. To improve the design of these crosslinkers we used fluorescent peptide zymography to measure which MMPs might be contributing to the degradation of each peptide. We found that MMP-1 and -2 are driving the degradation of the selected substrates by LPS cell lines. Future work will aim to improve the design of the peptide substrates to make them more selective for degradation by MMP-1 and -2 specifically.

Presenter: **James Staschiak**
Major: **Mechanical Engineering**
Advisor: **Dr. Jordan Clark**

Solar Air Conditioning with Metal Organic Frameworks: energy modeling; thermodynamic and psychrometric optimization

This research discusses the use of traditional air condition (AC) units in the U.S. and their environmental impacts on the world. Due to the negative effects associated with green-house gas (GHG) emissions, the ultimate goal of this research is to drastically reduce non-renewable energy consumption associated with the operation of AC units. This can be accomplished through the integration of metal-organic frameworks (MOFs) into a solar air conditioning system. This integration allows for a thermally driven cycle that does not require a non-renewable energy input because of MOF properties. Short-term objectives are outlined throughout this research to assist in the determination of the most efficient and effective incorporation of MOFs. Then focusing on creating building energy models in different environments to quantify and compare the cost and energy savings. This information can then be used to assess savings in both single homes and commercial buildings.

Presenter: **Jordan Stechschulte**
Major: **Aeronautical & Astronautical Engineering**
Advisor: **Dr. Clifford Whitfield**

Aerodynamic Performance Analysis of C-wing Configurations

This thesis investigates the aerodynamic performance of a C-wing. The primary goal of this study was to investigate how the vertical length, horizontal length, and sweep angle of the wing affect the aerodynamic performance of the C-wing. The performance characteristics for each wing was simulated using vortex lattice method in OpenVSP. OpenVSP was run using a wing with known data to determine appropriate settings and panel size. It was concluded that the change in coefficient of lift, coefficient of drag, and lift-to-drag ratio of the wing changed relatively linearly as the size of the C-wing increased. It was also found that changing the sweep angle of the vertical section had a slightly positive effect on the performance as the sweep angle was increased. It was also concluded that the C-wing had a locally ideal performance range when the vertical length was 12-17% and the horizontal length was less then 12%.

Presenter: **Sarah Teater**
Major: **Food, Agricultural & Biological Engineering**
Advisor: **Dr. Monica Daley**

Assessment of the reaction of pet dogs to novel stimuli using accelerometers

Behavioral studies as they currently exist often require labor intensive manual tracking and annotation. Accelerometers have recently been shown to be a less involved alternative to identifying behavior and have many uses in clinical and commercial applications. This study aimed to evaluate the reaction of a pet dog to a novel environment, while alone, with the owner, and in the presence of unfamiliar person. Accelerometers were used to measure activity during the entire test. The dog was left alone in an enclosure for two minutes, then had contact with an unfamiliar person for two minutes, followed by another isolation period and then contact with the owner. It was found that the unfamiliar person had a significant impact on the activity levels of the dogs (p<0.01, n=7). The owner interaction was not significantly different than the unfamiliar person interaction, but the general trend was towards less activity while the owner was present (p=0.0984, n=7). The unfamiliar person was able to calm the dogs down in a new space. There were also differences among individuals that opened questions about the impact of size on accelerometry readings and the impact of home life and training on activity levels with the owner.

Presenter: **Evan Wang**
Major: **Electrical & Computer Engineering**
Advisor: **Dr. Lisa Fiorentini**

Applications of Real-time Motion Planning on Autonomous Car in Multiple Situations Under Simulated Urban Environment

Advanced autonomous cars have revolutionary meaning for the automobile industry. While more and more companies have already started to build their own autonomous cars, no one has yet brought a practical AI-controlled autonomous car into the market. One key problem of their cars is lacking a reliable active real-time motion planning system for the urban environment. A real-time motion planning system makes cars can safely and stably drive under the urban environment. The final goal for this project is to design and implement a reliable real-time motion planning system to reduce accident rates in autonomous cars instead of human drivers. This real-time motion planning system includes lane-keeping, obstacle avoidance, moving car avoidance, accident avoidance, adaptive cruise control functions. In the research, car robots will be built and equipped with an image processing unit, a LIDAR, and many ultrasonic sensors to detect the environment. These environment data make it possible to implement a full control program in the real-time motion planning system. This control program will be implemented and tested in a scaled-down car robot with a scaled-down urban environment. The project has been divided into three phases: build car robots, implement the control program of the real-time motion planning system, and improve the control program by testing under the scale-down urban environment. Currently, the car robots have been built and the control program has been already implemented. Testing and improvement works will be finished in the next few weeks. The more data grab from tests, the more stability of the real-time motion planning system can be implemented. Finally, one reliable motion planning system will be built, which will be used in normal scale autonomous vehicles to reduce accident rates under the urban environment significantly.

Presenter: **Allison Whitney**
Major: **Materials Science & Engineering**
Advisor: **Dr. Tyler Grassman**

Development of Texturizable Optical Coatings for III-V Solar Cells

This paper examines the approach to creating a permanent anti-reflective coating (ARC) for III-V type solar cells. It was determined that polydimethylsiloxane (PDMS) can successfully be used as a medium to transfer texture from a grit paper of sizes 3, 6, and 9 µm, as well as transferring biomimetic texture from a rose petal. The sol-gel method was used to make a silica precursor to be formed into a thin film that can be used as an ARC on III-V type devices. Silica was chosen because of its ease of processing and ideal optical properties. The silica sol-gel was applied via drop coat and spin coat methods and formed a thin film over the solar device that could be used for small feature texturization. Melting gels have been investigated as a permanent anti-reflective coating for III-V solar cells because of their ability to melt at low temperatures (around 100°C) and be rigid at room temperatures. The gels can be cured at temperature around 160°C to induce cross-linking that, once the gel cools and hardens into a film, keeps the film rigid at high temperatures.

Presenter: **Zhaoji Wu**
Major: **Mechanical Engineering**
Advisor: **Dr. Sandip Mazumder**

Model Based Exploration Of A New Cooling Concept For Battery Packs In Automotive Applications

With increasing electrification of automobiles, thermal management of battery packs used in automobiles is becoming a major challenge. Currently, in automotive applications, a lithium ion battery is cooled by placing it on a metallic cooling plate, which is cooled by steady injection of a coolant fluid through the channels embedded in it. While this cooling concept is relatively straightforward and meets the requirements of hybrid-electric vehicles, it does not result in the cooling capacity that would be needed for battery packs to be used in full electric vehicles of the future. In this research, we propose to explore a new cooling concept in which rather than use steady coolant flow, oscillating (reversing) flow will be used. Oscillatory flows have been known to result in higher convective heat transfer rates compared to steady flows, and have already been used in other thermal management applications. In the first phase of the research, Computational Fluid Dynamics and Heat Transfer (CFD/CHT) analysis will be conducted using oscillatory flow conditions to investigate if the new concept has merit from a scientific standpoint. In the second phase, the means by which flow may be reversed will be investigated using a separate CFD study of a so-called fluidic oscillator. A fluidic oscillator is a powerless device (similar to a garden sprinkler) that is capable of reversing flow due to fluid instability. The second research phase will answer the questions as to what the operating conditions and size of the fluidic oscillator should be for the desired mass flow rates for the application in question. In the final phase of the research, the findings of the two phases will be combined, and a virtual design (using CFD/CHT) of a cooling circuit will be created and demonstrated.

Presenter: **Mia Zhang**
Major: **Electrical & Computer Engineering**
Advisor: **Dr. Jonathan Song, Dr. Vish Subramaniam**

Understanding the Biological Basis of Alternating Electric Field Therapy of Breast Cancer Metastasis

Triple negative breast cancer (TNBC) is often associated with poor prognosis, and identifying new treatment modalities is required to contain this deadly form of breast cancer. The migration of cancer cells is a fundamental step during metastatic dissemination, and one of the primary drivers is epidermal growth factor (EGF). Akt is an important signaling molecule downstream of EGF and its receptor (EGFR) pathway. This research aims to understand the effects of extrinsically applied, alternating electric fields on EGF-EGFR driven migration of TNBC cells by carefully evaluating intracellular Akt activation. We refer to these fields as inductive electric fields (iEFs).

We utilized an engineered variant of the TNBC cell line MDA-MB-231 cells that contained a kinase translocation reporter (KTR) construct for Akt that allowed us to dynamically monitor Akt activity through changes in fluorescent intensity in the nucleus and cytoplasm. The KTR cells were treated with four different combinations of EGF stimulation, Akt inhibition, and EGFR inhibition and observed under a multi-channel fluorescent time-lapse microscope. A MATLAB code automatically quantified the change in activation by measuring the change in cytoplasmic versus nuclear fluorescence.

Upon addition of EGF, cytoplasmic translocation of fluorescent was observed, indicating Akt activation. When EGF and one of the inhibitors were added simultaneously, no detectable change in Akt activation was observed. Interestingly, sequential application of the Akt inhibitor following EGF stimulation demonstrated faster deactivation of Akt than when the EGFR inhibitor was added following EGF stimulation, suggesting direct inhibition of Akt caused faster deactivation compared to upstream inhibition of EGF.

The results establish a strong basis to further explore the effects of iEFs on the motility of TNBCs. I will conduct an experiment under iEFs to discover the effects of iEFs on EGF-EGFR signaling, which has the potential to help design new and improved treatments for TNBC.