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Developing clinical tools and medical devices to evaluate vestibular function in patients expose to blast

Prof. Chenkai Dai

School of Aerospace & Mechanical Engineering/Biomedical Engineering

Hearing/balancing injury have been known as the consequence of expose to blast overpressure (BOP) or repeated loud noise in military and civilian population while hearing/balancing function loss was ignored due to it chronic progress. However, complaints of hearing loss and dizziness is increasing in population and the mechanism of hearing/balancing function loss due to BOP/loud noise remains partially unclear. We create a chinchilla model to test hypothesis: 1. The BOP can travel through air and fluid filled inner ear and cause acute impact on hearing/balancing function.
2. The acute impact of BOP/noise on hearing/balancing function could turn into chronic due to the slowly yet progressively change in auditory/vestibular system. To test above hypothesis, we will develop VOG plus smart motion system to measure the Vestibuloocular reflex (VOR) in chinchillas exposed to low/mild intensity BOP over time to characterize the balancing function change after blast. We also develop new tools to evaluate hearing function. The goal of this project is to provide solid preliminary data for future prevention, medicine treatments and protecting devices design. Undergraduate students who participate in this project will have an opportunity to learn about blast setup, animal ear surgeries, VOR measurements with video-oculography and smart motion system, statistical analysis and computational simulation. Students in all engineering disciplines are welcome to apply for this project.

Develop new clinical tools to detect early ear infection
Prof. Chenkai Dai
School of Aerospace & Mechanical Engineering/Biomedical Engineering

Otitis media (OM) is the most commonly diagnosed infectious disease in young children. The early diagnosis is critical for treatment and recovery but is difficult due to accurate limitation of current clinical tools. Our long-term goal is to develop new clinical tools by investigating the feasibility of early detection of infection/inflammation with novel laser scanning/OCT plus new algorithms derived by enhanced machine learning of data from simulation measurements in 3D printed ear and animal otitis model. In this project, we are going to measure the TM motion within the animal model and 3D printed ear with simulation of OM. The data collected from simulation in 3D printed ear will be used for machine learning to enhanced the algorithm of TM motion prediction. The data obtained from animal model will be used to validate the algorithms and FE modeling. Undergraduate students who participate in this project will have an opportunity to learn about 3D printing, FE modeling, machine learning, novel laser scanning and OCT measurements. Students in all engineering disciplines are welcome to apply for this project.

Novel Laser-Immunological Treatment for cholesteatoma in chinchillas model
Prof. Chenkai Dai
School of Aerospace & Mechanical Engineering/Biomedical Engineering

Acquired cholesteatoma is a destructive process of the middle ear resulting in erosion of the surrounding structures by squamous tissue in the middle ear space, thereby causing severe hearing loss, vestibular dysfunction, facial paralysis, or intracranial complications. The long-term outcomes from current ossicular prostheses are not optimal. There is an unmet need for developing new generation of treatments to improve the surgical outcomes. We hypothesize that photothermal therapy (PTT) + glycated chitosan, (GC) treatment will reduce the cholesteatoma significantly comparing with control. To test this hypothesis, we will test the novel LIT in chinchillas model. Our long term goal is to provide a breaking through new treatment for cholesteatoma patients.
Brain Data Analysis due to the Development of Crawling in Children at Risk of Cerebral Palsy

Prof. Lei Ding

Stephenson School of Biomedical Engineering

Typically developing infants initially learn to crawl through the generation of spontaneous limb and trunk movements. The rewarding locomotory experience drives infants to refine movements to intentional and exploratory skills. Infants with conditions such as cerebral palsy lack muscle strength, postural control, and motor coordination necessary for these early exploratory limb and trunk movements to result in locomotion. Without this positive feedback, the development of neural pathways for productive limb use is diminished, which results in delayed or lack of development of crawling and walking. We have used a designed robotic platform to promote crawling skills in infants and record electroencephalogram (EEG) to monitor the development of infants’ brain, particularly motor functions. So far we have collected EEG data from about 50 infants weekly from 4 months to 11 months old. In the project, we will need to analyze these data in order to understand the development of motor brain in both typical developing infants and infants at the risk of cerebral palsy.

Student involvement: The objective of the project is to help the student acquire knowledge about biomedical signal acquisition and processing by involving in an ongoing research project. The student will be instructed to perform EEG data analysis in order to understand the development of the human brain at the first year of life. Student tasks will include computational analysis, signal processing and the use of neuroimaging techniques.

Brain Computer Interface with Virtual Reality

Prof. Lei Ding

Stephenson School of Biomedical Engineering

Brain computer interface (BCI) refers to the communication between a human’s brain and a technological application. The primary method of this interaction is through electric potentials collected from the human brain known as electroencephalography (EEG). Sensors attached to a person’s scalp in a noninvasive manner can collect these evoked potentials to be amplified and processed. EEG collected during certain events or stimuli can be decoded to understand spatial and frequency response patterns in the brain. Inversely, specific EEG patterns produced consciously by a user can be used to control computer interfaces or electromechanical devices. Some major applications of BCI include smart home automation control, synthetic communication, and neuroprosthetics. The purpose of this project is to explore the capabilities of a framework of integrating BCI and virtual reality (VR). The student will be asked to explore a virtual-environment-based scenario and use BCI to control this scenario, which works with a cutting-edge headset named Oculus Rift (OR) to provide users with immersive VR experience and an EEG system to acquire brain signals for control. The objective of the study is to push the application of BCI in VR area for potentially rehabilitation purpose.

Student involvement: The objective of the project is to help the student acquire knowledge about biomedical signal acquisition and processing by involving in an exploratory new study. The
student will first be exposed to EEG acquisition practices using current lab equipment and procedures to understand the basics of data acquisition. The student will then work another student on setting up the BCI EEG hardware and software for experiments. This process will involve an extensive learning and understanding of the EEG electrodes, communication modules, and Visualizer software. Once the system setup has been established, we will begin testing with the existing protocol. Student tasks will include development of experimental procedure, data acquisition with human subjects, and use of signal processing techniques for implementation of BCI application. After the student is familiar with the system, it will be asked to develop a scenario independently. The project is more suitable for students to have the relevant background and who are motivated to work independently.

Bond Behavior of Non-Proprietary Ultra-High Performance Concrete
Prof. Royce Floyd, P.E., Ph.D.
School of Civil Engineering and Environmental Science

Ultra-high performance concrete (UHPC) is a cutting edge cementitious composite with a compressive strength up to ten times that of conventional concrete and exceptional durability properties. It also requires significantly shorter embedment lengths to develop the full strength of reinforcing bars. Unlike conventional concrete, UHPC has no large aggregate and contains a high percentage of steel fibers. The quantity of steel fibers has been observed to significantly influence bond behavior of typical reinforcing bars cast in the UHPC. In this project the student will work with graduate students at Fears Structural Engineering Laboratory to conduct reinforcing bar pull-out tests using epoxy-coated reinforcing steel and non-proprietary UHPC with varying fiber content. The results of these tests will be used to quantify the bond behavior of the epoxy coated reinforcing bars typically used for bridge applications and to develop a generalized prediction of bond behavior for reinforcing bars embedded in UHPC.

Internal Curing of Ultra-High Performance Concrete
Prof. Royce Floyd, P.E., Ph.D.
School of Civil Engineering and Environmental Science

Ultra-high performance concrete (UHPC) is a cutting edge cementitious composite with a compressive strength up to ten times that of conventional concrete and exceptional durability properties. The low water content of UHPC leads to significant quantities of unhydrated cement within the matrix, yet the low permeability of the concrete does not allow external curing water to reach the cement to continue curing. This unhydrated cement only contributes to the concrete as filler while increasing the overall cost. Researchers at the University of Oklahoma have developed a non-proprietary UHPC mix made with local materials with the potential to give state departments of transportation much more flexibility. Internal curing water provided by presoaked lightweight aggregate may be the answer to improve performance of this mixture by increasing concrete compressive strength and reducing concrete shrinkage through improved cement hydration. In this project the student will work with graduate students at Fears Structural Engineering Laboratory to evaluate the effect of internal curing on concrete compressive strength, shrinkage, and freeze-thaw.
durability. The student will develop the adjusted mix designs, cast required test specimens, and conduct all material testing.

**Novel Investigation of Hearing Damage Induced by Repetitive Blast Exposure Using the 3D Printed Helmet and Hearing Protection Devices in Animal Model of Chinchilla**

Prof. Rong Gan

*School of Aerospace and Mechanical Engineering*

To investigate whether the hearing protection devices (HPDs) can protect the central auditory system (CAS) against damage under repeated blast exposures, we have initiated a novel study by using a 3D printed helmet as a head protection device associated with the HPDs in animal model of chinchilla. The goal is to isolate the CAS damage resulted from the traumatic brain injury (TBI) from the cochlea injuries caused by blast pressure waves transmitted through the ear. The chinchilla “helmet” is created based on micro-CT images of a chinchilla skull. A 3D finite element (FE) model of the skull is generated and used to predict the change of pressure or stress in the intracranial tissues under blast overpressure loading when the helmet is applied on the skull. The experiments of measuring the pressure inside the brain will be conducted by inserting the pressure sensor through the skull, and the FE modeling results will be compared with the experimental data. Research undergraduates will work with graduate students in Biomedical Engineering Lab located at Stephenson Research Technology Center (SRTC).

**Construction and Testing of Full-Scale GRS Bridge Abutments under Surcharge Loading**

Prof. Kianoosh Hatami, PhD, PEng

*School of Civil Engineering and Environmental Science*

The Geosynthetic Reinforced Soil-Integrated Bridge Systems (GRS-IBS) technology has been developed over the last decade through extensive support and promotion by the Federal Highway Administration as a rapid and cost-effective bridge construction alternative to the conventional, deep-foundation abutment systems for local and county roads across the United States, as part of their EDC initiatives (e.g. https://www.fhwa.dot.gov/innovation/everydaycounts/edc-3/grs-ibs.cfm).

In this project students will join a research team to help build, instrument and test large-scale (8 ft-high) GRS abutments on the OU south campus to investigate their load bearing capacity and deformation. Results of the study are of interest to transportation agencies, and authorities in charge of repair and construction of bridges on local and state highways.

Interested students can contact Dr. Kianoosh Hatami at kianoosh@ou.edu for further information.
Development of Tensoresistive Geosynthetics for Performance-Monitoring of Infrastructure
Prof. Kianoosh Hatami, PhD, PEng
School of Civil Engineering and Environmental Science

Many public agencies in the U.S. are faced with the challenging task of developing and maintaining infrastructure across the country with limited financial resources. A significant portion of construction materials used in infrastructure projects involves earthworks (e.g. embankments, foundations, retaining walls and engineered slopes in roads and highways, bridge abutments, landfills, airports, levees, coastal structures and canals, among many others).

A branch of modern geotechnical engineering is specialized on the application of polymers as synthetic construction materials (termed as Geosynthetics) to enhance the performance and stability of earthwork structures. Meanwhile, performance monitoring of earthwork structures is vital to detect and avert the consequences of uncertainties encountered during their construction and operation. Performance monitoring can also lead to significant savings in the costs and delivery time of projects.

The research team of this multi-disciplinary project has been working on developing “smart” geosynthetics (called SEG) to detect deformations in geotechnical- and transportation-related structures. In this ongoing project, SEG samples are made by dispersing nanoscale conductive additives such as carbon nanotubes (CNT) and carbon black (CB) within a host polymer. So far, significant progress has been made in understanding the electrical conductivity and mechanical performance of SEG samples in the laboratory.

During the next phase of this project, the HERE research assistant will help the research team fabricate SEG samples and test them in small-scale blocks of soil in the laboratory to investigate their in-soil performance simulating actual conditions in the field. The objective of the study is to develop and validate SEG prototypes for large-scale production by geosynthetic manufacturers for field applications.

How to Make a Brain in a Billion Easy Steps
Prof. Dean Hougen
School of Computer Science

Member of the Robotics, Evolution, Adaptation, and Learning Laboratory (REAL Lab) conduct fundamental artificial intelligence research aimed at developing machines that can think in sophisticated ways. We focus primarily on six topics that may at first seem incongruous but that are deeply interwoven: Learning, nurturing, evolution, speciation, mutualism, and risk. These concepts come to us from biology, cognitive science, psychology, child development, sociology, education, and economics, among other disciplines. We pursue these topics individually and in combination, theoretically (mathematically) and experimentally. Research assignments will be based on particular interests and skills but are likely to include many of the following: Determining research questions; formulating hypotheses; conducting mathematical proofs; designing experiments; writing and modifying simulation software; porting software from simulation to real
Analysis of Fly Ash Leaching into Groundwater

Prof. Robert C. Knox

School of Civil Engineering and Environmental Science

The Grand River Dam Authority (GRDA) owns and operates the Grand River Energy Center (GREC), an electric power generating facility, located approximately three (3) miles east of the City of Chouteau in Mayes County, Oklahoma. Two (2) coal fired boilers are in place at GREC but only one (Unit #2) is currently operational. The coal fired boiler in use produces Coal Combustion Residuals (CCRs) consisting of fly ash and bottom ash. Fly ash comprises greater than 80% of CCRs generated at the facility and is largely sold for beneficial use purposes. Excess fly ash and bottom ash is disposed within an on-site permitted coal ash landfill. Recent groundwater monitoring well data might indicate that inorganic constituents from the landfill are leaching due to rainwater infiltrating into the fly ash.

This study would utilize natural clean groundwater mixed with a sample of landfill fly ash to assess what constituents, if any, are being leached out. The study would involve mixing fly ash from the GREC with natural, uncontaminated groundwater near the site. The fly ash and groundwater would be combined into one sample, along with one control (groundwater only sample). Fluids from the two samples would be extracted over time and analyzed for the major inorganic ions. The results of the analyses would be plotted on trilinear groundwater quality diagrams to show the effects of mixing and changes in chemistry over time. These results could provide insight as to what constituents might be leached from the fly ash landfill.

Statistical Analysis Of Participants In The Biennial OU Water Center Conference

Robert C. Knox, Ph.D., PE
Presidential Professor and Ted A. Kritikos Endowed Chair
Civil Engineering and Environmental Science

The OU Water Technologies for Emerging Regions (WaTER) Center seeks to develop sustainable solutions through integrating technology, business and social understanding. To that end, the WaTER Center host a biennial conference that culminates with the awarding of the OU International Water Prize. The WaTER Conference is designed to bring together participants from multiple disciplines world-wide in response to the UN Millennium Development Goals of bringing water and sanitation to emerging regions. Through six cycles of the biennial conference, the WaTER Center has developed a sizeable database regarding the attendees and participants. The objective of this project would be to analyze the WaTER Center database of abstracts and/or papers presented at the WaTER Conference and for trends for:

• Who is doing the research on water and sanitation (NGO’s, academics, governments, others)?
Who is doing the “implementations” (NGO’s, academics, charities, others)?
Who is being studied in the research (demographics of the study groups – towns, villages, neighborhoods, slums; affluent versus underserved)?
What novel ideas have come out of this research?
  - Scientific technologies (all of the various water purification devices)
  - Innovative social programs (e.g., Martha Gebeheyu’s “train the trainer” efforts, relocating female restroom facilities in schools, etc.) is the research
  - Economic studies (how much people are willing to pay papers)
  - Geographic distribution of where the abstracts are coming from
  - Demographics of the actual WaTER Conference presenters

The results of this investigation would be utilized in a paper to be submitted to the Journal of Contemporary Water Research & Education and would also be featured in one of the technical sessions for the 2019 OU International Water Conference.

Biomechanical Testing for Soft Biological Tissues
Prof. Chung-Hao Lee
School of Aerospace and Mechanical Engineering

Mechanical properties of soft biological tissues are important and necessary information for development of predictive computational models for many biological systems. This project aims at understanding the mechanical properties of native tissue materials, which consists of three key ingredients: (i) acquisition of biomechanical data for soft biological tissues, (ii) statistical analyses of the acquired data for subject-averaged biomechanical characteristics, and (iii) formulation of constitutive models that best describe the overall mechanical behaviors of tissues. Undergraduate students who participate in this project will have an opportunity to work on tissue experiments using a commercial biaxial mechanical testing device, learn about fundamental statistical analysis techniques, and gain experience on systematic fitting of the mechanical data for constitutive model parameter estimations. Students in all engineering disciplines are welcome to apply for this project.

Decellularization and Histological Analysis of Soft Biological Tissues
Prof. Chung-Hao Lee
School of Aerospace and Mechanical Engineering

Current replacements for failing heart valves suffer shortcomings such as requiring life-long blood thinner prescriptions, immune system suppressants, or the inability to grow with a patient. Tissue engineered heart valves are a promising alternative to current replacement heart valves due to their ability to better emulate a natural valve and develop alongside the patient. A first step in developing tissue engineered heart valves is through decellularization of tissues from healthy donor animals, such as pigs. Proper decellularization of a tissue requires several cycles of either chemical, physical, or biological treatments to remove the cells and DNA, as any remaining cells or DNA could elicit an immune response that would be harmful in patient implantation. To evaluate the efficacy of the various decellularization techniques, histological examination will be performed in which tissues are stained with dyes that allow microscopy-based evaluation of the remaining cells.
Synthesis and Characterization of Polymeric Materials for Biomedical Applications

Prof. Chung-Hao Lee

School of Aerospace and Mechanical Engineering

Shape memory polymers (SMPs) are unique materials capable of returning from large deformations to a single “programmed” shape when they are given a thermal trigger. They have a wide variety of potential uses, and our lab is interested in exploring their potential use in the field of implantable medical devices. The main objective of this project is to investigate a variety of synthesis and manufacturing methods for the production of shape memory polymers. This project will involve: (1) synthesis of polymers with various chemical compositions, (2) modifying synthesis procedures to produce unique SMP shapes and structures (ex: foams, solid beams, filaments and resins for 3D printing, etc.), and (3) exploring the use of additive components to allow for triggering mechanisms other than heat (e.g., light, electric current, chemical, etc.) Students from all engineering disciplines who are interested are welcome to apply for this project.

3D Geometry Reconstruction

Prof. Chung-Hao Lee

School of Aerospace and Mechanical Engineering

Analysis of biological systems can benefit by 3D geometric reconstructions of those systems from patient imaging data, which allow for subsequent computational frameworks to predict mechanical alterations to those biological structures. Specifically, aneurysms in the brain and the heart valves can be digitally reconstructed, which is an important first step towards developing innovative therapeutics. Hence, the execution of this project is two-fold: (i) acquiring micro-CT image data at the OU Advanced Medical Imaging Facility, and (ii) performing reconstruction of the 3D geometry of the brain aneurysms and heart valves and (iii) developing finite element meshes of the constructed geometries. Undergraduate students involving in this project will have an opportunity to gain experience on image segmentation via commercial software Amira as well as finite element mesh generation using software Hypermesh. Students from all engineering disciplines are welcome to apply for this project.

Experimentation with Biomedical Radar

Prof. Justin Metcalf

School of Electrical and Computer Engineering

Biomedical radar is an emerging non-ionizing alternative to computed tomography (CT) scans and magnetic resonance imaging (MRI) for several clinical applications. However, traditional
biomedical radars have significant design constraints that have kept radar from competing as a viable alternative technology. OU is in the process of building a new form of biomedical radar that will provide increased sensitivity, dynamic range, and resolution.

The HERE scholar will work at the Advanced Radar Research Center (ARRC) in south campus and be part of the team testing this new type of radar and comparing it to traditional biomedical radar designs. The radar will be tested on a range of materials, including 3D printed models, in the ARRC anechoic chambers. The HERE scholar will gain hands-on experience with two forms of radar, as well as familiarity with the data processing required to characterize the radar performance. No prior knowledge is required, but students should be willing to learn Matlab, Python, Labview, and the operation of 3D printers. Training will be provided for operation of the 3D printers and the radar. Students interesting in radar, biomedical engineering, or electromagnetics are encouraged to apply.

Understanding the Interaction Between 5G and Its Neighbors

Prof. Justin Metcalf

School of Electrical and Computer Engineering

The electromagnetic spectrum is a fixed, finite resource that has long been used to support diverse applications such as radio and television broadcasts, air traffic control, weather radar, radio astronomy, cell phone telecommunications, and military radar and communications. Economic pressures have pushed the government to auction off spectrum to telecommunications companies, allowing 5G networks to spread to new frequencies adjacent to other users. The impact of 5G networks on other types of spectrum users – such as weather and defense radar – is not well understood. Some studies have suggested that the signals used by 5G networks aren’t always good “spectral neighbors”. As an additional complication, the concept of “spectral neighbors” is a difficult concept to illustrate and demonstrate.

Therefore, the HERE scholar will work with a team to study the interaction between 5G signals and other applications. The scholar will research 5G frequency bands and the types of users adjacent to those bands (e.g. as a starting point, weather and defense radar). The scholar will learn to use the open source GNU Radio software to control software defined radios (SDRs) – providing a tool with which to “view” the spectrum and demonstrate the interaction between neighboring spectral users. Students should be willing to learn Python and Matlab. Students interested in radar and wireless communications are encouraged to apply.

Bilevel Decision Making Based On Partitioning, Coordination And Surrogate Model Approximations

Reza Alizadeh (Doctoral Candidate, ISE), Professor Janet K. Allen (ISE), Professor. Farrokh Mistree (AME)

Systems Realization Laboratory; ISE/AME Joint Enterprise
School of Industrial and Systems Engineering

Almost all of application problems in engineering design, healthcare, supply chain, business analytics, manufacturing, and energy management involve two levels of formulation, where one
decision making task is nested inside the other. These problems are known as bilevel decision making problems and have been widely studied by researchers in the area of mechanical engineering, computer science, industrial and systems engineering, data science, energy and environmental engineering. Bilevel decision making problems are known to be computationally demanding. Most of the solution procedures proposed until now are either computationally very expensive or applicable to only a narrow class of bilevel decision making problems involving small number of variables.

In this project, we propose a partitioning-coordination algorithm for bilevel decision making where a data science model is used instead of the original objective function to reduce the computational expense by iteratively approximating an important mapping in bilevel decision making; namely, the lower level decision making problem value function mapping. The lower level decision making value function is useful in reducing the two-level decision-making task to one; however, identifying this function is not straightforward. Using our approach, we aim at meta-modeling this mapping and solving a number of auxiliary single level problems to arrive at the bilevel optimum.

In this project, the HERE scholar will be assisting Ph.D. candidate Reza Alizadeh. The HERE scholar will have an opportunity to learn about optimization, compromised decision support problem, and practice data science. HERE scholar will learn how to develop machine learning algorithms to tackle a well-framed, healthcare and supply chain problem. The results may be presented at peer-reviewed conferences or academic journals. Students with prior experience in Python, high enthusiasm to read and learn ML, and plan to take a maximum of 15 semester credits are strongly encouraged to apply.

Designing Complex Engineered Systems For An Uncertain Environment

Gehendra Sharma (MS Candidate, AME), Professor Janet K. Allen (ISE), Professor Farrokh Mistree (AME)

Systems Realization Laboratory; ISE/AME Joint Enterprise
School of Aerospace and Mechanical Engineering

Designing complex engineered systems involve making numerous design decisions that often influence one another. In practice, such design decisions involve decisions that are to be taken concurrently or involve series of decisions which are to be taken one after the other, which form different decision levels. Furthermore, the uncertainty that lies at each stage of decision-making need to be properly addressed to render the effectiveness and accuracy of the undertaken decisions. In this project, Decision Support Problems (DSPs) are to be used as decision genes to model design decisions in the design of complex engineered systems. To develop a method and be able to model the decision interactions, concept for coupling the DSPs is to be studied along with various strategies to handle associated uncertainties. In this project, the HER scholar will work with Gehendra Sharma (MS student) to develop robust design process involving decision interactions, crucial for designing complex engineered systems under uncertainty. As such, the idea is to effect better decision-making in the design of such engineered systems by studying and exploring ways to:

- Identify critical decisions for designing such systems.
Incorporate analyses from various knowledge domains that govern these decisions.

• Identify and model how the design decisions pertaining to subsystems interact.

• Addressing uncertainties arising from various sources (noise, operations, design, manufacturing)

We look forward to the HERE scholar be a co-author on a paper that eventuates from this work. A HERE scholar, who will be taking no more than 15 units in Fall 2020, with some knowledge about the design of machine elements, interest in mathematics and programming and a willingness to learn and contribute is highly encouraged to apply.

Development of A Framework For Sustainable Development Projects In Rural India

Lin Guo (Doctoral Candidate, ISE), Professor Janet K. Allen (ISE), Professor. Farrokh Mistree (AME)

Systems Realization Laboratory; ISE/AME Joint Enterprise
School of Industrial and Systems Engineering

To carry out sustainable development projects in a large, diverse developing country, such as India, we need a framework to standardize and customize the process and make the knowledge reusable. In this project, we plan to establish a framework for sustainable development in rural India by integrating the micro simulation, agent-based modeling (ABM), with the macro simulation, System Dynamics (SD). We want to create a workflow to integrate scenario planning and policy making in the evaluation and adjustment of the outputs of the ABM and SD. Our scenario planning may include but not limit to i) scenario analysis, which is to capture the variability of model results, and ii) sensitivity analysis, which is to identify sensitive factors responsible for certain variability. With the output of scenario planning, we plant to identify and navigate the multiple trade-offs between factors and results, and make recommendations on scenario selection and policy making based on stakeholders’ requirements and preferences, which may vary over time and conflict with on another. We need to illustrate the use of this framework with two test problems – enhancing villagers’ socioeconomic status by promoting two-season planting in an island village and improving villagers’ awareness of sustainable development through policy making in sense of environment protection, investment in continuing education and improvement of social welfare.

We look forward to the HERE scholar be a co-author on a paper that eventuates from this work. A HERE scholar, who will be taking no more than 15 units in Fall 2020, with a keen interest in coding, interest in mathematics and programming and a willingness to learn and contribute is highly encouraged to apply.

Development of A Template For Robust Design Of Engineered Systems And Validation Of The Template Using Simulation

Zhenjun Ming, PhD (Postdoctoral Research Associate), Professor Janet K. Allen (ISE), Professor. Farrokh Mistree (AME)

Systems Realization Laboratory; ISE/AME Joint Enterprise
School of Aerospace and Mechanical Engineering
In engineering design, designers usually confront a variety of uncertainties. One strategy for dealing with uncertainty is to mitigate uncertainty by seeking “perfect” models, collecting more data, developing improved methods to model, calculate and quantify uncertainty through expensive computations. The limitation of this strategy is that it is impossible to build “perfect” models during the design phase since information is usually incomplete and inaccurate. We are not interested in eliminating but rather managing uncertainty. We have developed several robust design protocols such as the Design Capability Indices (DCI) and Error Margin Indices (EMI) for managing different types of uncertainties. But we lack of a reusable and executable template for designers to formulate robust design problems using those protocols. In this project, HERE scholars will work with Dr. Zhenjun Ming to develop a reusable and executable robust design template. The template will be validated using simulation experiments and data analytics. The validated template will be deployed in a Cloud-Based Platform for Decision Support in the Design of Engineered Systems (CB-PDSIDES). HERE scholars with a strong interest in coding, some knowledge of design optimization, information modeling, and willingness to read and learn, and plan to take no more than 15 credits (including this course) are encouraged to apply.

Helping Football Players To Recover From Concussion Faster Using Data Science

Reza Alizadeh (Doctoral Candidate, ISE), Professor Janet K. Allen (ISE), Professor. Farrokh Mistree (AME)

Systems Realization Laboratory; ISE/AME Joint Enterprise
School of Industrial and Systems Engineering

The NFL has spent $100 Million in concussion research. More than half of this research is using data science as the analysis method. Known also globally as the 'silent epidemic,' early detection and diagnosis of mild Traumatic Brain Injury (mTBI) are critical for the prevention of concussion progression. Our investigation of mTBI implements thermography as an assistant for mTBI. We hypothesize that patients with mTBI will exhibit temporal and spatial dynamics in thermal signature on the surface of the skin and that these dynamics reflect the inflammatory process. We implemented far-infrared (FIR) thermography using a blunt mTBI rat model to analyze changes in the external surface temperature gradient as an indication of internal inflammation. Based on preliminary results, there is a consistent increase in average surface temperature (AST) after 0.5 days of recovery post-impact. The AST trend appears to correlate well with the inflammatory process seen in published mTBI inflammatory biomarker concentration dynamics. Therefore, thermography may be used as a diagnostic screening tool for on-site, early detection of TBI. However, to prove this hypothesize, we need to process the thermography images via data science and machine learning algorithms.

In this project, the HERE scholar will be assisting Ph.D. candidate Reza Alizadeh. The HERE scholar will have an opportunity to learn about NFL supported concussion research and practice data science. The HERE scholar will learn how to develop machine learning algorithms to tackle a well-framed, healthcare problem. The results may be presented at peer-reviewed conferences or academic journals. Scholars with prior experience in Python, TensorFlow or Keras,
high enthusiasm to read and learn ML, and plan to take a maximum of 15 semester credits are strongly encouraged to apply.

Modeling robustness for coupled decision problems encountered in engineering

Ghendra Sharma (MS Candidate, AME), Professor Janet K. Allen (ISE), Professor. Farrokh Mistree (AME)
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School of Aerospace and Mechanical Engineering

Decision Support Problems (DSPs) are used to model design decisions involving multiple trade-offs. In practice, such design decisions are also coupled, i.e., selection and compromise decisions have to be made concurrently accounting for the influence they exert on one another. Selection involves making choice among a number of alternatives considering several attributes while compromise involves synthesizing design variables against multiple conflicting requirements. In context of designing a gearbox, the decision about gearbox geometry must come from the requirements such as torque and speed, low weight, constraint on size, noise and vibration reduction, etc., which leads to a compromise decision. We also have numerous material alternatives available for selection. These two decisions have to be made concurrently by considering the influence of one decision over the other. Further, it is imperative that the design decisions are robust against the expected variability in design variables, material properties and manufacturing process. In this project, the HERE scholar will work with Ghendra Sharma (MS student) to further our effort to develop decision support that aids:
• Modelling of coupled decision problems encountered in design of a gearbox
• Incorporating robustness into the model
• Exploring design decisions against multiple conflicting goals (more than 3 goals)
We look forward to the HERE scholar be a co-author on a paper that eventuates from this work. A HERE scholar, who will be taking no more than 15 units in Fall 2020, with some knowledge about the design of machine elements, interest in mathematics and programming and a willingness to learn and contribute is highly encouraged to apply.

Social Responsibility and Green Supply Chain Relationships

Reza Alizadeh (Doctoral Candidate, ISE), Professor Janet K. Allen (ISE), Professor. Farrokh Mistree (AME)
Systems Realization Laboratory; ISE/AME Joint Enterprise
School of Industrial and Systems Engineering

Global warming, resulting from fossil fuel consumption and greenhouse gas (GHG) emissions, threatens the environment. Transportation accounted for 29%, and electricity generation accounted for 28% of GHG emissions in the United States in 2019. Both transportation and electricity consumption are the main elements of a supply chain. So, by designing a green supply chain (GSC), near to 60% of GHG will be mitigated. That is the reason Walmart has promised that it will minimize one billion m3 tons of GHG emissions from its SC network by 2030.
Also, Jeff Bezos, Amazon’s CEO, commits $10 Billion to address Climate Change. Inspiring from Walmart and Amazon’s vision and goals, we use the term purchasing social responsibility (PSR) to describe the involvement of purchasing managers in socially responsible activities. Our purpose in this research is to examine the potential impact that PSR might have on green supply chain relationships. The expected findings will be identifying the PSR’s effect on supplier performance, as well as its impact on green supply chain performance through improved trust and cooperation. These findings will hold important implications not only for purchasing managers but also for logistics managers in the areas of customer service, distribution, and business-to-business marketing.

We have already designed the GSC and undertaken a comprehensive sensitivity analysis. So, it is a well-defined problem that will help the HERE scholar to learn about how to frame a problem on the green supply chain with a focus on economically profitable, environmentally friendly, and socially sustainable. The HERE scholar will also learn about social justice, and corporate social responsibility will have the opportunity to learn how to develop mathematical models to quantify a real-life sustainable development problem. Also, the HERE scholar will have a chance to showcase the results at peer-reviewed conferences or academic journals. Scholars with prior experience in Python, high enthusiasm to read and learn ML, and plan to take a maximum of 15 semester credits are strongly encouraged to apply.

Using Data Science To Create Finite Element Analysis-Based Mathematical Surrogate Models For Occupant Brain Injury Due To Vehicular Impacts

Reza Alizadeh (Doctoral Candidate, ISE), Professor Janet K. Allen (ISE), Professor. Farrokh Mistree (AME)
Systems Realization Laboratory; ISE/AME Joint Enterprise
School of Industrial and Systems Engineering

Vehicular impacts are one of the leading causes of injury and death globally, with a reported 1.35 million deaths each year. In the United States alone, 14% of the approximately 2.8 million Traumatic Brain Injury (TBI) cases annually are the result of motor vehicle accidents. The widespread nature of this crash-induced injury and death has led to an increased interest in understanding the biomechanical responses behind head trauma as a means of better designing and optimizing safety features for consumer vehicles. Advances in human-centric automotive research, both experimental and computational, have led to a downward trend in the overall occurrence of TBI-related injuries per year. Computational modeling techniques, such as finite element (FE) analysis, are often used to simulate potentially dangerous impact scenarios that would be unviable in a physical experimentation setting. In this project, we will develop statistical predictive models to predict the impact of variables like velocity, location of the accident, and angle of the accident on the brain damages.

In this project, the HERE scholar will be assisting Ph.D. candidate Reza Alizadeh. The HERE scholar will have an opportunity to learn about NFL supported concussion research, finite element analysis, and practice data science. The HERE scholar will learn how to build predictive
models to deal with a real-life mechanical problem and also a healthcare problem. Also, the HERE scholar will have an opportunity to showcase the results at peer-reviewed conferences or academic journals. Students with prior experience in Python, R, high enthusiasm to read and learn ML, and plan to take a maximum of 15 semester credits are strongly encouraged to apply.

Advanced power system protection relaying under distorted electromagnetic transient phenomena
Dr. Paul Moses
School of Electrical and Computer Engineering
In modern power systems, electrical faults are normally detected by devices known as protection relays which are installed in substations for monitoring high voltage transmission and distribution circuits. Unfortunately, there are many transient disturbances that go undetected resulting in severe damage to equipment such as transformers. For example, distributed energy resources such as rooftop solar photovoltaics and wind power farms complicate protection system design due to volatile bidirectional power flows and dynamics which have been known to cause maloperation of relays and unintended tripping of circuit breakers. This project aims to 1) investigate the response and limitations of modern protection relays in detecting dynamic disturbances, and 2) improve the protection of critical components such as power transformers operating under distorted grid conditions. The project consists of computer simulation and laboratory experimental studies. Students with an interest in power engineering and have taken ac and dc circuit courses are encouraged to apply.

Aging of distribution transformer insulation in distorted networks
Dr. Paul Moses
School of Electrical and Computer Engineering
Power transformers are ubiquitous vital links in power networks. As the power grid becomes more chaotic with new dynamic loads, volatile renewable energy generation and other distortions, the stresses on transformer insulations increases, thus reducing the service life of the unit. This project investigates the accelerated aging of transformer insulation degradation under these distorted conditions. The researcher will assist in a series of experimental and computer modelling studies that will subject transformers to different stress patterns and help examine the impact on insulation performance. Students with an interest in power engineering and have taken ac and dc circuit courses are encouraged to apply.

Coupling small Unmanned Aerial System (sUAS) Technologies with In-Situ Sampling to Develop Estimations of Mining Waste Material Mass Loading Rates
Dr. Robert W. Nairn
School of Civil Engineering and Environmental Science
Waste materials from mining operations pose substantial risks to human health and the environment. At the Tar Creek Superfund Site (the Oklahoma portion of the now derelict Tri-State Lead-Zinc Mining District) approximately 500 million tons of mining waste material were produced during a century of operations. Locally known as “chat”, these waste materials continue to pose risk, as elevated concentrations of lead, zinc and cadmium are found in various environmental media (e.g., soils, surface and ground water, biota). Over the decades, the volume of waste materials has decreased due to appropriate and inappropriate reuse, remedial efforts and other activities. At the present time, the Oklahoma Department of Environmental Quality (ODEQ) estimates that about 30 million tons of chat remain on the surface in the Tar Creek area. The goal of this proposed research project is to quantify the environmental impact of chat on aquatic ecosystems. Utilizing imagery derived from small Unmanned Aerial Systems (sUAS) operated by the Center for Restoration of Ecosystems and Watersheds (CREW), digital surface models (DSMs) will be developed to estimate the quantity and transport potential of chat remaining on the surface at selected locations within the Tar Creek Superfund Site. Physical and chemical examinations of the chat will be performed to help determine contaminant mass loading rates. Expected deliverables include estimates of waste material volumes and transport potential, physical and chemical characterization of mining waste materials, and resulting approximate mass loading rates of mining wastes into local streams.

What happens to blood cells when they flow through medical devices?

Prof. Dimitrios V. Papavassiliou

School of Chemical, Biological and Materials Engineering

When blood flows through medical devices (like artificial heart valves), red blood cells may be damaged, depending on the flow conditions. The hemodynamic flow field induces stresses on the cell membrane leading to cell trauma. We want to understand exactly what type of flow conditions lead to cell death, to determine what type of stresses are the most important for causing the red blood cells to be damaged, and to see whether such conditions are met in cases of heart valve implants. We use computational fluid dynamics software (mainly ANSYS Fluent) to probe the blood flow through the valves. Our prior work has led validity to the hypothesis that small scale features in turbulent blood flow (smaller than about 10 µm) is mainly responsible for blood cell trauma. Comparing experiments and simulations can lead us to model this process. A student who has had intermediate Fluid Dynamics classes and an interest in computing would be the better fit for this project. Skills to be developed include the use of computational fluid dynamics software, the use of data analysis techniques, presenting research results and thinking critically about open-ended problems.

Harnessing Interfacial rheology to Control Foam Stability

Prof. Sepideh Razavi

School of Chemical, Biological, and Materials Engineering

Diminishing world energy resources requires the employment of novel and effective methods in oil and gas production. Foam-based fluids are an attractive alternative to traditional methods due
to their unique properties. In particular, particle-stabilized foams are suitable candidates for applications in petroleum industry because of the effectively irreversible adsorption of particles to interfaces, the viscoelasticity of the interface imparted by the particles, and the stability of particle-stabilized foams in presence of oil. Despite their tremendous potential, the limited knowledge available on tuning the stability of foams has been a roadblock to their widespread application in petroleum industry. A gap exists in understanding the mechanisms and critical factors influencing the performance of foams. In particular, there is a critical need to fundamentally understand the role of interfacial rheology in the drainage of foam lamellae, the bubble dissolution, and the dynamical response of foams. In this project, the student will set up experiments using a foam analyzer and characterize the stability of Pickering foams prepared from colloidal particles with varying properties. Students with some knowledge in the design of experimental setups who are willing to learn and contribute ideas are encouraged to apply.

Janus Nanoparticles Targeted for Membrane Applications

Prof. Sepideh Razavi
School of Chemical, Biological, and Materials Engineering

Separation and purification processes, such as distillation, consume a substantial amount of energy and contribute to environmental pollution. For instance, CO2 removal accounts for a large fraction of costs in oil and gas processing. Membrane technology offers a promising alternative to traditional thermal separation methods. Membrane-based separations require an amount of energy which is two order of magnitude lower than traditional processes. Despite their potential, use of membranes is limited by the intrinsic trade-off between permeability and selectivity. Highly permeable membranes often exhibit poor selectivity, and vice-versa, such that the performance of gas separation membrane materials remains constrained to below an upper limit. In this project, using rational criteria, we are developing a new membrane material tailored to CO2 removal from natural gas and CO2 sequestration from process effluents. These membranes will contain Janus nanoparticles, a particle with a dual characteristic that is composed of both polymer and silver compartments. The presence of Janus nanoparticles in the composite will enhance the membrane permeability (i.e., membrane productivity) by disrupting the polymer chain packing, that is, by creating additional pathways for penetrant transport. In addition, the presence of silver in the particle will boost the CO2 sorption in the membrane. The student will synthesize the nanoparticles, fabricate the membranes, and carry out transport measurements on the membranes. Students with some knowledge in chemical synthesis who are willing to learn and contribute ideas are encouraged to apply.

Magnetic Colloidal Particles and their Tunable Assembly

Prof. Sepideh Razavi
School of Chemical, Biological, and Materials Engineering

The process of assembly in a system of building blocks gives rise to ordered structures as a result of specific local interactions among the components. In nature, assembly manifests itself in form of complex biological architectures such as viral capsids. Inspired by the plethora of naturally occurring assemblies, scientists are employing the assembly principles to design materials with a tailored set of properties using synthetic building blocks. In this project, we will use polymeric
nanoparticles as the building block for assembly and coat their surface with magnetic nano-layers in order to obtain anisotropic nanoparticles. We will study the self-assembly of these particles followed by the use of magnetic fields in driving the assembly via induced dipole interactions. Our findings will guide us in engineering structures that are reconfigurable and possess tunable functional properties. In this project, the student will design an experimental setup suitable to a system of micron-sized colloidal particles that are coated with a thin layer of magnetic materials. Next, the student will expose these particles to magnetic fields and measure their response and assembly behavior. Students with some knowledge in the design of experimental setups who are also familiar with electromagnetism and are willing to learn and contribute ideas are encouraged to apply.

Human-Machine Interaction within Technology: Toward Measuring and Predicting Technology Adoption

Prof. Randa Shehab
School of Industrial and Systems Engineering

The goal of technological advances is to enhance the human experience, and technology has evolved over time and continues a rapid trajectory. One space where this phenomenon can be observed is the ground transportation space. As automated vehicles are being developed, there is a lot of focus on how this technology will be introduced to the public. As automation helps mitigate human error related to driving tasks, integrating automated vehicles into the roadways should holistically enable a safer transportation system.

The Technology Acceptance Model (TAM) illustrates a process by which a user perceives, uses, and adopts technology. This study seeks to provide an understanding of trust and acceptance of technology within the ground transportation system and learn how automated vehicles may enhance that. Auto-pedestrian accidents remain a major public safety concern, as there are over 5,000 pedestrian fatalities each year (National Highway Traffic Safety Administration). Given the magnitude of these and other statistics, this study will focus on vulnerable road users.

This study will be a mixed methods study containing both qualitative and quantitative measures. Qualitative methods will use structured interviews and surveys ascertain elements of the TAM focusing on automated vehicle technology. Quantitative metrics on human interaction with this technology will be obtained utilizing a virtual reality (VR) system where participants will interact with various roadway traffic scenarios. Results of this study will enhance the understanding of acceptance (both perception and behavior) of technology not yet available to the public.

Develop a smart thermostat application module for a test home facility on the OU campus

Prof. Li Song (Building Energy Efficiency Laboratory - BEEL)
School of Aerospace and Mechanical Engineering
The project is to explore the possibility of implementing custom-made control module into a smart thermostat to make A/C operate more efficiently. An advanced learning-based A/C operation algorithm has been already developed by BEEL under the DOE sponsorship. This project is designed to explore the approaches to implement the algorithm into an ecobee thermostat that is installed in a test home facility on the OU campus. ecobee is one of the three largest smart thermostat company. The ecobee API provides an http-based interface for control and access to the ecobee thermostats. The student who participate in this project will given with an API access of a thermostat installed in a test home on the OU campus.

**Tilt-Rotor Multicopter Drone Design, Build and Fly**

*Prof. Wei Sun*

**School of Aerospace and Mechanical Engineering**

Drones, especially multicopters, have found application in a large variety of applications including search-and-rescue, remote-inspection, environmental monitoring, drone delivery network, surveillance and tracking. This project aims to design, build and fly a multicopter drone with tilt-rotors which will become a platform for tasks such as onboard sensing and package delivery. This project will involve: (i) research on various tilt rotor mechanisms and determine the most suitable mechanism for multicopters, (ii) design and implement the tilt rotor mechanism on a multicopter, (iii) model and control the multicopter in a simulation environment, (iv) test fly the multicopter and (v) gain experience in using state-of-the-art software and hardware for robotics systems. Students in aerospace, mechanical, electrical, and computer engineering are welcome to apply. Prior exposure to Matlab, Python, C++ and familiarity with dynamics and control of any multicopter including quadcopter will be helpful.

**Developing Novel Endoscopic System for Early Cancer Detection**

*Prof. Qinggong Tang*

**Stephenson School of Biomedical Engineering**

Early detection of neoplastic changes remains a critical challenge in clinical cancer diagnosis and treatment. If the neoplastic changes can be identified at an early stage, therapeutic interventions can have the greatest impact. Many cancers arise from epithelial layers such as those of the gastrointestinal (GI) tract. White-light endoscopy guided excisional biopsy and histopathology is currently the gold standard for GI cancer diagnosis. However, it suffers from high false negative rates due to sampling errors since current standard endoscopic technology is unable to detect those early-stage subsurface lesions.

Fluorescence laminar optical tomography (FLOT) is novel imaging method which can reconstruct the depth-resolved images of the subsurface tumors. In this project, the student will help to develop the FLOT system and integrate it into a portable endoscopic system that can be used with the clinical colonoscope. The students will help on building the system, system calibration (imaging resolution, field of view and sensitivity of the endoscope). If time allows. The student will also help to investigate the ability of the FLOT endoscope to distinguish normal tissue from adenomatous polyps on ex-vivo tissue.
Examining Microstructure of Stimuli Responsive Polymers Using Rheology

Prof. Keisha B. Walters

School of Chemical, Biological and Materials Engineering

Stimuli responsive polymers change their size and/or shape in response to external conditions. External conditions that trigger large scale polymer conformation change are considered the stimuli. We synthesize and characterize polymers that contain positive and/or negative charged groups, polyelectrolytes. The design of these polyelectrolytes, stimuli responsive polymers (SRP), is done to target causing changes in polymer properties at specific temperatures, pH values, wavelengths or light, etc. In this project, students will be evaluating the effect of pH and temperature on a series of SRPs with the goal of developing relationships between the polymer structure and chemistry and the resulting material properties. Specifically, this project will use rheology to examine the viscoelastic properties of SRPs—in solution and as hydrogels. While applications of these materials are wide ranging, the SRPs to be examined in this project are targeted for biomedical applications including drug delivery and tissue scaffolds.