Fall 2016/Spring 2017 HERE Projects

Multi-pedestrian Tracking with OpenCV
Prof. Samuel Cheng
School of Electrical and Computer Engineering
Multi-pedestrian tracking with OpenCV. In this project, you will need to get familiar with OpenCV and try to track individual pedestrian motion from sequences captured from a stationary camera. Ideally, your algorithm will perform similar to the result shown in this link (https://www.youtube.com/watch?v=InqV34BcheM). Prerequisite for the above projects: comfortable with programming and familiar with at least one general programming language such as Fortran, C/C++, Python, Matlab, R, Java, etc. Python is preferred. But if you are familiar with another general language, you should be able to get familiar with Python very quickly.

Automatic Chord Assignment with Machine Learning
Prof. Samuel Cheng
School of Electrical and Computer Engineering
As the title suggests, you will be developing an automatic algorithm to assign chords to an input melody. As one essential task of the project, you will need to prepare a dataset of songs with known chord arrangements and known melodies. Some machine learning knowledge is useful. But probably can be acquired during the project. Prerequisite for the above projects: comfortable with programming and familiar with at least one general programming language such as Fortran, C/C++, Python, Matlab, R, Java, etc. Python is preferred. But if you are familiar with another general language, you should be able to get familiar with Python very quickly.

Interruptible algorithms: Human over-the-loop data analytics
Profs. Christian Grant & Le Gruenwald
School of Computer Science
As the amount of data collected and stored around the world grows, the need to perform data mining tasks on data of extremely large sizes increases. For many of these data sets, even the simplest algorithms require a large amount of time to run a substantial amount of “knobs” needs to be adjusted to obtain a desired output. Our recent research suggests that certain algorithms can be instrumented to allow human intervention --- inviting humans into the analytic process. This research would help define this new class of algorithms. The student will take an existing set of algorithms and make them interruptible. The student should be comfortable learning new with math, statistics, databases, algorithms, and data processing principles. The student should be comfortable working with linux, scripting languages, as well as low- and high-level languages.

“I only look at pictures” Using neural networks to create searchable images
Prof. Christian Grant
School of Computer Science
In addition to text, archives and libraries typically have thousands or millions of images available for search. However, unlike text there are no accepted interfaces for searching or exploring images. The goal of this research project is to use emerging neural network techniques to build a scalable system to computationally tag images, making them searched as easily as scanned and text processed using OCR. The student will use scripts to collect archived images and associated text from the web. The student will start with using the Stanford NeuralTalk 2 recurrent neural network to annotate images. The system will be hosted on a public website as a viable alternative to manual tagging for archives that can’t afford to pay workers to tag millions of images. The student should be familiar with or prepare to quickly learn the following technologies: Python, Flask, Docker, Lua, Torch and Neural Networks.
**Customizable Robots**

**Prof. Chad Davis**  
**School of Electrical and Computer Engineering**

A project titled “customizable robots” was completed in 2013 by a group of ECE students in an ECE 4990 special studies course. The goal of the project was to produce a small microcontroller-based robot with numerous types of sensors so it could perform a variety of tasks. The goal was to eventually produce numerous identical robots that could be used in courses that involve programming, robotics, or control systems. This would allow students to have a versatile platform to learn the material and compete against each other in various different robotics competitions. The first version of the “customizable robot” was completed, but there are a lot of improvements that could be done. Writing new fully documented programs that could extend the capability of the robot is one area of interest. While the current software is written in C it would be beneficial to also have some programs written in LabVIEW. Additionally, improving and documenting the hardware and electronic design so that it could function better and be more easily replicated would also be very important. 3D printing parts that make up the chassis instead of purchasing parts would be another area of interest. This project could support the following types of students: EE, CpE, CS, or ME. It would be preferable, but not mandatory, that students who are interested in the programming aspects of the project have already completed ECE 3223 since the microcontroller currently used in the customizable robot is the same one used in that course.

**3D Printing of Electrically Functional Materials**

**Prof. Hjalti Sigmarsson**  
**School of Electrical and Computer Engineering**

Additive manufacturing has revolutionized the world with the emergence of inexpensive 3D printers. These printers can readily be used to generate three-dimensional objects. This processing has been around for decades and is generally referred to as solid-freeform fabrication, but only recently has the cost become low enough that these printers are deemed feasible for hobbyists and other small scale use. Today, we can even find such printers in our local stores, such as Sam’s Club and BestBuy. However, there is still a lot of research that is necessary in order to increase the applicability of 3D printing to real-life engineering systems. In this project new methods for printing electrically functional materials will be investigated. A wide variety of 3D printers is available at the Radar Innovations Laboratory and it is envisioned that several will be used during this study. The materials will include conductors, dielectric, and possibly even more exotic materials such as phase-change materials and ferroelectrics. It is expected that the student(s) will learn how to use several 3D printing tools, how to prepare custom build materials, and how to design basic building blocks both for materials and electrical characterization.

**Changes of Ear Soft Tissue Mechanical Properties after Blast Exposure**

**Prof. Rong Gan**  
**School of Aerospace & Mechanical Engineering**

When exposed to blast, the human auditory system is vulnerable to both peripheral and central damage from the overpressure. Mechanical properties of soft tissues in the ear, such as the eardrum and ossicular joints, will change after blast exposure and these changes may contribute to hearing loss, the most common physical disability for veterans. However, the tissue mechanical changes associated with the blast exposure are largely unstudied. This research project will use the human and chinchilla ears to expose to blast overpressure in our blast testing chamber. Several material testing systems such as the DMA system and split Hopkinson tension bar (SHTB) will be used for experimental measurement with the assistance of finite element modeling.
Development of 3D Finite Element Model of Human Pediatric Ear to Study Age-Related Otitis Media Mechanism
Prof. Rong Gan
School of Aerospace and Mechanical Engineering
Otitis media, an infectious middle ear disease, is typically diagnosed in young children under 5 years of age. However, there are no reports describing age-dependent biomechanical changes in the middle ears either human infants or young children, or young animals. This project is proposed to construct the 3D finite element (FE) model of the pediatric ear based on CT-scanning images of young children under 5 years of age with normal middle ear structure. The model will consist of the ear canal, eardrum, ossicular chain, and middle ear cavity with material properties assigned for all components. The fluid will be simulated in the cavity and the acoustic-structure-fluid coupled analysis will be conducted in the model over the auditory frequency range in ANSYS.

Next Generation of Biomedical Imaging System Development
Prof. Liangzhong (Shawn) Xiang
School of Electrical and Computer Engineering
The goal of the project is to build a photoacoustic imaging system with numerous types of ultrasound sensors so it could perform a variety of tasks for biomedical applications. The project will involve electronics, optical engineering, programming, robotics, control systems, or software development. This would allow students to have a versatile platform to learn the material and collaborate to each other in the project. The first version of the “photoacoustic microscopy” was completed with two undergraduates in the summer, but there are a lot of improvements that could be done. Upgrade the hardware that could extend the capability of the imaging system is one area of interest. We are using LabVIEW software for the hardware control and Matlab for the signal processing. This project could support the following types of students: EE, BME, CpE, or CS. It would be preferable, but not mandatory, to have junior or senior students joining the project. The results of the final project will be published as a journal paper or presented in a national conference.

Student Experiences with Engineering Competition Teams
Prof. Randa Shehab
School of Industrial & Systems Engineering
The Research Institute for STEM Education (RISE) at OU has researched engineering education cultures for 15 years. We have developed models of inclusion that focus on equity of opportunities and equity of outcomes for all students. Development of these models is framed by interdisciplinary methods and requires multi-dimensional analysis of student’s complex experiences as engineering students. Most recently we are studying the cultures of engineering competition teams and how they contribute to a student’s educational experience. We distributed a survey directly to respective registered team members of several different competition organizations. Our responses represent the diversity of engineering competition teams: different types of design competition, different types of schools, different team structures, etc. We also have responses from multiple members within the same team so that we gain multiple perspectives regarding the team experience. The students participating in this project will employ mixed-methods analysis and interpretation of the existing data. Students will begin with a literature review that will help them learn and understand the research design, previous analyses, and the general engineering education context. They will be guided through exploration of existing survey data and executing appropriate statistical analyses. There may also be a need to incorporate existing qualitative interview data analysis. The course deliverable will be a research report in the form of a conference paper.
Why and How Particles and Heat Are Mixed by Turbulent Flows
Prof. Dimitrios V. Papavassiliou
School of Chemical, Biological and Materials Engineering
The movement of fluids around us (in the atmosphere, oceans, rivers) and in industrial processes is turbulent. One of the defining characteristics of turbulence is its ability to mix mass and energy, and a plethora of industrial applications is based on this feature of turbulent flows. We seek to understand why this happens, and we use simulations with high end computers (locally, at the OU supercomputing center for education and research, as well as across the country) to observe turbulent flow in well-controlled conditions. We then release (in the computer program) thousands of particles and let them propagate in the flow. From the particle trajectories, we can learn the details of the effects of flow on transport, and can develop models to describe the 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 programming, working with high end computers, presenting research results and thinking critically about open-ended problems.

Developing and Testing Unmanned Aircraft Simulators
Prof. Andrea L’Afflitto
School of Aerospace and Mechanical Engineering
Undergraduate students participating in this research project will design an aircraft simulator for quadrotors, develop the graphical interfaces, and test their results on real platforms at the Advanced Control Systems Lab. Moreover, participating students will assist Dr. L’Afflitto and his collaborators in testing control algorithms for unmanned aerial vehicles. Preferred degrees: Aerospace or Mechanical Engineering with good knowledge of Matlab/Simulink. Some knowledge of Solidworks or CATIA is preferable. Motivated students from other engineering majors are welcome.

Unmanned Aircraft and Formation Flying
Prof. Andrea L’Afflitto
School of Aerospace and Mechanical Engineering
Undergraduate students participating in this research project will gain hands-on experience in robotics, multi-vehicles coordination, and formation flying. By considering unmanned aircraft as flying computers, HERE students will challenge their programming skills and will assist Dr. L’Afflitto and his collaborators in testing control algorithms for formations of unmanned aerial vehicles. Preferred degrees: Computer Science, Electrical engineering, Aerospace or Mechanical Engineering with strong competence in Linux. Some knowledge Matlab/Simulink is preferable. Motivated students from other engineering majors are welcome.

Intelligent Metrology
Prof. Shivakumar Raman
School of Industrial & Systems Engineering
Industrial processes and products must be constantly measured for effective control and better designs. One of the industry standards for measurement is the coordinate measuring machine, whether it is in the design of parts for aircrafts, or for automobiles. These machines measure the coordinate positions of part features, and evaluate the conformance of part geometries, through suitable sampling methods and surface determination strategies. As versatile as they are for measuring static components, they cannot be easily used for measuring surfaces during manufacture. Optical scanners and other non-contact methods are now available that can do a simultaneous evaluation of processes and products. This research seeks to examine the capabilities of such non-contact machines in measurement. For fully developed machine-machine communication, and for intelligent data exchange in the modern intelligent factories, it is imperative that issues of dynamic calibration, camera positioning, and such be suitably evaluated.
Discovering Circuits in the Human Brain  
Prof. Han Yuan  
Stephenson School of Biomedical Engineering  
Our brains make us who we are. Capabilities like thinking, perceiving, learning, deciding, and acting to achieve our goals are the essence of our minds and the aspects of being human that matter most to us. Many units in the brain are actively engaged in cognitive processes, forming neural circuits.

Understanding the circuits in the human brain that govern cognitive processes and how the circuits are comprised in aging or neurological conditions is critical for early detection of cognitive dysfunction. This project will use devices of electroencephalogram and near-infrared spectroscopy to image the activities in the human brain. Students in the HERE program will involve in the design of experiments, collection of imaging data in human participants, analysis and modeling of neural circuits.

Developing a multiscale finite element model for hot rod rolling using ABAQUS and VUMAT subroutine  
Anand Balu Nellippallil (Doctoral Candidate, AME), Professor Janet K. Allen (ISE)  
Professor Farrokh Mistree (AME)  
Manufacturing a product involves a host of unit operations and the end properties of the manufactured product depends on the processing steps carried out in each of these unit operations. In order to couple the material processing-structure-property-performance spaces, both systems-based materials design and multiscale modeling of unit operations are required followed by integration of these models at different length scales (vertical integration). This facilitates the flow of information from one unit operation to another thereby establishing the integration of manufacturing processes to realize the end product (horizontal integration). A classic example of such a manufacturing problem is the design of a rolling system for manufacturing a steel product mix (rod). This is a sequential process design problem in which information flows from first rolling stage to last rolling stage and the decisions made at first pass influence the decisions that are made at the later passes.

In this project, the HERE scholar will be assisting Anand Balu Nellippallil in developing a multiscale model for hot rod rolling process which will be further implemented into a decision-based design framework. The focus for the HERE scholar is on studying a user material subroutine (VUMAT) for ABAQUS used to define the thermo-mechanical history of a material during deformation. This will be followed by developing the VUMAT specifically for an ABAQUS hot rolling model. Some knowledge in manufacturing processes, mechanics of materials, some work experience with ABAQUS software and willingness to learn are desired for this project.

Solution Space Exploration in the Context of Supply Network Design  
Lin Guo (Doctoral Student, ISE) and Professors Janet K. Allen (ISE) and Farrokh Mistree (AME)  
Our aim is to manage uncertainties in supply networks and make the networks robust and resilient by exploring the solution space generated by exercising a compromise Decision Support Problem thereby gaining insight into the behavior of the computational model. The HERE Scholar will be assisting Lin Guo in developing answers to the following questions:

- How will the solution space change if we adjust the priority of our goals in the network?
- How sensitive are our solutions to relaxing or tightening one or more of the constraints in the model?
- What are the solutions that are relatively insensitive to several types of uncertainties in the network?
- How can we increase robustness based on our knowledge solution space?
A HERE Scholar with some knowledge of linear programming, an interest in tele-communication or airline logistics, an interest in networks and a willingness to learn is preferred.

Concurrent Design of Mechanical and Control Systems for Multistage Manufacturing
Jelena Milisavljevic (Doctoral Student, AME), Prof. Farrokh Mistree (AME), Prof. Janet K. Allen (ISE) and Sesh Commuri (ECE)
Multistage manufacturing processes (MMPs) are complex processes consisting of multiple manufacturing stations and operations and are commonly encountered in applications such as automotive machining, assembly of electronic products, and semiconductor lithography processes. Currently, the mechanical system and the control system with associated sensors and controls for each station in the MMP are designed independently making it very difficult to diagnose the source of errors and accommodate them during the multistage manufacturing process.

In this project, the HERE scholar will be assisting Jelena Milisavljevic in developing a systematic method to design MMPs that simultaneously address different conflicting requirements and lower the overall cost while ensuring that system constraints are satisfied. The focus for the HERE Scholar is on building and verifying electro-mechanical models in MATLAB and manipulating and presenting data in Excel. Hence, some knowledge in electrical engineering and manufacturing, some experience with MATLAB and Excel, a general knowledge of statistics, and willingness to learn are desired.

Determining the Value Proposition for the Electrification of Off-Grid Villages in India
Abhishek Yadav (Masters Student, ISE) and Professors Janet K. Allen (ISE) and Farrokh Mistree (AME)
In the Systems Realization Laboratory, we are developing a computer-based method to help the social entrepreneurs determine the value proposition for raising funds for the electrification of off-grid villages in India using solar power. One element of the computer-based method involves the use of system dynamics to answer “what if” questions. System dynamics (SD) is a method for understanding, designing, and managing change. It is used to model the relationships between elements in a system and how these relationships influence the behavior of the system over time.

In this project, the HERE scholar will be assisting Abhishek Yadav in incorporating system dynamics into the computer-based method. A HERE scholar with an interest in learning about rural development, finding and evaluating information from various sources, and a willingness to learn system dynamics is preferred.

Tracking Individual Student Learning in a Project-Based Design Course
Jackson Autrey (Masters Student AME), Farrokh Mistree (AME), Zahed Siddique (AME)
School of Aerospace & Mechanical Engineering
As the pedagogical focus in engineering design education shifts from a “design-outcome” to a learning-focused outcome, instructors are increasingly in need of tools to assess student learning through reflection on doing. In AME4163: Principles of Engineering Design, we endeavor to assess what students learn by reflecting on designing, building and testing a device by analyzing “learning statements,” a construct arising from David Kolb’s experiential learning construct. As we collect the “Best Practices” learning statements for assignments and in-class submissions, we see that some students frequently appear near the top and others rarely, if at all. We are interested in tracking individual student submissions over the course of a semester to identify what are the qualities of students who frequently express strong insight, what is the progression of the “average” student in such a course, and how can other students be taught to reflect and express their learning as deeply as the “Best Practice” students?
In this project the HERE scholar will be assisting Jackson Autrey in gathering and organizing the data on learning statements, performing statistical analysis of the data (using R), and analyzing the results to draw conclusions about student learning in the course. A HERE scholar with an interest in education pedagogy, analyzing data and drawing conclusions, some knowledge of R and/or Visual Basic, and a willingness to learn is preferred.

Investigating State-of-the-art Methodologies for Effective Learning and/or Evaluating Human Performance
Prof. Kang Ziho
School of Industrial & Systems Engineering
State-of-the-art technologies such as eye tracking (e.g. Tobii eye tracker), augmented reality (e.g. Google glasses or lens), and virtual reality devices (e.g. Oculus) will become ubiquitous in our everyday lives. However, these technologies are only used for mere entertainment (e.g. Pokemon Go), and we are missing out on the vast opportunities to use these technologies for the betterment of the society. These technologies can be used as a medium to learn effectively, increase human performance, support the disability, and even save lives. I am searching for highly motivated students who will investigate these technologies and perform a small scale study using at least one of those technologies. The students who are considering to take on sophisticated research opportunities (possibly with the Federal Aviation Administration or the Boeing Company) in the following years through pursuing a graduate degree is highly recommended to apply. The student must be able to attend to details, have good writing skills, and afford time to actively learn human factors (or ergonomics), data processing methods, and statistical methods. Upon successful completion, it is likely that the research results will be presented at the Human Factors and Ergonomics conference. The Cognitive Engineering and Decision Making Laboratory, launched two years ago, has been expanding more than anticipated. Starting with 1 M.S. student, we now have two Ph.D. students, four M.S. students, and one undergraduate student, and expect to have several more Ph.D. or M.S. students this semester alone. Please visit the CEDM lab website at: http://zihokang.oucreate.com/CEDM.

Biomechanical Testing for Soft Biological Tissues and Synthetic Biomaterials
Prof. Chung-Hao Lee
School of Aerospace & 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 both native and synthetic tissue materials, which consists of three key ingredients: (i) acquisition of biomechanical data for soft biological tissues & synthetic biomaterials, (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 commercial biaxial mechanical testing device, learn about fundamental statistical analysis techniques, and to 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.

3D Finite Element (FE) Simulations of Valve Interstitial Cell Microenvironment
Prof. Chung-Hao Lee
School of Aerospace & Mechanical Engineering
The metabolism and mechanobiology of valve interstitial cells (VICs) regulate the remodeling processes associated with collagen biosynthesis and tissue microstructural changes. Alterations in the microenvironment of VICs in response to external stimuli are essential for better understanding of disease progression mechanisms as well as for individual-optimized surgical treatment for cardiovascular
diseases. Therefore, the main objective of this project is to construct high-fidelity 3D finite element (FE) models for VIC microenvironment and perform FE simulations to investigate (i) how cell down- or up-regulations will alter the overall structure and mechanical properties of the heart valve tissues, and (ii) how cellular geometry and mechanics will affect tissues’ biomechanical behaviors. Undergraduate students participating in this project will gain hands-on experience on FE model development as well as FE simulations in ABAQUS software, and will contribute to the generation of simulated VIC biomechanical data integrated with a multiscale tissue modeling framework. Students in all areas with basic background in engineering mechanics and entry-level programming skills are strongly encouraged to apply for this project.

Heart Valve 3D Geometry Reconstruction  
Prof. Chung-Hao Lee  
School of Aerospace & Mechanical Engineering  
The proper opening and closing of the four heart valves control the unidirectional blood flow in the two chambers on both sides of the heart. For predictive biomechanical modeling of the cardiovascular system of interest, development of 3D geometry for the heart valves based on medical images is an important first step. Hence, the execution of this project is three-fold: (i) designing a flow loop system that can fix cardiac myocardium and valve tissues under physiological pressure loading, (ii) acquiring micro-CT image data at the OU Advanced Medical Imaging Facility, and (iii) performing reconstruction of the 3D geometry of the heart valves. Undergraduate students involving in this project will have an opportunity to gain experience on the development of fixation-pressurization system and will work 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.

Development of Tensoreisitive Geosynthetics for Performance-Monitoring of Infrastructure  
Prof. Kianoosh Hatami  
School of Civil and Electrical Engineering  
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.
Vehicular Communications for Increased Driver Safety

Prof. Mohammed Atiquzzaman
School of Computer Science

Modern vehicles are equipped with lots of sensors for measurement of vehicle operating conditions and the surrounding weather conditions. The sensors collect information about the vehicle, such as location, speed, braking intensity, road traction, etc., some of which can represent road weather conditions. The objective of this project is to reduce vehicle crashes, fatalities and injuries due to adverse weather conditions, by alerting drivers in real-time of potentially hazardous road conditions in the region based on information from neighboring vehicles. The project aims at developing applications, based on the recent Dynamic Short Range Communication (http://www.its.dot.gov/factsheets/dsrc_factsheet.htm) wireless communication standard for inter-vehicle communication, to warn drivers of potential road hazards, including weather and surrounding careless drivers, to increase safety of drivers and passengers.

An experimental testbed will be constructed using vehicles outfitted with DSRC capability to wirelessly communicate with neighboring vehicles. A safety application will analyze the information from neighboring vehicles and develop a threat map to alert the driver of potentially hazardous road conditions. The application will also help in improving self-driving vehicles by providing additional information for navigation. The undergraduate student will help the faculty to develop a Linux-based application running on DSRC based routers from Arada Systems (http://www.aradasystems.com/) to warn drivers of potential hazards.

Measurement of Small UAS Propeller Performance

Prof. Thomas Hays
School of Aerospace and Mechanical Engineering

Proper design and optimization of unmanned aerial vehicles requires in depth knowledge of the performance of all propulsion components between the battery and airflow. For small electric UAV’s characterization of batteries and motors to acceptable accuracy is possible with a small number of available coefficients, but similar coefficients are not provided for small UAV propellers.

Students involved with this project will continue the development of AME’s small UAS propulsion dynamometer. Presently capable of static thrust, torque, and power measurements, the desired capability expansion will include testing of these parameters across the complete range of functional advance ratios to generate complete small UAS propeller performance maps (Ct, Cp, J). This work will specifically require design and fabrication of a portable UAS propulsion specific wind tunnel. Desired applicants will have strong Solidworks CAD skill, understanding of Arduino microcontrollers and the proper interfacing of those controllers with the dynamometer system.

All students are welcome to apply, but students specializing in Aerospace Engineering or Mechanical Engineering will be preferred for the work of this project.

Optimization of Membrane Wing Performance

Prof. Thomas Hays
School of Aerospace and Mechanical Engineering

Membrane based wings offer unique packaging and durability advantages for small unmanned aerial vehicles. The detriment to these flexible wings is the lowed lift to drag ratios achievable in comparison to more typical rigid UAV wings. This work will center around evaluating membrane wing structural options and the resulting aerodynamic performance of those designs at low Reynolds number. Students
involved with this project should have a strong desire for hands on work with sufficient craftsmanship capabilities to support the detailed and intricate work of fabricating novel membrane wings.

All students are welcome to apply, but students specializing in Aerospace Engineering will be preferred for the work of this project.

**Measuring Structural Responses with Video Cameras**  
*Prof. Scott Harvey*  
*School of Civil Engineering and Environmental Science*  
In the immediate aftermath of an earthquake, inspectors are responsible for assessing the serviceability of buildings. Currently, this is primarily done visually and relies on observations following the event. This research project aims to develop and validate a transformative approach to post-earthquake assessment of buildings that uses vision-based techniques to measure 3-dimensional structural responses. Current vision-based approaches simply observe the motion or deformations from a third-person perspective. The proposed approach brings a new perspective, a first-person perspective, which involves interpreting the motion of the structure through the motion of surveillance cameras that are integrated and distributed throughout buildings. If successful, this approach will provide critical information to inspectors and first responders such as inter-story drifts, enabling rapid post-earthquake damage assessment and better-informed decisions on buildings’ suitability for occupancy following significant seismic events. This research project will investigate and validate this innovative framework through shake table experiments on a scale three-story building instrumented with video cameras. Applicants from Civil Engineering & Environmental Science, Electrical & Computer Engineering, and Aerospace & Mechanical Engineering are encouraged to apply. Experience with LabView or Matlab is helpful but not required.

**How Surface Functionalization Affects Surfactant Adsorption**  
*Prof. Liangliang 'Paul' Huang*  
*School of Chemical, Biological and Materials Engineering*  
Surfactants are widely used in enhanced oil recovery processes where they are pumped into oil reservoirs to lower oil/water interfacial tension and enhance mobility of trapped oil. The loss of surfactant due to adsorption on reservoir rocks is a major challenge in practical surfactant enhanced oil recovery processes. To understand surfactant adsorption mechanism on surfaces, to predict surfactant adsorption on specific surface under realistic conditions, and to design surface properties to reduce surfactant adsorption are vital for industrial applications. In this project, molecular dynamics simulations will be carried out to study the adsorption of anionic sodium dodecyl sulfate (SDS) on zwitterion modified Al₂O₃ surfaces. We will study computationally the influence of state variables (temperature, pressure and composition) on adsorption and conformation of surfactants on Al₂O₃ surfaces. We will also investigate how surfactant adsorption can be controlled via surface functionalization density and fine-tuning of zwitterionic moieties with different charge groups.

**Robot Assistants for Promoting 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. In the present project, we will use a designed robotic platform to promote crawling skills in infants and record Electroencephalogram (EEG) to monitor the development of infants’ brain, particularly motor functions.
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 first receive training for preparing and recording EEG using EEG sensor net from experienced lab members and training videos. Then the student will join other members in the research team to conduct experimental recordings in OU Health Sciences Center every week to gain hands-on experience. The student needs to finish a free online course (CITI) before interacting with human subjects and starting EEG recordings, as required by the Institutional Review Board of the University of Oklahoma (http://irb.ou.edu/education.asp). The student will also 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 handling and maintenance of EEG equipment, interaction with human infant subjects, and computational analysis of signal processing and neuroimaging techniques.

**Brain Computer Interface with Vehicle Driving Simulator**  
*Prof. Lei Ding*  
*Stephenson School of Biomedical Engineering*

Brain computer interface 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 an open source wireless BCI system developed by Open BCI (http://openbci.com/). An R&D kit containing the necessary hardware and software for experiments will be purchased. We will test the EEG feedback capabilities of this product when a subject is exposed to a car driving simulator to record biometrics of brain responses to driving and eventually attempt to use this BCI system as a mechanism for control of the driving simulation.

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 with a graduate student on setting up the Open BCI hardware and software for experiments. This process will involve an extensive learning and understanding of the EEG electrodes, communication modules, and Visualizer software. Additionally, a 3D printed design of the biosensing headset will be provided for the student to print one or more headsets for experiments. Once the system setup has been established, we will begin testing with the car driver simulation. Student tasks will include development of experimental procedure, data acquisition with human subjects, and use of signal processing techniques for implementation of BCI application.

**Multimodal neuroimaging of resting state networks in different body positions**  
*Prof. Lei Ding*  
*Stephenson School of Biomedical Engineering*

Resting state networks (RSNs) have been widely studied in brain research due to their close relationship to different neuronal processes, as well as different neurological and psychiatric disorders. In the literature, RSNs are mostly revealed in hemodynamic signals as measured in functional magnetic resonance imaging (fMRI), which usually recorded brain signals in a supine position due to the restriction of MRI device. On the other hand, RSNs have also been elucidated in other neuroimaging modalities, e.g., electroencephalogram (EEG) that directly measures neuronal electrical signals and could provide neurophysiological aspects of RSNs, e.g., oscillatory characteristics. Here, brain signals are mainly
recorded in sitting position. To fully probe RSNs using different modalities, it is in great demand to evaluate RSNs in different body positions. In the present project, we will record brain signals from healthy human subjects using EEG, fMRI and fNIRS, in three different body positions, i.e., sitting, standing, and supine, when subjects perform different tasks.

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 firstly receive training for preparing and recording EEG using EEG sensor net from experienced lab members and training videos. Then the student will join other members in the research team to conduct experimental recordings in the lab in OU research campus to gain hands-on experience. The student needs to finish a free online course (CITI) before interacting with human subjects and starting EEG recordings, as required by the Institutional Review Board of the University of Oklahoma (http://irb.ou.edu/education.asp). The student will also be instructed to perform EEG data analysis, especially the preprocessing to remove artifacts from EEG signal. Student tasks will include handling and maintenance of EEG equipment, interaction with human subjects, and computational analysis of signal processing and neuroimaging techniques.

**Synthesis of Zeolite Nanotubes**  
**Prof. Steven Crossley**  
**School of Chemical, Biological and Materials Engineering**  
Zeolites are crystalline materials with high surface area with a broad range of applications ranging from water purification to catalysts for the production of gasoline. For many applications, the reason why zeolites are so effective is due to the high surface area and the microporous environment. In many cases, for example several applications related to catalytic upgrading, the diffusion of molecules into the micropores of the zeolite is often the slowest step in the catalytic reaction. By introducing larger pores, one essentially creates highways for molecules to quickly access the micropores of the zeolite. This project explores a unique approach by crystallizing of zeolites in the presence of cylindrical carbon nanotubes that are vertically aligned. By nucleating the zeolite precursors on the nanotube surface and thin films of zeolite result that retain the shape of the nanotubes. By subsequently burning the nanotubes, highways can be created that should lead to dramatically improved performance for several chemical reactions. This project will involve the synthesis as well as collaboration with two graduate students to carry out detailed characterization and catalytic reactions of the materials that are produced.

**Creation of Bijels for Catalytic Reaction in Biphasic Systems**  
**Prof. Steven Crossley**  
**School of Chemical, Biological and Materials Engineering**  
Bicontinuous interfacially jammed emulsion gels (bijels) are a type of soft solid, which offer the possibility for selective reactions to be carried out in a continuous process. Currently bijels are formed when particles jam at the interface of two liquids which spinodally decompose when heated. The spinodal decomposition creates a flat interface that can be jammed by the particles creating a gel, which is capable of sustaining a force or flowing liquid. Selective reactions can be carried out with emulsions, but for separation of the chemical products from the catalyst the emulsion must be broken. Breaking the emulsion interrupts the reaction process, which is costly. The first goal of the project will be to tune the wettability of carbon nanotubes or silica to wet equally in both liquid phases, a requirement for successful bijel formation. Once a bijel is formed a metal catalyst will be deposited on the solid particles, allowing for chosen chemical reactants to be used to determine if selective reactions are possible and if a continuous process can be made.
Responsive Particles for Switchable Reactions in Biphasic Systems
Prof. Steven Crossley
School of Chemical, Biological and Materials Engineering
The ability to tune reaction selectivity tune reactions based on a catalyst particle at an interface has applications in a variety of areas, including biofuels upgrading, water purification, and oil recovery. This project will involve several techniques to modify the surface of particles containing catalytically active sites with functional groups that are responsive to external stimuli. We have already developed a technique to evaluate the precise location of nanoparticles at an oil/water interface by using chemical reactions. The materials created during this project will be tested in simple systems as well as with emulsions, where selectivity is tuned due to the external stimuli. This project will focus on lab scale characterization of particle movement due to external stimuli at an interface, but real world applications to using switchable catalysts that can change reaction selectivity or clean surface species on the fly will be useful for a wide range of future processes.

Converting Landfill Waste from a Refinery to Hydrophobic Magnetic Particles Capable of Cleaning Offshore Oil Spills
Prof. Steven Crossley
School of Chemical, Biological and Materials Engineering
Fluid Catalytic Cracking is one of the most widely used processes for the production of gasoline. Over time, metal contaminants from crude oil deposit on these catalysts and they must be discarded. We have developed a technique to treat these low value spent catalyst particles, that typically end up in landfills, to make them hydrophobic. We have found that we can use this technique to separate the catalysts that still have activity from those that are completely spent. Further, during the process, the particles become hydrophobic, and float on water, while retaining their magnetic properties. This project will involve synthesizing the hydrophobized refining catalysts, separating spent from active particles, and studying their properties for unique applications in catalysis and oil recovery.

Compressive Sensing with Non-Classical States
Prof. Kam Wai Clifford Chan
School of Electrical and Computer Engineering
Compressive sensing (CS) is a novel sampling paradigm that can reduce the amount of data needed to acquire in signal measurement by exploiting the sparseness of the distribution of the signals. It has been applied to imaging to efficiently retrieve the spatial information of an unknown object. Through spatial encoding with a spatial light modulator, the spatial information can be obtained even using a single-pixel detector. Such a scheme with reduced data samplings and a simplified detecting system is especially beneficial to quantum imaging applications, in which the non-classical light usually has low photon flux and a high efficiency high spatial-resolution photon-number-resolving detector is currently unavailable. Notable related works include quantum ghost imaging, photon-counting lidar, object tracking using entangled photons, squeezed light imaging, investigation of high dimensional entanglement, and direct measurement of quantum wave function.

A variety of CS reconstruction algorithms have been developed. These are deterministic algorithms and they solve the CS problem recursively based on the well-established methods of convex optimization. Up till now all quantum imaging experiments utilize these types of algorithms, which nevertheless assume a Gaussian noise model. Such an assumption in principle corresponds to the high photon flux regime. When the quantum properties of the photons play roles in the signal processing problem, it is uncertain whether these algorithms are optimal. In this project, the student will study the effects of the different statistics of the input signal to the existing CS reconstruction algorithms. The candidate should be experienced with Matlab and computer simulations.