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.

Developing Novel Otoscope System for Middle Ear Inspection
Prof. Qinggong Tang
Stephenson School of Biomedical Engineering

Optical coherence tomography (OCT) is an established biomedical imaging technology for subsurface imaging of tissues with high resolution (<10 µm) and 1-2 mm penetration depth, which is comparable to the size of standard pinch biopsy and histology.
In this project, the student will help to develop the novel otoscope based on OCT system, which can noninvasively and quantitatively determine tympanic membrane (TM) thickness and the presence and thickness of any middle-ear biofilm located behind the TM. These new metrics has the potential to differentiate normal, acute, and chronic otitis media (OM) infections in pediatric subjects. The students will help on building the system, system calibration (imaging resolution, field of view and sensitivity of the otoscope).

Machine Learning for Severe Weather Prediction
Prof. Amy McGovern
School of Computer Science

Machine learning (ML) is a growing area of computer science where computers learn to improve from experience. A student working on this project can work on developing and applying ML methods to the task of improving severe weather prediction. This is an important real-world problem where ML can be used to save lives and property by improving the quality of predictions of severe weather phenomena including hail, tornadoes, wind, and flooding. A successful student on this project would have strong programming and math skills and be proficient in Python.

Teaching kids about STEM using Drones
Dr. Amy McGovern
School of Computer Science

Drones are increasingly ubiquitous, leading to natural interest by many. We are working on a K-12 outreach project where we will be teaching middle and high school students to program drones and to have them fly autonomously. We would love a student who is passionate about outreach and exciting kids about science to join us in supporting this program. A successful student will be able to interact with beginning programmers, proficient in Python, and interested in drones.

Utilize short channels and peripheral measurements to improve the performance of fNIRS
Prof. Han Yuan
Biomedical Engineering

Functional Near-Infrared Spectroscopy (fNIRS) measures the hemodynamic response associated with the brain activity, similarly to functional Magnetic Resonance Imaging (fMRI). fNIRS utilizes light in the near-infrared window to probe the changes in oxyhemoglobin and deoxyhemoglobin in the cerebral tissue. Compared with fMRI, fNIRS has demonstrated competitive advantages, including low cost, portability, and compatibility with other electronic medical devices in patients. However, due to the fundamental principle that fNIRS relies on light passing through the brain to measure brain activities, fNIRS is very sensitive to the superficial layers of the head, i.e. the scalp and the skull, where systemic interference occurs. To address this problem, this project aims to improve the performance of fNIRS by using short-distance channels which are mainly sensitive to superficial layers in the brain as well as peripheral measurements which monitor the cardiac activity and respiration of the subject as sources of physiological noises. Based on these measures, regressional methods are proposed to remove the interference in the signals from long-distance channels that reflect the brain activity. **What the student will do: (1)** design an experiment that human subjects will perform several tasks to activate the brain: (2) design the positions of optodes on the head; (3) operate the fNIRS system with short channels and peripheral measurements when the subjects perform the tasks; (4) analyze the data and quantify the improvement of fNIRS obtained by using short channels and peripheral measurements. The data processing might involve signal processing, regression analysis and other techniques.

Engineering nanoparticles for cellular delivery
Prof. Stefan Wilhelm
Stephenson School of Biomedical Engineering

Nanoparticles are materials with dimensions in the nanometer size range and can be used to diagnose and treat diseases, including cancer. One concept in cancer treatment is to design nanoparticles as drug carriers for selective delivery of chemotherapeutics to malignant cells. This project aims at understanding how nanoparticle design parameters (e.g., size, shape, and surface chemistry) affect delivery to cancer cells. In the first step, students will synthesize nanoparticles with defined sizes, shape, and surface properties. Students will then expose cancer cells to these nanoparticles using tissue culture techniques and measure their uptake into cells.

This will allow a correlation between nanoparticle design parameters and cellular delivery efficiency. These studies have the potential to create a foundation for downstream in vivo and pre-clinical testing.

Using biomolecules to design nanoparticle-based assembly structures for diagnostic applications
Prof. Stefan Wilhelm
Stephenson School of Biomedical Engineering

Gold nanoparticles (AuNPs) exhibit unique size-dependent optical properties based on surface plasmon resonance, which makes them attractive for diagnostic applications. These optical properties can be further modulated by changing inter-nanoparticle distances. Molecular assembly strategies allow the control of these inter-nanoparticle distances and a modulation of AuNPs' surface plasmon resonance. This can lead to a color change that can be observed by the naked eye.
In this project, students will synthesize AuNPs with defined sizes and use them as building blocks for superstructure assembly. The surface of AuNPs will be modified with biomolecules, such as DNA and peptides. The presence of biomolecules on the AuNP surface will guide and facilitate nanoparticle assembly into superstructures. Students will engineer the nanoparticle superstructures so that they break down in the presence of analyte molecules, for example pathogenic nucleic acids. The controlled disassembly of superstructures will induce a color change and indicate the presence of the target analyte molecules. Results from this project may potentially lay the groundwork for future diagnostic assays to measure biomarkers in point-of-care settings.

Direct Ink Printing of Novel Shape Memory Polymers and Sensors
Prof. Yingtao Liu
School of Aerospace and Mechanical Engineering

The goal of this project to develop a unique 3D printing technology to additive manufacture multifunctional polymers using shape memory polymers and composites. The polymer formulation will be adjusted to optimize the 3D printing capability. Once the formulation is confirmed, the material will be printed into novel shapes in both 2D and 3D structures. The applications of 3D printed materials will be investigated, particularly focusing on the load and stress sensors and sensor arrays.

Self-Deployable Origami Composite and Structures for Aerospace Applications
Prof. Yingtao Liu
School of Aerospace and Mechanical Engineering

Description: The development of deep space exploration requires novel lightweight structures that can be highly folded and packed for launching into space. A self-deployable origami composite structure will be synthesized, manufacturing, and characterized in this project. The student will first synthesize the polymer and manufacture into composite laminate materials. The deployment capability of the developed composites will be characterized and verified. Various deployment techniques, such as Joule heating and IR heating, will be investigated.

Unmanned Aerial Manipulators
Prof. Andrea L'Afflitto a.lafflitto@ou.edu
School of Aerospace and Mechanical Engineering

One of the next great challenges in robotics is given by unmanned aerial manipulators, that is, flying robots. These vehicles combine the agility of quadcopters and the dexterity of robotic arms and will be of incredible help to people performing tasks at home and work. Students participating in this research will help modeling and designing autopilots for these futuristic vehicles.
Preferred degrees: Aerospace or Mechanical Engineering, Computer Science, with good competence in CAD or C++. Some knowledge Matlab/Simulink is preferable. Motivated students from other engineering majors are welcome.

Vestibulo-ocular reflex measurement after blast in Chinchillas
Prof. Chenkai Dai
School of Aerospace & Mechanical Engineering

Hearing injury have been known as the consequence of expose to blast overpressure (BOP) in military and civilian population while balancing function loss was ignored due to smaller population of complaints. However, complaints of dizziness and disequilibrium is increasing in senior veteran population and the mechanism of balancing function loss due to BOP remains largely 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 balancing function. 2. The acute impact of BOP on balancing function could turn into chronic due to the slowly yet progressively change in peripheral/central vestibular system. To test above hypothesis, we will measure the Vestibulo-ocular reflex (VOR) in chinchillas exposed to low/mild intensity BOP over time to characterize the balancing function change after blast. The goal of this project is to provide solid preliminary data for future prevention, medicine treatments and protecting devices design in future. 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.

Development of a Novel Bioreactor for Rotator Cuff Tendon Tissue Engineering
Prof. Matthias Nollert
School of Chemical Biological and Materials Engineering

Rotator cuff tears are a common cause of pain and disability affecting more than 250,000 individuals each year. Current surgical treatments include tendon reattachment with sutures for small tears and artificial tendon grafts for large tears. While the success rate for surgical repair of small tears is quite good, the success rate for treatment of large tears with a graft is generally less than 50%. Tissue engineered tendons, specifically designed to mimic the intrinsic properties of natural tendons, have the potential to improve success rates for large rotator cuff tears. We have developed a novel bioreactor system that provides mechanical stimulation to a cell seeded scaffold. While most bioreactors for tendon tissue engineering developed up to now stimulate the cells with a constant displacement, ours stretches the tendons for a specified level of force. We hypothesize that this novel design will improve the performance of the tissue engineered construct. This project aims to optimize the design of the bioreactor by developing an improved feedback control system for the amount of stretching the sample is exposed to.

Use of Adipose Derived Stem Cells for Tendon Tissue Engineering
Prof. Matthias Nollert
School of Chemical Biological and Materials Engineering

Adipose-derived stem cells represent a reliable adult stem cell source thanks to their abundance, straightforward isolation, and broad differentiation abilities. Alternate sources of stem cells, such as from human bone marrow are better studied, but are far more invasive to obtain. Consequently, adipose-derived stem cells (ASCs) have been used in vitro for several innovative cellular therapy and regenerative medicine applications. Our goal is to use ASC's seeded onto a decellularized human amniotic membrane in order to recreate the structure of a rotator cuff tendon. This tendon is wide and rather flat and has multiple layers with cells oriented perpendicular to one another in order to provide strength in several directions. By pre-stressing and layering individual sheets of amniotic membrane, we believe that we can recreate the complex physiology of this tissue. Samples would then be loaded into a tendon bioreactor that delivers appropriate levels of mechanical stretching to the construct along with other required media components. The goal of this project would be to define an appropriate differentiation protocol for the stem cells that would cause them to become more like tendon cells. These cells would then remodel the amniotic membrane scaffold into a structure with greater mechanical strength

Protection of power systems under distorted electromagnetic transient phenomena
Prof. Paul Moses
School of Electrical and Computer Engineering

New dynamic electrical disturbances are beginning to infiltrate modern power systems. These are partly caused by the rapid infusion of volatile renewable energy sources and distorted loads interacting with the network. Instead of the traditional flow of power going from the generators to the consumer, bidirectional power flows are increasing with more distributed generation such as rooftop solar photovoltaics. The volatile nature of customer load and generation patterns is inducing electromagnetic transient disturbances on to distribution feeders such as flicker, frequency and voltage deviations, resonances, harmonic distortions, imbalances and many other issues. Such behaviour can adversely impact critical power grid components such as transformers and switchgear resulting in higher failure rates and blackouts. This project aims to 1) experimentally investigate the response of modern protection relays and how effective they are in detecting dynamic disturbances, and 2) improve the protection of critical components such as power transformers operating under distorted conditions. The project will consist of both 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.

Modelling and simulation of next generation naval power systems
Prof. Paul Moses
School of Electrical and Computer Engineering

Naval vessels are soon moving to higher voltages and dc power system architectures in order to meet the demanding electrical requirements for future mission loads. Solid-state lasers, advanced radar systems and electromagnetic aircraft launching systems require megawatts of power to be delivered in very short time periods. This type of rapid power cycling is known as pulsed power and will become increasingly more common in future warships. The goal of this project is to build an electrical simulation model of a shipboard power system and study the effects of pulsed power load disturbances. The project will involve developing power system models using Matlab-Simscape/Simulink software and carrying out simulation case studies of different pulse power characteristics. Students with an interest in power engineering and have taken ac and dc circuit courses are encouraged to apply.

Plug-in Electric Vehicles in Smart Grids
Prof. Paul Moses
School of Electrical and Computer Engineering

Modern power systems are evolving at a rapid pace towards a "smart grid" with the infusion of distributed generation in residential solar photovoltaic (PV) systems as well as emerging consumer load patterns with smart appliances and plug-in electric vehicles (PEV). An interesting aspect of smart grids is the use of PEV batteries to support the grid in times of high demand to reduce line congestions and generator loading during peak times or emergencies. This is known as vehicle-to-grid (V2G) operation in which utilities may incentivize PEV owners to allow dormant vehicles that are plugged in to temporarily discharge their
batteries to supply the grid. This project investigates V2G operation of PEVs by simulating a small residential network with multiple PEVs. The power flows during the day under different loadings and variable solar PV performance will be studied. The student will be required to run power system simulations using existing MATLAB software codes and modify the simulations for different case 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
Prof. 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.

Exploration of the Solution Preferences Under Uncertainties using Metamodels
Lin Guo (Doctoral Candidate, ISE), Professor Janet K. Allen (ISE), Professor. Farrokh Mistree (AME)

In a social-ecological network, such as the dam-network on the Red River Basin, the allocation of water to different user-groups evolves with changes in the water supply and water demand. To manage the allocation, we identify inflow scenarios and outflow scenarios, use limited known data to predict the unexpected, unknown situations. Metamodels are used to facilitate the reduction of the computational complexity and facilitate prediction. In this project, the HERE scholar will assist PhD candidate Lin Guo in modeling the dam-network problem, identifying the scenarios representing typical situations, creating/revising approximation algorithms and solution algorithms, visualizing the design preferences, and realizing the process using object-oriented programming language. A journal article co-authored by the HERE scholar is a possibility. HERE scholars with some knowledge of operations research, statistics and geometry, experience with Python, and willingness to read and learn, and plan to take no more than 15 credits (including this course) are encouraged to apply.

Finding Control Nodes Under Uncertainties Using Partitioning
Reza Alizadeh (Doctoral Student, ISE), Professor Janet K. Allen (ISE), Professor. Farrokh Mistree (AME)

In a dam network on the Red River Basin, uncertainties such as variation in inflows and outflows of each node, capacity of each node, and connectivity among nodes are the main reasons for these disruptions. To improve the overall robustness of the dam-network, the control nodes in the network need to be identified. Finding these control nodes should be in line with the possibility of improving the network structure. In other words, identifying the control nodes should result in being able to improve the management of the uncertainty in flows among nodes and the water storage within dams. In this project, the HERE scholar will assist PhD student Reza Alizadeh in modeling the dam-network problem, creating network partitioning algorithms, implementing these algorithms and visualizing the modeled network and partitioned network using Cytoscape OR Gephi software. A journal article co-authored by the HERE scholar is a possibility. HERE scholars with some knowledge of network science and statistics, experience with "Cytoscape" OR "Gephi" and "R" OR "Python", and willingness to read and learn, and plan to take no more than 15 credits (including this course) are encouraged to apply.

Cloud-Based Platform For Decision Support In The Design Of Engineering Systems
Dr. Zhenjun Ming (Postdoctoral Research Associate, AME), Professor Janet K. Allen (ISE) and Professor Farrokh Mistree (AME)

We believe that the principal role of engineering designers is to make decisions. Hence, providing appropriate and sufficient decision support to human designers is key to speeding up the design process and generating quality designs. One of the challenges in providing decision support in the design of engineering systems, especially complex systems, occurs because of the complexity embodied in the decision workflows that embody multiple coupled decisions networked in various degrees of complexity. In order to address this challenge, we are designing and implementing a Cloud-Based Platform for Decision Support in the Design of Engineering

Systems (CB-PDSIDES). Salient features of CB-PDSIDES include but are not limited to: 1) core decision support functionalities such as executable decision (or decision workflow) templates, design space exploration techniques, complexity and uncertainty analysis tools, etc. are formally represented as autonomous service agents and are deployed in the cloud; 2) service customers such as product design and manufacturing companies can configure, select and utilize customized decision support agents in the cloud according to the their particular needs; 3) CB-PDSIDE can automatically compose the customized services and deliver them to customers as packages. We look forward to working with a HERE scholar who is interested in addressing frontier research issues in the field of digital design and manufacturing and will be taking no more than 15 units (including this course) in Spring 2019. Specifically, the HERE scholar will work with Dr. Zhenjun Ming to define the functionalities in CB-PDSIDES, design a Service-Oriented Architecture (SOA) for CB-PDSIDES, implement a prototype CB-PDSIDES, and co-author a research paper.

Modelling Robustness For Coupled Decision Problems Encountered In Design Of A Gearbox
Gehendra Sharma (MS, AME), Professors Janet K. Allen(ISE) and Farrokh Mistree (AME)

Decision Support Problems (DSPs) are used to model design decisions involving multiple trade-offs. In practice, such design decisions are also coupled, that is., selection and compromise decisions have to be made concurrently accounting for the influence they exert on one another. Selection involves making choice among several 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 must 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. 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 (including this course) in Spring 2019, 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. The HERE scholar will work with Gehendra Sharma (MS student) to model coupled decision problems encountered in design of a gearbox, incorporate robustness into the model, and explore design decisions against multiple conflicting goals.

Mechanical Characterization of 3D Printed Human Ear and Middle Ear Implants
Prof. Rong Gan
School of AME

The 3D printing system (Object350, Stratasys) with selected materials has been used to print two biological structures in our lab: 1) human temporal bone (or ear), consisting of the ear canal, eardrum, middle ear ossicular chain, and middle ear cavity; 2) middle ear prostheses, including the eardrum grafts and ossicular replacement implants. However, these structures need to be characterized in mechanical properties of the printed materials and the system functions. This project will focus on these areas with the design tools and advanced material testing techniques. Research undergraduates will work with graduate students in Biomedical Engineering Lab located at Stephenson Research Technology Center (SRTC).

3D Finite Element Modeling of Cochlear Damage Induced by Blast Waves in Chinchilla
Prof. Rong Gan
School of AME

The hearing damage induced by exposure to blast overpressure is currently investigated in chinchilla model in our lab. The cochlear hair cell damage is evidenced in scanning electron microscopy (SEM) images of post-blast ears. However, there is a challenge to model the relationship between blast overpressure and cochlear injury. This project is proposed to use our 3D finite element model of the chinchilla ear to simulate the cochlear damage when blast waves are reaching the ear canal. The results will be compared with the experimental data and further extended to human ear model. Research undergraduates will work in Biomedical Engineering Lab located at Stephenson Research Technology Center (SRTC) with all modeling and experimental facilities.

Interfacial Rheology of Protein Layers
Prof. Sepideh Razavi
Chemical, Biological, and Materials Engineering

A wide range of technological applications - such as food industry, personal care products, pharmaceutics, and oil recovery - involve the processing of interfacial systems in which surfactants, nanoparticles, proteins, and other surface-active species are present at the air/liquid or liquid/liquid interfaces. Therefore, engineering suitable materials with a desirable set of properties requires us to understand how the surface-active species interact at an interface and how these interactions alter the properties of that interface. Rheology is a powerful tool for probing the response of materials subjected to deformations. In this project, we will focus on studying proteins at interfaces to examine their interfacial assembly and its impact on the resulting interfacial rheology. The acquired knowledge will guide us in designing protein solutions suitable for a specific application.

Assembly of Janus Particles Targeted for Biological Applications
Prof. Sepideh Razavi
Chemical, Biological, and Materials Engineering

Janus particles are nano- to micron-sized particles named after the Roman God Janus that has two faces: one looking into the future and one to the past. As the name suggests, Janus particles possess anisotropic surface properties; i.e., one side can be hydrophilic, whereas the other surface is hydrophobic. Owing to the tunable composition and morphology of Janus particles, they have a promising potential for biomedical applications including imaging, diagnostics, and biosensing. Therefore, studying the interaction of Janus particles with protein corona plays a key role in determining the effect of these particles on the biological systems. This project aims at understanding the assembly behavior of Janus particles under physiological conditions to unravel the effect of the asymmetric nanoparticle morphology on the adhesion of plasma proteins.

Tunable Assembly of Magnetic Janus Particles
Prof. Sepideh Razavi
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.

A Software Prototype to Detect and Explain Outliers for Big Data Stream Applications Using GPUs
Prof. Le Gruenwald
Computer Science

In many monitoring applications, such as sensor networks, web-click stream analysis and power usage monitoring, data are in the form of streams. A data stream is an infinite sequence of data points with explicit or implicit timestamps and has many special characteristics including transiency, a notion of time, a notion of infinity, uncertainty, dynamic distribution, and multi-dimensionality. For applications involving multiple related streams, additional characteristics exist, such as asynchronous data arrival, dynamic relationships among streams, and schema heterogeneity of data from different streams. Although data streams are different from regular (non-stream) data in many respects, they are not free of outliers. An outlier is a data point which has a significantly different value compared to other data points in the same dataset. In practice, outliers are inevitable in any data acquisition process as they can be introduced into a dataset because of numerous reasons, such as malicious activity or instrument error. Thus, outlier detection is an important part in the data engineering and analysis process. Instead of making outlier detection as a black box, for outlier detection to be beneficial, explanations about the properties and causes of the outliers discovered need to be provided.
Because of the special characteristics of data streams and the intrinsic difficulty of detecting outliers, outlier detection and explanation in data streams is a very computationally challenging problem. One way to tackle it is by using Graphics Processing Units (GPUs), which are parallel co-processors that can be leveraged for general purpose programming, and that can achieve up to an order of magnitude of higher instruction throughput than comparable multicore CPUs. Despite the performance benefits, popularity and affordability of GPUs, there exists little research on data stream outlier detection focusing on such hardware. To fill this gap, the OU Database group (OUDB) in the School of Computer Science together with the Database

Research team at the University of Minnesota Duluth are developing novel algorithms for detecting and explaining outliers in multiple data streams using GPUs.
In this project, the student will work with the OUDB team and the University of Minnesota Duluth Database Research team to help build and test a software prototype to discover and explain outliers in data streams using Nvidia GPUs and CUDA. The student will learn how to exploit the parallel computing capabilities of GPUs to tackle real-life Big Data problems for Data Science and Analytics applications.

A Prototype of a Mobile Cloud Database System Using Android Phones and Cloud Computing
Prof. Le Gruenwald
Computer Science

Innovated mobile technologies offer interesting opportunities in many domains, such as health care, transportation, and commerce. They enable distant monitoring and permit consideration of parameters such as patient and physician mobility. This makes it possible to develop applications, such as mobile health services for telemedicine and assisted ambient living (particularly in rural areas) and mobile traffic services. Nevertheless, the amount of data to be generated and queried is very large and diverse, collected from multiple sources. The combination of big data and mobility leads to a major challenge: how to efficiently process queries from a myriad of mobile devices on a large amount of data, especially when the data are to be stored in a novel data management system supplied by several cloud providers with possibly different pricing models? This challenge is not addressed in the existing work on cloud query processing. To fill this gap, the Database Research group in the School of Computer Science (OUDB) together with the Database Research team at the University of Rennes in France have developed a novel mobile cloud data management prototype using Android phones and cloud computing. This prototype employs semantic caching and novel query processing algorithms that take mobile users' mobility, disconnection, energy limitation, and cloud provider's pricing models into consideration in order to improve query response time, while reducing the amount of money that must be paid to the cloud service providers. Working on the Honors Engineering Research Experience (HERE) project, the student will work with the OUDB team and the University of Rennes Database Research team to extend the prototype to implement more complex queries for mobile cloud database applications, demonstrate their executions, and evaluate their performance.

Smart Fiber-Optic Communication based on Machine Learning
Prof. Kam Wai Clifford Chan
School of Electrical and Computer Engineering

Optical fibers form the workhorse of the telecommunications industry today. Their information carrying capacity has risen spectacularly. Even so, demand for higher capacity will continue at an increasingly rapid rate due to the rise of cloud computing, distributed data centers, and the Internet of Things (IoT). The objective of this proposal is to address such a need by fully exploiting the polarization property of light for information transmission that can significantly surpass the capability of the technologies employed in current optical fiber communication systems.

Polarization of light has been used in optical communications for carrying or switching information. Current applications mostly focus on utilizing the two independent polarization channels to double the data transmission capacity of a single-mode optical fiber. The goal of this research is to significantly increase the capacity by exploiting the very large number of possible states of polarization (SOPs) to encode information. This is accomplished by maximizing the number of distinguishable SOPs with the use of a machine-learning-based optimal polarization modulation format over an integrated transmitter-channel-receiver architecture in the fiber optic communication system. In particular, the transmitter, channel and receiver are to be treated as a deep neural network and to be trained as an autoencoder.
In this project, the student will apply the techniques of machine learning to a real world telecommunication problem. The candidate should be experienced with Matlab and computer simulations.

Design and Implement Control Algorithms on Quadcopter Drones
Prof. Wei Sun
School of Aerospace and Mechanical Engineering

The goal of this project is to design control algorithms under constraints such as power constraint and external obstacles and implement them on a real-world aerial robotics application, namely, a quadcopter system. This project will involve: (i) determine the best-fit quadcopter in the market for the current project, (ii) incorporate control/state constraints to currently available algorithms so that they can handle various types of constraints, (iii) implement the new algorithm to quadcopter system, and (iv) gain experience in using state-of-the-art software and hardware for robotics systems. Students in aerospace, mechanical, electrical, computer engineering, and computer science are welcome to apply. Prior exposure to Matlab, Python, C++ will be helpful and experience in ROS is a big plus.

Characterizing and Testing 3D Printed Structures
Prof. Scott Harvey
School of Civil Engineering and Environmental Science

The relatively recent advent of additive manufacturing (or 3D printing) is an exciting opportunity to rapidly fabricate and test scale models of structures. The characteristics and behavior of these models are fundamentally similar to their full-scale counterparts, permitting lab-scale validation of concepts not easily or feasibly constructed at full scale. The behavior of the 3D printed models depends on the geometry of the structure, as well as the 3D printer settings and the material properties of the thermoplastics. This project aims to characterize the material properties and the structural behavior of 3D printed structures through both static and dynamic tests. Static load tests will help to identify the material properties such as Young’s modulus, while shake table tests will be used to characterize the structures’ dynamic responses when subjected to seismic loads. Seismic mitigation devices will be integrated into the models to assess these devices performance. Students participating in this research will be exposed to experimental techniques, such as data acquisition and data processing. Applicants from Civil Engineering & Environmental Science and Aerospace & Mechanical Engineering are encouraged to apply. Experience with AutoCAD, Solidworks, LabView, and/or Matlab is helpful but not required.

Biomechanical Testing for Soft Biological Tissues
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 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 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.

Heart Valve and Brain Aneurysm 3D Geometry Reconstruction
Prof. Chung-Hao Lee
School of Aerospace & Mechanical Engineering

Analysis of biological systems can be 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.

Synthesis and Characterization of Polymeric Materials for Biomedical Applications
Prof. Chung-Hao Lee and Prof. Yingtao Liu
School of Aerospace & 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.

In-Vitro Flow Loop Design and Validation for Replicating Blood Flow in Intracranial Aneurysms
Prof. Chung-Hao Lee
School of Aerospace & Mechanical Engineering

Aneurysms are weak areas of the blood vessel wall that have begun to bulge outward under pressure from the blood being transported by the vessel. The growth and eventual rupture of an aneurysm in the brain depends heavily upon the characteristics of blood flow in and around the aneurysm's location. This project aims to replicate blood flow properties in the brain at a larger scale using a closed loop flow system. Such a system will allow our lab to investigate the flow patterns that emerge upon the introduction of a variety of aneurysm shapes to better inform treatment efforts. With guidance from other student researchers, students involved in this project will likely spend time performing some or all of the following tasks: (1) researching the flow characteristics, (2) performing calculations to scale this flow to more manageable dimensions (as arteries in the brain can be only millimeters in diameter), (3) selecting and validating pumps and sensors for use in the flow system, and (4) assembling all components into a functional testing apparatus. Students from all engineering disciplines who are interested are welcome to apply for this project.

Potential recovery of rare earth elements from mine drainage residuals
Prof. Robert W. Nairn
School of Civil Engineering and Environmental Science

The OU Center for Restoration of Ecosystems and Watersheds (CREW) has generated a substantial, long-term dataset on water quality improvement performance of passive treatment systems for metals retention. Through promotion of a variety of naturally occurring oxidative and reductive processes, these ecologically engineering ecosystems retain elevated concentrations of ecotoxic metals (Fe, Zn, Ni, Pb, Cd, As). Recent research has identified the potential for retention of rare earth elements (REEs) in mine drainage passive treatment residual solids, even when concentrations in the untreated waters are below detectable limits. REES include the 15 lanthanides (Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Pm, Sm, Tb, Tm, Yb) as well as Sc and Y, some of which are economically important. This project will include field-collection of both accumulated iron oxyhydroxide and organic matter solids from oxidative and reductive passive treatment process units, respectively. These solids will be hot microwave digested and analyzed via inductively coupled plasma spectroscopy for REE content. If found in recoverable concentrations, further examinations may include the efficacy of recovery, processing and production.

Recovery and reuse of spent acid generated from hydrogen sulfide stripping
Prof. Robert W. Nairn
School of Civil Engineering and Environmental Science

Granular activated carbon (GAC) has been demonstrated to be an effective control for elevated gaseous hydrogen sulfide concentrations. At a field-scale sulfate-reducing bioreactor operated by the OU Center for Restoration of Ecosystems and Watersheds (CREW), a 180-kg GAC tower receiving approximately 30 ft^3/minute of humid, sulfide-rich air addresses sulfide concentrations up to several hundred ppm. The system operates wholly off-the-grid using solar power. However, although still performing as designed in terms of air quality improvement, the system recently began to produce sulfuric acid. This project will characterize the acid produced and explore potential reuse options, including the treatment of recovered iron oxide residuals to generate wastewater treatment flocculants. Other possibilities to be explored include the production of fertilizers, if the materials do not exceed Resource Conservation and Recovery Act (RCRA) criteria, and other industrial applications. The project will examine the potential for resource recovery from passive treatment systems addressing substantial environmental liabilities.

Characterizing dynamical modes of interdependent networked systems
Prof. Andrés D. González
School of Industrial and Systems Engineering

Interdependent networked systems are ubiquitous in nature and society. These cyber-physical-social interdependent systems, including critical infrastructure (telecommunications, power, water, gas, and transportation, among others), are often vital for the proper operation of organizations and communities. Thereby, it is imperative to develop informative and computationally efficient analysis methods for interdependent networked systems, that can help to reveal their dynamical properties. The objective of this project is to determine and analyze the main dynamical modes of systems of interdependent networks, by constructing a reduced-order linear representation of high-fidelity models (which are often computationally expensive and intractable in time-sensitive contexts). In this project, students will join a high-impact multidisciplinary research effort that combines tools and concepts from fields such as physics, industrial, civil, electrical, and aerospace engineering. Participating students are expected to have some experience with programming and linear algebra. Also, experience with optimization and/or machine learning is desired but not mandatory. Considering the multidisciplinary nature of this research initiative, students from all engineering backgrounds are encouraged to participate. For further information, please contact Dr. Andrés D. González at andres.gonzalez@ou.edu

Non-linear FEM models for bending of trees due to wind loading
Prof. Andrés D. González
School of Industrial and Systems Engineering

The objective of this work is to present a realistic yet flexible way to model tree deformations under wind loads. In previous research, we have developed a mathematical model to generate tree structures. Using such tree structures, a typical wind loading (which is a function of the vertical position) is applied on each branch. In this project, we seek to use finite element methods (FEM) to determine the deformation of a tree (based on beam elements describing each branch). Using the proposed computational model, we intend to find possible fractures in the studied trees, in order to support decisions for efficient mitigation strategies for natural hazards. Participating students are expected to have some experience with programming and finite element methods. Also, experience with large deformation models is desired but not mandatory. For further information, please contact Dr. Andrés D. González at andres.gonzalez@ou.edu