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A Prototype of an Autonomous Indexing Advisor for Multi-Tenant Cloud Databases Using Deep Reinforcement Learning

Dr. Le Gruenwald
School of Computer Science
Index selection plays a vital role in reducing the I/O cost for databases. Existing index advisors apply different heuristic methods to search the large search space of possible attributes for indexing and do not take the service level agreements (SLAs) between the tenants and the cloud provider into consideration. These heuristic methods are prone to miss some good index configurations which would negatively impact the query response time and may lead to many SLA violations. To solve this problem, the Database Research group in the School of Computer Science at OU (OUDB) together with the Database Research teams at the University of Minnesota Duluth (UMD) and the University of Rennes in France have developed and prototyped a novel autonomous indexing advisor using Deep Reinforcement Learning. This advisor is for distributed databases deployed on a cluster of computers. Working on the Honors Engineering Research Experience (HERE) project, the student will work with the OUDB team, the UMD team, and the University of Rennes Database Research team to extend the prototype to implement it for multi-tenant cloud databases, demonstrate its executions, and evaluate its performance.

Automated Classification Algorithms to Detect Power-Quality Disturbances

Dr. Talayeh Razzaghi
School of Industrial and Systems Engineering

The high degree of interdependence among various systems within an electric power sector promises great potentials but at a considerable risk level. Power quality disturbances (PQDs) refer to sudden variation or distortion in steady supply voltage, frequency, and waveform. Such disturbances may originate from multiple sources including unbalanced and nonlinear loads, failure of components, switching devices, and decrease of equipment lifetime in both industrial and household devices. Hence, it is crucial to detect such disturbances in their early stages of formation. In this regard, manual inspection to detect PQDs is tedious and prone to several errors. However, automatic machine-learning (ML) algorithms are far more interesting for this purpose. One should note that PQDs represent rare incidents in smart grids, which results relatively small size for the disturbance class versus the normal class. This may highly deteriorate the performance of ML algorithms. To deal with this issue, this project proposes a new approach to detect PQDs using an advanced deep neural network model. The proposed model will compared with state-of-the-art algorithms using the data simulated from a microgrid system. The HERE scholar will have a great opportunity to develop ML algorithms to tackle real-life problems for an Energy Analytics application. The results having the potential to be presented at peer-reviewed conferences and/or academic journals. HERE scholars with prior exposure to Python, high enthusiasm to read and learn ML, and plan to take a maximum of 15 semester credits are strongly encouraged to apply. Prior experience in machine learning is a plus.

Big Data Analysis and Applications of Global satellite precipitation data

Professor Yang Hong
School of Civil Engineering and Environmental Science

Integrated Multi-satellitE Retrievals for Global Precipitation Measurement (IMERG) is a remotely sensed precipitation product at half-hour temporal resolution since 2000. This project intends to apply Big Data
Biomechanical Characterization of 3D Printed Human Ear and its Application for Measurement of Sound Transmission

Prof. Rong Gan
School of Aerospace and Mechanical Engineering

The 3D printing system (Object350, Stratasys) with selected materials has been used to print biological structures in our lab including the human ear or temporal bone (TB). The 3D printed TB consists of the ear canal, eardrum, middle ear ossicular chain, and middle ear cavity. The 3D printed TB needs to be characterized in mechanical properties of the components and the entire system (TB) functions for sound transmission in comparison with the real human ear. This project will focus on testing 3D printed TB with advanced material testing techniques and laser Doppler vibrometers. Research undergraduates will work with graduate students in Biomedical Engineering Lab located at Stephenson Research Technology Center (SRTC).

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.

Catalytic upgrading of waste plastics to high value chemicals

Prof. Steven Crossley
School of Chemical, Biological, and Materials Engineering

Many environmental concerns have led to interest in minimizing the amount of waste polymers that we generate as well as lowering the carbon footprint of the polymers that we make. One approach is to take polymers, such as the common polyolefins, polyethylene, polypropylene, and polystyrene, and convert them back to their monomers. If this process is carried out efficiently, much less waste will be generated and the net amount of petroleum processed will decrease. One of the most promising families of catalysts that has been shown to carry out this chemistry are zeolites. We use zeolites to crack petroleum to generate much of the olefins such as propylene in refineries. In this project, we investigate the role of two interesting variables that we have recently learned may have fascinating effects on conversion of hydrocarbons, trace
levels of moisture and extra-framework aluminum species within the zeolite. The student will carry out polyolefin cracking reactions in collaboration with PhD students in our group to investigate the influence of these catalyst properties on the regeneration of monomers from waste polymers.

**Characterization of acid site proximity in zeolites to explain catalytic activity**

**Prof. Steven Crossley**  
**School of Chemical, Biological, and Materials Engineering**

Zeolites are crystalline materials with very 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 unique behavior of the catalytically active site located in a microporous environment. Most zeolites used for catalytic applications consist of Si oxides with small amounts of Al. The charge imbalance due to the presence of Al results in active sites that catalyze a variety of reactions. While it is straightforward to characterize the total number of active sites present in the zeolite, characterization of the exact location is much more of a challenge. This project will involve synthesizing zeolites with different templates to control the distance between active sites, and further using unique probe molecules to determine the location and distance between the active sites. Students will work in a team consisting of undergraduate students and graduate students during this project. Students will focus either on synthesizing the zeolite materials, characterizing the resulting materials using a new procedure, or using probe reactions relevant to petroleum refining and renewable fuels to evaluate the resulting catalytic behavior.

**Characterizing and Testing 3D Printed Vibration Isolators**

**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 and devices. 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 their geometry, as well as the 3D printer settings and the material properties of the thermoplastics. This project aims to characterize the material properties and the dynamic behavior of 3D printed vibration isolators 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 devices’ dynamic responses when subjected to seismic loads. Students participating in this research will be exposed to experimental techniques, such as data acquisition and data processing. Applicants from Civil Engineering & Environmental Science or Aerospace & Mechanical Engineering are encouraged to apply. Experience with AutoCAD, Solidworks, LabView, and/or Matlab is helpful but not required.
Characterizing dynamical properties 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

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

Prof. Kianoosh Hatami, PhD, PEng
School of Civil Engineering and Environmental Science

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

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

Interested students can contact Dr. Kianoosh Hatami at kianoosh@ou.edu for further information.

Design a data acquisition system to instrument a living laboratory – a test home facility on the OU campus

Prof. Li Song
School of Aerospace and Mechanical Engineering
This project is to design and install a data acquisition system for a single-family house on the OU campus for research purpose. The measured variables include outdoor weather conditions, indoor air and wall surface temperatures, A/C operational variables and etc. A total of more than 30 sensors will be connected through WiFi using Raspberry PI’s to a main server. A student who is interested in writing Python codes to facilitate the data transmission among all the Pi’s and server is desired for the project. The collected data will be used for a three-year DOE sponsored project that is to enable energy-efficient and grid-interactive home A/C operations based on weather, home thermal properties and OG&E rate structure.

Design and build two housings for Raspberry Pi and its accessories

Prof. Li Song
School of Aerospace and Mechanical Engineering

This project is to design and built two different housings for a special use of Raspberry Pi and a connected circuit board on top of it. One housing is for indoor use and the other is for outdoor use. The housings need to provide necessary standard protections to the Pi and it is electronic accessories while providing access to all the connection ports. In addition, heat ventilation feature needs to be included in the housing design to reject the heat generated by the processor. Prototype materials and a 3D printer will be provided.

Design and Prototype Construction of a Pervious Concrete Cleaning Apparatus

Dr. Jason Vogel, P.E.
School of Civil Engineering and Environmental Science

Pervious concrete is a low impact development stormwater control practice that allows water to infiltrate into the subsurface through the pavement instead of running off, thus decreasing runoff and associated water quality impacts. One of the issues holding back widespread implementation of pervious concrete in Oklahoma is the cost and ease of the maintenance that is required to prevent clogging. This project will help design and construct an attachment for a Vactor truck that could drastically reduce the cost and effort involved with maintaining pervious concrete.

Design and Prototyping of a Low Cost Vertical Takeoff and Landing Autonomous Atmospheric Sensing Platform.

Dr. Thomas Hays
School of Aerospace and Mechanical Engineering.

The Center for Autonomous Sensing and Sampling conducts multiple atmospheric sampling missions. To expand their sensing capabilities, this project has been established to design and test a vertical takeoff and landing autonomous aircraft carrying a minimum of 3 lbf payload (goal 5 lbf) for a duration of two hours. Previous VTOL work has been conducted and can serve as guidance for this system development. The design should use consumer off the shelf components wherever possible in combination with low cost and robust materials for the airframe. The vehicle will make use of the Pixhawk autopilot platform. The focus of the vehicle is on service to the science mission. Extensive background in aerospace engineering, UAS
technologies, RC aircraft, and/or autonomous systems is required. This undergraduate project will be conducted in association with an Aerospace Engineering senior capstone project during the spring semester.

Developing clinical tools and medical devices to diagnosis and treat ear disorders after blast
Prof. Chenkai Dai
School of Aerospace & Mechanical Engineering/Biomedical Engineering

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

Development of a Water Balance Model for the Blue-Boggy Planning Region in Southeastern Oklahoma
Dr. Jason Vogel, P.E.
School of Civil Engineering and Environmental Science

With the passage of the Water for 2060 Act, Oklahoma established a statewide goal of consuming no more freshwater in 2060 than was consumed in 2012. A quantitative analysis of net freshwater consumptive use in Oklahoma not only allows quantifiable water use goals for 2060 to be set, but is also useful for water resource-managers across the state to track water use, and determine if and what conservation strategies may be beneficial. This project will develop a water balance model (WBM) to quantify consumptive water use by estimating the volumes of each inflow and outflow component for the Blue-Boggy Planning Region in southeastern Oklahoma to estimate net consumptive use in the region. The information provided from this model will likely be highly important for future water resource management and conservation in Oklahoma.
Development of Tensoresistive Geosynthetics for Performance-Monitoring of Infrastructure

Prof. Kianoosh Hatami, PhD, PEng
School of Civil Engineering and Environmental Science

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

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

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

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

Develop new clinical tools to detect early ear infection

Prof. Chenkai Dai
School of Aerospace & Mechanical Engineering/Biomedical Engineering

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

Acquired cholesteatoma is a destructive process of the middle ear and causes severe hearing loss, vestibular dysfunction, facial paralysis, or intracranial complications. The long-term outcomes from current ossicular prostheses are not optimal and reduction of the air-bone gap to less than 20 dB is achieved in less than 60% of patients undergoing these procedures. In this project we hope to improve the middle ear reconstruction in cholesteatoma ears by developing an individual-specific prosthesis with 3D printing technology, tissue engineering, and analyzing middle ear mechanics. Collaborated with Dr. Wei Chen at UCO, we plan to develop an combined immunology-laser technology to treat the cholesteatoma.

Effect of heterogeneous particles and surfactants on the stability and rheology of fluid interfaces
Prof. Sepideh Razavi
School of Chemical, Biological, and Materials Engineering

Fluid-fluid interfaces, such as air-water interface in a soap bubble, are commonplace in a variety of products such as in household cleaning, cosmetics, and pharmaceuticals. Oftentimes, very small particles and some specific molecules (called surfactants) are used to stabilize such interfaces (to prevent them from popping). Therefore, the stability and strength of these interfaces is dictated by the type and strength of interactions between the small particles and surfactants. The goal of this project is to investigate the combined effect of particles and surfactants on the stability and flow behavior of interfaces. Micro- and nanoparticles with several types of heterogeneities, particularly shape and surface chemical heterogeneity, will be fabricated and experimental analysis of particle-laden interfaces will be conducted in the absence and presence of surfactants. The anticipated outcomes, rooted in fundamental understanding, include design rules for heterogeneous colloidal particles/surfactant systems with tailored interfacial behavior and rheology at fluid/fluid interfaces. Our findings will lead to scientific advances in a wide range of technological applications from targeted delivery of drugs to recovery of oil trapped in underground reservoirs. In this project, the student will carry out experiments on the interfacial behavior of a system of micron-sized colloidal particles and surfactants at the air/water interface. Students with some knowledge in the design of experimental setups who are willing to learn and contribute ideas are encouraged to apply.

Enhancement of the North Campus Student Wind Tunnel
Dr. Thomas Hays
School of Aerospace and Mechanical Engineering

To follow the success of a 2017 HERE student wind tunnel project, this portion of work will seek to provide functional improvements to the tunnel, and increase the maximum velocity achievable. Construction and low speed function of the tunnel is complete. Three main objectives for this project will be: 1) Design and fabrication of components to better seal the tunnel during operation. 2) Design and installation of a high power motor drive system and fan for the small tunnel (likely 230V as power is already installed.
nearby). 3) Characterization of tunnel flow, and determination if a flow straightening section is necessary. Students should have previous experience in wooden fabrication, electrical installation/safety, mechanical design, and interest in aerodynamics. A two student team for this project is desired.

**Experimental study for the development of a Smart Home Thermal Comfort System**

**Prof. Li Song**  
**School of Aerospace and Mechanical Engineering**

The research aims to develop and validate an affordable smart home comfort SYSTEM that can utilize thermostat data, along with other key information, to make homes both comfortable for the resident and more energy efficient. A home thermal model that can capture the heat transfers from multiple heat gains and predict the HVAC thermal energy output is particularly important for the SYSTEM development. Specifically, this project is designed to collect operational data in a test home located in Norman OK to validate and improve the accuracy of a previously developed home thermal model. A student with basic skills of excel/Matlab is preferred.

**Fecal Indicator Bacteria Study in Freshwater Streams**

**Dr. Jason Vogel, P.E.**  
**School of Civil Engineering and Environmental Science**

Indicator bacteria, enterococcus and E. coli, are used as a measure to determine potential fecal contamination in freshwater streams and rivers for USEPA 303(d) impairment determination and beneficial uses. Oklahoma currently has over 7,500 stream miles that are listed on the 2016 303(d) list for both E. coli and enterococci. Bacteria concentrations to determine human health risk, primary body contact recreation (PBCR), were established by the USEPA through a series of studies in marine and freshwater beaches. E. coli is well-documented in literature as a quality indicator of pathogenic bacteria in freshwater for predicting human health hazards and fecal contamination in both lentic and lotic freshwater bodies. However, limited information is available to understand the dynamics of enterococcus bacteria colony populations in freshwater lotic waterbodies (streams and rivers). The objective of this study will be to better understand survivability of enterococcus in a controlled environment (constant temperature, no light, enclosed container) by collecting water and sediment from three Oklahoma streams/rivers and monitoring the colony counts over an 8-week period at three different temperatures in a mesocosm experiment. Resulting information will be used to assess enteric bacteria survivability under these conditions, and may lead future work to identify the environmental factors that drive enterococcus to survive and replicate in freshwater stream and river conditions in Oklahoma.

**Finite Element Analysis-Based Mathematical Surrogate Modeling of Occupant Brain Injury Due to Vehicular Impacts**

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

In this project the HERE scholar will be assisting PhD candidate Reza Alizadeh. The HERE scholar will have an opportunity to learn how to develop predictive models to deal with a real-life healthcare problem. Also, the HERE scholar will have an opportunity to showcase the results at peer-reviewed conferences and/or academic journals. Students with prior experience in Python, R, high enthusiasm to read and learn ML, and plan to take a maximum of 15 semester credits are strongly encouraged to apply.

Heart Valve and Brain Aneurism 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.

How to Assess the Benefits of Connected and Autonomous Vehicles to OKC Transportation Networks?

Prof. Shima Mohebbi  
School of Industrial & Systems Engineering

Connected and Autonomous Vehicle (CAV) is a radical evolution of the regular vehicles that we see on the roads today which are driven by humans. A CAV can communicate with its environment through wireless networks where the environment can include other cars, pedestrians and other infrastructural elements such as traffic lights. I am searching for energetic and persistent students who can improve existing spatial-agent-based simulation models to quantify CAVs impacts in terms of travel time and safety. The project also includes crash data analyses for OKC metro area. Programming skills in Java will be a plus. Students will
How does turbulent flow affect the transport of mass or heat?

Prof. Dimitrios V. Papavassiliou  
School of Chemical, Biological and Materials Engineering

Turbulent flow is the dominant flow regime in industrial process equipment (e.g., reactors, distillation columns, heat exchangers, etc.). While a lot of fundamental research has been devoted in studying mixing in isotropic turbulence flows (like for example flows in the atmosphere or in oceans), not as much has been done for anisotropic flows (i.e., the flows where the solid walls of process equipment are present). We want to understand exactly this type of flows, and the effects the solid walls have on the transport of particles and large molecules. 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.

Implementation of New Methods to Secure Internet Privacy

Prof. Song Fang  
School of Computer Science

This project aims to revisit the security mechanisms for various online systems and propose new methods to further protect Internet privacy from unauthorized access. There have been proposed multiple ways to secure online accounts, such as biometric authentication (e.g., using fingerprint, voice), two-step authentication, SMS-based verification codes, security questions, etc. However, each category of such techniques has limitations and may suffer respective cyber attacks. For example, voice based authentication scheme may be vulnerable to replay attacks, and security questions based mechanisms are susceptible to attacks by guessing answers. The student will first investigate the advantages and disadvantages of various Internet privacy protection techniques. On the basis of identifying vulnerabilities in one type of those techniques, the student will then begin to develop approaches which can either secure the corresponding online system or guide users to avoid using weak passwords. A student with solid programming skills and a strong interest in cybersecurity is preferred.

Innovative Rainfall Frequency Analysis based on Multi-Radar Multi-Sensor Precipitation Observation for H/H Infrastructure Designs

Professor Yang Hong and Dr. Shang Gao  
School of Civil Engineering and Environmental Science
Rainfall frequency analysis (RFA) generates the design criteria for almost every hydrologic/hydraulic (H/H) engineering practice. Traditionally in the U.S.A., RFA has been based on precipitation observations from rain gauge network, which inherently lacks spatial representation and thus propagate uncertainty into further H/H infrastructure designs. Originated from this problem, one emerging outcome is that more and more flood insurance claims are coming from outside the FEMA flood zones. Alternatively, in this project, we will leverage state-of-the-art precipitation observations from NOAA/OU National Weather Center Multi-radar Multi-sensor to develop an innovative RFA paradigm. We will also evaluate the benefits and engineering applications in terms of hydrology, hydraulics, and social economics.

Janus Nanoparticles Targeted for Membrane Applications

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

Separation and purification processes, such as distillation, consume a substantial amount of energy and contribute to environmental pollution. For instance, CO$_2$ removal accounts for a large fraction of costs in oil and gas processing. Membrane technology offers a promising alternative to traditional thermal separation methods. Membrane-based separations require an amount of energy which is two order of magnitude lower than traditional processes. Despite their potential, use of membranes is limited by the intrinsic trade-off between permeability and selectivity. Highly permeable membranes often exhibit poor selectivity, and vice-versa, such that the performance of gas separation membrane materials remains constrained to below an upper limit. In this project, using rational criteria, we are developing a new membrane material tailored to CO$_2$ removal from natural gas and CO$_2$ sequestration from process effluents. These membranes will contain Janus nanoparticles, a particle with a dual characteristic that is composed of both polymer and silver compartments. The presence of Janus nanoparticles in the composite will enhance the membrane permeability (i.e., membrane productivity) by disrupting the polymer chain packing, that is, by creating additional pathways for penetrant transport. In addition, the presence of silver in the particle will boost the CO$_2$ sorption in the membrane. The student will synthesize the nanoparticles, fabricate the membranes, and carry out transport measurements on the membranes. Students with some knowledge in chemical synthesis who are willing to learn and contribute ideas are encouraged to apply.

Kinetics of metal particle mobility during catalyst regeneration

Prof. Steven Crossley
School of Chemical, Biological, and Materials Engineering

Ruthenium is an excellent catalyst for several reactions, such as the conversion of renewable biomass to fuels and high value chemicals. For several of these reactions, Ru demonstrates activity comparable to or better than others such as Pt that are an order of magnitude more expensive. One of the major reasons Ru is not used more frequently industrially for these applications is due to its instability under oxidizing environments. After a chemical reaction has occurred for a long period of time, the catalyst must be regenerated to remove carbon deposits. Under these conditions, Ru is oxidized to a volatile compound and is lost from the catalyst support. We have recently found very interesting behavior upon studying Ru nanoparticles supported on various phases of titania. We have found that the interaction of Ru with TiO2 is much stronger, and this leads to less mobility of the Ru under oxidizing environments. This ultimately leads to a more stable catalyst that has far greater potential for industrial application. This project aims to physically mix different oxides that can be used as supports for Ru nanoparticles, and study the rate of Ru
mobility from particle under high temperatures in the presence of oxygen. This will allow us to both identify promising catalysts, and better understand the mechanism for Ru stabilization over specific oxides such as titania. The resulting materials will be characterized in detail using electron microscopy and a variety of other techniques. They will then be tested for their potential as catalysts in collaboration with a graduate student. The end result will be the development of a predictive kinetic model to study mobility of metals and stability of nanoparticles on several catalyst support surfaces.

Magnetic Colloidal Particles and their Tunable Assembly

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

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

Mathematical models to enhance the resilience of cyber-physical-social systems

Prof. Shima Mohebbi
School of Industrial & Systems Engineering

There are 16 Critical Infrastructure sectors identified by Presidential Policy Directive 21 (PPD-21). These infrastructures are defined as cyber-physical-social systems, comprised of physical components (e.g. facilities, vehicles, and pipelines), computerized systems (e.g. SCADA, traffic control sensors) and human components (e.g. decision makers, community/households). Cyber-physical-social systems are complex entities and understanding these potentially large-scale networks requires systems thinking and analyses. I am searching for energetic and persistent students who can contribute to developing small-scale decision models using operations research and game theory. Programming skills in python will be a plus. Students will begin with a literature review that will help them learn and understand the research scope, and previous works. They will be mentored to develop and solve mathematical models, and obtain programming, statistical analyses, and modeling skillsets. The course deliverable will be small-scale decision models, write-ups for two sections of a conference paper, and a presentation at the Undergraduate Research Day (April of each spring).
Memory-Aware Compiler Transformations for High-Performance Computing

Prof. Martin Kong
School of Computer Science

Polyhedral compilers are well known in the high-performance community for their ability to compute and apply very aggressive code restructuring transformations to improve the locality and parallelism of programs. At the core, polyhedral compilers represent program entities such as for-loops and matrices as multi-dimensional integer sets bounded by multiple hyper-planes, shaping them as polyhedra. Program analyses and transformations are performed on these mathematical objects, quite often with the help of Integer Linear Programming (ILP). In particular, the problem of finding optimal program transformations consists on building one or multiple ILPs with specific linear/affine constraints and cost functions, both of which have to be carefully crafted by the compiler designer, and solving it with lexicographic optimization. This task requires embedding the constraints and objectives with semantic knowledge taken from the target computer (e.g. number of processing cores, memory characteristics) and the domain application.

This project will initiate the student in high-performance computing and optimizing compilers. The research tasks include: identifying program transformations to be computed, evaluating the efficiency of transformations, designing novel ILP memory constraints in a polyhedral compiler, and potentially submitting the results to a workshop or conference. Strong analytical and C-programming skills are necessary, while a background in computer architecture, linear/convex optimization, mathematical/computational modeling or research operations would be highly recommended.

Methane emissions detection using an unmanned aerial system

Dr. Pejman Kazempoor and Dr. Wei Sun
School of Aerospace and Mechanical Engineering

Methane is a more potent greenhouse gas than carbon dioxide. Methane leaks from the oil and gas sector can substantially increase greenhouse gas emissions. Unmanned aerial systems can increase the reliability and speed of methane detection and quantification, especially in remote and hazardous locations. The main objective of this project is to install a laser-based sensor on a commercial drone to detect artificial methane leaks in a controlled environment. The HERE scholar will have an excellent opportunity to work with drones and laser-based sensors and learn how the data can be transferred from a UAV to the ground station. Programming skills in python is needed.

Methane emissions detection using ground-based sensors

Dr. Pejman Kazempoor
School of Aerospace and Mechanical Engineering

Methane is a more potent greenhouse gas than carbon dioxide and is a global problem. North America emission is 25% of the global methane emission from the oil and gas sector. Ground-based methane sensors are effective tools to identify, monitor, and reduce methane emissions while also increase safety for operators. The main objective of this project is to design and test a distributed wireless sensor network (a group of spatially dispersed and dedicated sensors for monitoring and recording) for fugitive methane
emissions. The HERE scholar will have an excellent opportunity to understand: 1- principle operation of methane sensors 2- distributed wireless sensing 3- dynamic data sampling 4- data transformation from sensors to the cloud. Programming skills in python is needed.

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.

Novel glassy polymers containing configurational free volume

Prof. Michele Galizia
School of Chemical, Biological and Materials Engineering (CBME)

Sustainable energy and chemicals supply is critical for mankind’s survival. Energy-efficient membrane technologies have raised significant attention in the last three decades, as they can successfully compete with traditional thermal separation processes, such as distillation. Development of competitive membrane systems relies, however, on a solid molecular-level understanding of transport mechanism in the membrane material, which is the main focus of this project. Glassy polymers exhibiting (ultra)microporosity have recently shown great promise in overcoming the limitations of conventional membrane materials. Among these high-performing microporous polymers, triptycene-based polymers are of particular interest, largely due to their unique molecular structures involving “configurational free volume” defined by the shape of triptycene units. Triptycenes are 3-dimensional functional groups made of 3 aromatic rings in a paddlewheel-like configuration.

However, most of the literature on triptycene-based polymer membranes focuses primarily on their separation performance, with limited or no fundamental understanding of small molecule transport mechanism in these innovative materials. Such fundamental knowledge is essential to take advantage of the exceptional performance (high permeability and selectivity, combined with resistance to physical aging and plasticization) exhibited by these materials. In this project, we will fill this gap in the literature, in
collaboration with the University of Notre Dame. Students that are willing to work in an interdisciplinary, collaborative environment are encouraged to apply. The undergraduate student involved in the project will be co-author of peer-reviewed publications in international journals.

**Organic solvent nanofiltration: a new separation technology to change the world**

**Prof. Michele Galizia**  
School of Chemical, Biological and Materials Engineering (CBME)

The vast majority of industrial organic synthesis occurs in solution. Downstream processes, such as solute concentration and solvent recovery, play a crucial role in the chemical industry and pose problems that are as relevant as the synthesis process itself. Separation and purification technologies often rely on distillation. In the US, we have over 40,000 distillation columns that consume 50% of the energy required by the American chemical industry, and account for 6% of the total US energy use. Novel, energy-efficient technologies based on polymer membranes are emerging as a viable alternative to thermal processes. Despite organic solvent nanofiltration (OSN) could revolutionize the chemical, petrochemical, food and pharmaceutical industry, its development is still in its infancy for two reasons: i) the lack of fundamental knowledge of elemental transport phenomena in OSN membranes, and ii) the instability of traditional polymer materials in chemically challenging environments. While the latter issue has been partially solved, the former was not addressed at all. In this project, we propose a fundamental investigation of small molecule transport in OSN membranes. These studies will help to design next generation membrane materials, in collaboration with the Georgia Institute of Technology and the University of Notre Dame. Students that are willing to work in an interdisciplinary, collaborative environment are encouraged to apply. The undergraduate student involved in the project will be co-author of peer-reviewed publications in international journals.

**Resource Allocation and Management in Multi-Tenant NVM-aware Cloud Database Management Systems**

**Dr. Le Gruenwald**  
School of Computer Science

Cloud service providers, such as Amazon AWS, Microsoft Azure, and Google Cloud, provide their Database-as-a-Service offers to their clients (known as tenants in this context) all over the world. These offers are financially and organizationally attractive to tenants. They remove the concerns of having to purchase/maintain/upgrade the database software, database servers, dedicated server facility, database administrators’ services, etc. Instead, the tenants pay a predictable price for the database services they need at any given moment in time and let cloud providers worry about everything above. Furthermore, cloud providers even provide database performance guaranties (uptime, throughput, query response time, etc.) to the tenants (called service level agreements or SLA). Violating these guarantees results in financial compensation to the tenants.

For the cloud providers to stay financially successful, one of the concerns they have to overcome is an efficient use of the hardware resources (servers) they own. Resources are used toward simultaneous processing of the database workloads of tens of thousands of their tenants. One part of that problem is an
efficient allocation of a subset of available resources to a subset of tenant workloads who are expected to be compatible with each other (impose different performance bottlenecks, for example). Another part of the problem is managing allocated resources in such a way that when an unexpected workload behavior occurs, the event results in the least possible number of tenant performance guarantee violations.

The above problems become even more interesting when we extend the traditional database management system data storage architecture, commonly consisting of two layers, the disk, and the memory, with a device belonging to the novel storage technology called Non-Volatile Memory (NVM). NVM storage device is faster than disk and more spacious and cheaper (per byte) than the main memory. Its inclusion requires substantial redesign of multiple database management system components and allows more efficient solutions to the resource allocation and management problems in multi-tenant cloud database management systems.

While working on this Honors Engineering Research Experience (HERE) project together with the Database Research Group in the School of Computer Science (OUDB) and the Database Research team at the University of Rennes in France, the student will have an opportunity to implement novel algorithms for Resource Allocation and Management in Multi-Tenant NVM-aware Cloud Database Management Systems integrated into mature open-source software (such as PostgreSQL) and run the experiments to study their efficiency.

Social Responsibility and Green Supply Chain Relationships

Reza Alizadeh (ISE), Professor Janet K. Allen (ISE), Professor. Farrokh Mistree (AME)
School of Aerospace and Mechanical Engineering

We use the term purchasing social responsibility (PSR) to describe the involvement of purchasing managers in socially responsible activities. Our purpose in this research is to examine the potential impact that PSR might have on green supply chain relationships. The expected findings will be identifying the PSR’s impact on supplier performance, as well as its impact on green supply chain performance through improved trust and cooperation. These findings will hold important implications not only for purchasing managers but also logistics managers in the areas of customer service, distribution, and business-to-business marketing.

In this project the HERE scholar will be assisting PhD candidate Reza Alizadeh. The HERE scholar will have an opportunity to learn how to frame a problem on green supply with a focus on social sustainability, social justice and corporate social responsibility and develop mathematical models to quantify a real-life sustainable development problem. Also, the HERE scholar will have an opportunity to showcase the results at peer-reviewed conferences and/or academic journals. Students with prior experience in Python, high enthusiasm to read and learn ML, and plan to take a maximum of 15 semester credits are strongly encouraged to apply.

Synthesis of specialty carbon nanotubes to answer fundamental questions in catalysis

Prof. Steven Crossley
School of Chemical, Biological, and Materials Engineering

Carbon nanotubes are remarkable materials with the potential for a wide range of applications. In this project, we take advantage of the unique properties of carbon nanotubes to allow hydrogen to migrate along
their surface, serving as hydrogen highways. The ultimate goal is to quantify the rate that hydrogen can migrate along the surface of the nanotube, as this will allow us to answer many fundamental questions in catalysis. We will first use an approach developed in our lab to grow forests of aligned carbon nanotubes with precise length and surface properties. We will then evaporate on one end of the tube forest a metal that is capable of splitting hydrogen, and on the opposite end of the forest we will deposit an oxide material that itself cannot split hydrogen. The oxide reacts with the hydrogen that migrates along the tube and serves as a sync. By measuring the rate of oxide reduction via temperature programmed reduction (TPR), we will quantify these rates of hydrogen migration. This information will help us to answer many longstanding questions in heterogeneous catalysis. These experiments will be conducted in collaboration with a PhD student.

**Systematic Characterization of Dental Biomaterials Using Atomic Force Microscopy**

**Dr. Pedro Huebner**  
**School of Industrial and Systems Engineering**

Micro- and nano-indentation devices, such as atomic force microscopes (AFM), offer unmatched capabilities to characterize, at remarkably small scales, the topographical features and mechanical properties of a wide variety of samples. However, AFM-generated datasets are highly extensive and complex, therefore challenging the process of data interpretation and statistical analysis. This project will be executed in collaboration with the College of Dentistry at OUHSC for sample preparation and generation of preliminary AFM data on dental biomaterial interfaces featuring highly heterogeneous topographical and mechanical characteristics across and within samples. Ultimately, students will work alongside a graduate research assistant to discuss, evaluate, and implement appropriate strategies for automated feature recognition and analysis using image-processing-based algorithms developed with Python, MATLAB, ImageJ, and other tools. Students from all fields of engineering are welcome to apply granted that they are comfortable and have demonstrated experience with the referenced programming languages. Eventual travel to OUHSC may be expected during the early stages of the project.

**Using Deep Learning for Automated Early Diagnosis of Brain Injury in a Rat Model Based on Thermographic Monitoring Inflammation**

**Reza Alizadeh (ISE), Professor Janet K. Allen (ISE), Professor. Farrokh Mistree (AME)**  
**School of Aerospace and Mechanical Engineering**

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

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

### Ultrasonic-driven separation of natural gas from crude oil

**Dr. Pejman Kazempoor**  
**School of Aerospace and Mechanical Engineering**

Storage tanks are responsible for 6% of methane emissions in the oil and gas production sector. A storage tank can vent up to 96000 scf of natural gas and light hydrocarbon vapors to the atmosphere each year. One potential option to solve this problem is to separate the associated gas from the crude oil before sending it to the storage unit. This project will examine a novel gas separation technique using acoustic waves. The HERE scholar will design a test stand to evaluate the concept feasibility in a lab environment. An analytical model will also be developed in Matlab software to validate the experimental results.

### Water Quality Depth Profiling of Abandoned Mine Waters of the Picher Lead-Zinc Field at the Tar Creek Superfund Site

**Dr. 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 water quality dataset for streams, artesian springs and selected groundwater locations in the Tri-State Lead-Zinc Mining District of Oklahoma, Kansas and Missouri. Mining and associated pumping operations ceased several decades ago, and groundwater recharge, coupled with surface water interaction, filled extensive and complex underground mine voids, resulting in an approximately $1.2 \times 10^8$ m$^3$ (100,000 acre-foot) mine pool, contaminated by dissolved iron, zinc, lead, cadmium, arsenic, nickel and sulfate. The voids extend several hundred feet below the surface. As environmental remediation and restoration efforts proceed, a need exists to develop discrete depth profiles of selected water quality parameters in mineshafts, boreholes, and monitoring wells. The project will include field data generation (multiparameter water quality data sondes), sample collection (following USEPA methods), laboratory analyses (microwave-assisted hot acid digestion and inductively coupled plasma-optical emission spectroscopy), data interpretation and report writing. Data analyses will include comparisons to historic sampling events conducted in the 1970s, 1980s, and early 2000s.

### What happens to large molecules, like polymers and surfactants, when they travel through pipes and pumps?

**Prof. Dimitrios V. Papavassiliou**
School of Chemical, Biological and Materials Engineering

When suspensions of surfactant molecules or polymer molecules move through pumps or other high stress settings (like porous media), their molecular structure changes because of hydrodynamics stresses acting on them. Such molecular changes can result in changes in the macroscopic behavior of the suspensions, for example changes in the viscosity and changes in the interfacial tension. We use molecular level simulations to understand the changes that surfactant undergo when they get to flow through carefully controlled stress environments. The two extreme conditions are shear flows (where shear stresses are exerted on the molecules) and elongational flows (where normal forces act on the surfactants). We want to see what are the conditions that lead to significant changes in the way the molecules are structured and to develop guidelines for the design of flow devices. We use simulations with high end computers (locally, at the OU Supercomputing Center for Education and Research, as well as across the country) to simulate molecular interactions and to generate the flow conditions for purely shear and purely elongational flows. A student who has had intermediate Physical Chemistry and Fluid Dynamics classes and an interest and skills 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.

Wind Field Estimation and Reconstruction with Quadcopter Drones

Dr. Wei Sun
School of Aerospace and Mechanical Engineering

The goal of this project is to design algorithms to estimate and reconstruction wind field in an area with a team of quadcopter drones. This project will involve: (i) determine the best-fit sensor that can collect wind data and can be mounted on a quadcopter, (ii) design algorithms to collect local wind data from the quadcopters without dedicated wind sensors if needed and reconstruct the wind field from local data, (iii) implement the algorithm to a simulated quadcopter system, (iv) test the algorithm on real quadcopters and (v) 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 coding is a big plus.

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. The goal is to co-print materials with different properties to form fully functional circuits that are 3D printed.
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.