University of Pittsburgh
Mascaro Center for Sustainable Innovation

2021 Undergraduate Summer Research Project Descriptions

Application link: Sustainability Summer Research Application
Applications Due: February 24th
Program Runs: May 10 – July 30, 2021
***All Projects are Convertible to Remote Research in Elevated and High Risk Posture unless noted otherwise*

Metal distributions in Urban Soils and Green Infrastructure
Toxic trace metal contamination is common in urban systems, however, the spatial distributions of these metals are poorly defined. The student will focus on the measurement of sediment trace metal concentrations in situ and/or in the lab to characterize patterns around historical polluters and in green infrastructure and assess potential human exposure disparities resulting from these patterns.
Advisor: Daniel Bain, Geology and Environmental Science

Assessing Environmental (In)justices in U.S. Public Housing Siting Decisions
While spatial inequities in public housing have been previously documented, it is unclear if occupants in public housing have historically been disproportionately exposed to pollution. Using unique and previously unpublished historical air quality data, the project team is exploring any historical environmental (in)justices associated with public housing siting decisions. Interns should expect to assist with data discovery, collection, and visualization.
Advisors: Michael Blackhurst, University Center for Social and Urban Research
Randy Walsh, Economics

Exploring cryptic diversity in temperate forests: Do seed banks promote forest sustainability and resilience in wind-disturbed and logged temperate forests?
Hundreds of plant species lie dormant as seeds for decades in forest soils only to emerge *en masse* following disturbances such as tornados. We will examine whether salvage-logging following windstorms, long thought to be harmful to our forests, is actually a means by which we can restock seed banks and conserve plant biodiversity, and at the same time generate revenue.
Advisor: Walter Carson, Biological Sciences

Clogging riparian zones in small tributaries throughout Western, New York: How non-native plant species are reshaping our riparian forests.
Non-native plant species are currently invading small riparian watersheds where they arrest forest succession and create forests with near zero economic value and sequester little carbon. We will examine the underlying causes for this stagnation using hundreds of experimental mesocosms where we have planted native and exotic riparian species to see how they change microbial communities thereby "poisoning" native plant species.
Advisor: Walter Carson, Biological Sciences

The sustainable ocean in the box
The ocean flows on large scales can be well-approximated as two-dimensional flow, and we simulate the ocean flow experimentally using a thin-layer electromagnetically driven flow device in the lab. This project mainly focuses on managing the transport and mixing of the pollutants for a sustainable ocean.
Advisor: Lei Fang, Civil and Environmental Engineering

Simulating social-distanced crowd
The recent global spread of SARS-CoV-2 and the resulting coronavirus disease (COVID-19) require a social distance between individuals, which poses a significant challenge to existing infrastructures. We will use crowd modeling to study the dynamics of the social-distanced crowds to improve the existing infrastructures' transport efficiency.
Advisor: Lei Fang, Civil and Environmental Engineering

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Bugs Against Drugs: Taking the Headache out of Ibuprofen and Naproxen Pollution by Harnessing the Degradation Power of Microorganisms
Domestic wastewater effluent is one of the main contributors of pain relief medications such as ibuprofen and naproxen into the environment, due to incomplete removal at the treatment plant. The presence of these drugs in aquatic environments has been linked to adverse health outcomes in various organisms, hence there is an immediate need to find a way to reduce the concentration of these drugs leaving the treatment plant. This project will involve identifying and isolating ibuprofen and naproxen degrading bacteria from the environment, which could be used in a batch reactor to reduce the concentration of these drugs. *This project is partially convertible to remote research.*
Advisor: Sarah Haig, Civil and Environmental Engineering

Improving the efficiency of microgrids by integrating weather forecasts into optimization models
This project will develop a controller that reduces the expected fuel used by a diesel generator in a microgrid consisting of a wind turbine, battery and diesel generator. The controller will be based on Markov decision processes and will integrate weather forecasts. Preferred skills: coding, data analysis, and knowledge of Markov chains (IE 1082).
Advisor: Oliver Hinder, Industrial Engineering

Machine learning green chelating agents
The project will require an undergraduate student to carry out computational screening to identify hypothetical molecules that would be biodegradable as well as effective chelating agents. The project may involve opportunities for entrepreneurship activities in the subsequent year.
Advisor: John Keith, Chemical and Petroleum Engineering

Life cycle analysis of computational chemistry
This project will require an undergraduate student to do a life-cycle analysis of computational chemistry algorithms and their impact on energy consumption and CO2 emissions.
Advisor: John Keith, Chemical and Petroleum Engineering

Artificial Intelligence Algorithms for Distributed Energy Resource Management Systems (DERMS)
In this undergraduate research project, a student researcher will work to develop artificial intelligence algorithms to increase the penetration of photovoltaic energy systems with storage capability. The goal of these algorithms is to manage these energy systems in an effort increase their efficiency, while keeping them and other connected equipment protected. The algorithms will be developed using the Python 3 programming language and the distribution system simulation tool OpenDSS. A general background in electric power is preferred, but not necessarily required. Students should be comfortable with computer programming, linear algebra, multivariate calculus, and statistics & probability.
Advisor: Robert Kerestes, Electrical and Computer Engineering

Using machine learning models to identify wildlife species in field recordings
Our lab uses small, inexpensive acoustic recorders to record soundscapes at field sites across the United States. We are interested in hosting a summer fellow who will work with us on this research. The main tasks will be developing and testing machine learning models to identify species of birds, bats, frogs, and/or insects within long field recordings, but tasks may also include deploying recorders in the field, managing incoming data, and testing new hardware designs.
Advisor: Justin Kitzes, Biological Sciences

Developing a wireless sensing system for in-situ seed imbibition monitoring
Seed imbibition in soil is affected by soil moisture, soil structure, and pericarp permeability so that different recipes of soil and species can be evaluated by monitoring the initial seed size growth, which is very helpful for agriculture people, but unfortunately there is no in-situ imbibition sensing solution. In this research project, a student will understand the previously developed solution for size-to-resistance conversion, research for resistance-to-digital conversion and wireless data transmission using off-the-shelf components, design a PCB for a complete imbibition monitoring system, and test the developed system with a maize seed in soil.
Advisor: In Hee Lee, Electrical and Computer Engineering

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Developing a wireless localization technique to track small animals
Wireless localization technique enables scientists to understand living patterns of animals and thus identify their unique characteristics or environment changes so that a global positioning system (GPS) has been applied for typical animals, but the GPS device cannot be applied to small animals due to its bulky size or heavy weight. In this research project, a student will learn how to operate the previously developed miniature battery-powered radio signal transmitter, develops a wireless localization technique by using received signal strength (RSS) from multiple gateways in known positions, evaluate the developed wireless localization technique, and further reduce the size of the radio signal transmitter to widen its application to smaller animals.
Advisor: In Hee Lee, Electrical and Computer Engineering

Simulation of FirstSolar Solar Modules
FirstSolar is the largest manufacturer and recycler of solar modules in the United States. This project seeks to evaluate the performance of various FirstSolar modules designs for efficiency.
Advisor: Paul Leu, Industrial Engineering

Self-Cleaning and Antireflecting Solar Glass
Solar modules are often installed in cities or deserts where there they may be covered with particulates that reduce efficiency. This project seeks to evaluate new types of solar module glass that offer antireflection and self-cleaning properties.
Advisor: Paul Leu, Industrial Engineering

Electrochemistry for a zero-waste chemical economy
We are developing new chemical processes that use renewable electricity to recycle pollutants like CO2 back into useful chemical fuels. MCSI summer undergraduates are invited to apply to be part of this effort on a project that encompasses experimental or computational studies of new materials and methods for CO2 recycling.
Advisor: James McKone, Chemical and Petroleum Engineering

Optical fiber diameter tracking via machine vision
Machine vision provides an on-line measurement and feedback on the fiber growth condition in Laser Heated Pedestal Growth system used for growing single crystal fiber materials. Optical fiber diameter tracking is one of the most important parameters. This project seeks optimized method in tracking fiber diameter with minimum standard deviation.
Advisor: Paul Ohodnicki and Bo Liu, Mechanical Engineering and Materials Science

Rapid Thermal Processing of Soft Magnetic Nanocomposites
Novel electromagnetic processing can achieve desired microstructures and enhanced soft magnetic properties which allows for dramatically higher power density and reduced cost for application in end-use components such as motors, transformers, and inductors relevant for vehicle / aircraft electrification and power electronics. Proposed work will target unique thermal processing such as radio frequency induction heating and laser annealing enabling ultrafast phase transformation of metal amorphous alloy ribbons.iation.
Advisor: Paul Ohodnicki and Ahmed Talaat, Mechanical Engineering and Materials Science

Data Science for Sustainability: Real-World Problem-Solving Techniques for Teachers
The goals of this project include assisting with evaluative research on STEAM/Computer Science Professional Development Institute (including data collection and in elementary and middle school classrooms), creation of repository of resources for schools and teachers, and dissemination of results in NSTA's (National Science Teacher's Association) Science Scope Magazine. Additionally, this research will inform this summer's professional development institute by providing an opportunity to iterate the institute.
Advisors: Cassie Quigley, Department of Teaching, Learning and Leading, School of Education
Aileen Owens, Director of Innovation at South Fayette School District
David Sanchez, Civil and Environmental Engineering

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Environmental Justice Teaching
The goal of this project is to rethink the way environmental problems are taught to youth and brainstorm ways to reframe environmental problems toward environmental justice. By utilizing existing curricula, this project includes creation of asynchronous lessons that can be used to support K-8 teachers, piloting implementation, and evaluation of this work. The results of this work will be published in SEED (Science Education for Equity and Diversity)
Advisor: Cassie Quigley, Department of Teaching, Learning and Leading, School of Education

Data-Driven Vaccine Allocations (Parallelization and Cluster Computing)
We use public mobility and clinical data to train a generative model of disease outbreaks across different localities and use the trained model to propose (guaranteed approximately optimal) allocations of epidemic control resources (sentinel surveillance, targeted testing, and vaccination). The undergraduate researcher will assist with implementation of the designed algorithms to work with large-scale state and national scale data (parallelization and cluster computing).
Advisor: Amin Rahimian, Industrial Engineering

Data-Driven Vaccine Allocations (API and Dashboard Design)
We use public mobility and clinical data to train a generative model of disease outbreaks across different localities and use the trained model to propose (guaranteed approximately optimal) allocations of epidemic control resources (sentinel surveillance, targeted testing, and vaccination). The undergraduate researcher will assist with the design of API and dashboards that provide user friendly access to the input and output data.
Advisor: Amin Rahimian, Industrial Engineering

Outreach projects for promoting STEM careers and the social appreciation of engineers.
In depth analysis of over 50 outreach projects developed by SSOE/ChE students. Proposal and development of a social-media platform to socialize the results. Structure of an expanding social network of people and institutions, state and nationwide. Literature research and background summary for publications. Benchmark and best practices. Extensive guidelines and rubrics.
Advisor: Joaquin Rodriguez Alonso, Chemical and Petroleum Engineering

Global projects for developing cultural diversity and global awareness in engineering careers.
In depth analysis of 11 global projects developed by SSOE/ChE students joining foreign partners all over the world. Proposal and development of a social-media platform to socialize the results. Structure of an expanding worldwide social network of people and institutions. Literature research and background summary for publications. Benchmark and best practices. Extensive guidelines and rubrics.
Advisor: Joaquin Rodriguez Alonso, Chemical and Petroleum Engineering

Microbial Fuel Cells to degrade emerging contaminants of concern
There is a growing portfolio of emerging contaminants in the environment that are unregulated but pose risks to human and environmental health. The goal of this project is to evaluate the potential for biofilms and micro-electrodes to degrade these contaminants. The project will focus on designing micro-electrodes for biofilms, and selectively adapting electrodes to degrade these contaminants. Additional aims will focus on identifying governing parameters (material morphology, electrochemical activation) to optimize degradation kinetics.
Advisor: David Sanchez, Civil & Environmental Engineering

Smarter Riversheds –real-time sensor networks
Combined sewer overflows result in over 9 billion gallons of sewer/stormwater flowing into Pittsburgh's rivers each year. Identifying water-quality trends in real-time is essential to solving this problem projected to cost over $3billion for Pittsburgh. With many cities across the US facing this challenge, this project focuses on triangulating historical, historical, and grab sample water quality data to understand water quality dynamics in real-time and to evaluate Green infrastructure. Student will gain experience in environmental sampling and analytical chemistry techniques,
Advisor: David Sanchez, Civil & Environmental Engineering

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Soft Robotics for Environmental Monitoring and Sampling
We will pursue biomimetic designs of polymeric soft robotic swarms, which can be remotely powered and steered to perform environmental monitoring and sampling. We envision designing and fabricating insect-scale robots that can manipulate in the natural world, in an unobtrusive fashion to sample and detect contaminants and pollutants.
Advisor: Ravi Shankar, Industrial Engineering

Comparative Study of Plastic First Mile Policies
The logistics of collecting and sorting plastic waste - a process known as the Plastic First Mile - determine if a single-use plastic cup, box, or bottle will make it to a recycling bin or be added to the flow of plastic leaking into the ocean. This project compares policies regarding the PFM across the globe, seeking the most effective responses from environmental, economic, and social perspectives. *This project will be remote.*
Advisor: Kay Shimizu, Political Science

Analysis of impact of Connected and Automated operations on fuel consumption at signalized intersections
Students will work with Anonymized Logger Data set from the University of Michigan Connected and Automated vehicle experiments to identify various factors which impact fuel consumption at connected signalized intersections. The analysis will help to correlate such field data with simulated data and draw conclusions on various factors which impact fuel consumption and vehicular emissions on urban streets.
Advisor: Aleksandar Stevanovic, Civil and Environmental Engineering

Analyzing operations of commercial fleets to reduce fuel consumption on urban roads
Students will work with Fleet DNA data set from a fleet of vehicles driven around US in order to mine the various characteristics of Fleet DNA data, conduct analysis (e.g. machine learning and innovative visualization) to help understand the operational characteristics of commercial vehicles and optimize fuel consumption.
Advisor: Aleksandar Stevanovic, Civil and Environmental Engineering

A novel process for purely thermal desalination
This project will implement a bench-top continuous desalination process in which a polymer selectively binds water from a salt+water mixture, and then releases it upon gentle heating. Preliminary results from last summer show that the phase diagram of salt-polymer-water is such that even high salinity water may be desalinated. The project is mostly experimental, but may involve some process modeling using the Aspen software. *This project is partially convertible to remote research.*
Advisor: Sachin Velankar, Chemical and Petroleum Engineering

Towards a Circular Economy: Chemical Recycling of Plastics Waste via Liquid Metal Catalysis
Plastics – synthetic polymers with a broad range of uses and properties which are essential for our current quality of life – are causing an increasingly severe global environmental plastics waste problem. We are exploring a novel technology, based on the use of liquid metals, to depolymerize plastics into their molecular constituents in order to re-use this vast waste stream for synthesis of virgin synthetic polymers and thus enable a more sustainable, circular use of plastics materials.
Advisors: Goetz Veser and Eric Beckman, Chemical and Petroleum Engineering

Design spinel ferrite magnetic adsorbents for water purification
In this project, computational materials methods will be used to predict the capability of a series of spinel ferrites for removing metal ions (such as Pb, As) from industrial wastewater. The outcome of the project is to identify the optimal composition and morphology of spinel ferrite particles to chemically adsorb and remove metal ions from the water.
Advisor: Guofeng Wang, Mechanical Engineering and Materials Science

Entrapment of manganese ions in sol-gel derived silicates for contaminant degradation by manganese peroxidase
Manganese peroxidase (MnP) is an oxidative enzyme that is capable of degrading various emerging contaminants. However, its strict requirement for manganese ions (Mn2+) as the catalytic mediator limits its application in systems where Mn2+ is absent. In this project, we will develop a Mn2+-doped sol-gel silica material that allows for the application of MnP in Mn2+-free systems. *This project is NOT convertible to remote research.*
Advisor: Meng Wang, Civil and Environmental Engineering

Machine learning of graded alloys made by additive manufacturing for power plant with high energy efficiency
The development of 3D printing methods has changed the landscape of materials research over the past decade. Researchers are just beginning to realize the full potential of benefits AM possesses over standard subtractive methods. One of these benefits is the ability to fabricate parts that utilize material composition gradients to yield optimized local material properties. The ability to use AM to produce parts with gradient compositions will enable an engineer to design components that utilize multiple exotic materials, thus improving overall performance. The students working in this project will learn the techniques regarding graded alloy build and study process-structure-property relationships for the graded alloy manufacturing, including post-heat treatment. The materials will be used in repairing the power plants, and some critical materials design models will be developed through this mini-project.
Advisor: Wei Xiong, mechanical engineering and materials science

Design of high strength alloys for energy efficiency
This project directly performs the new alloy design, which is critical to improve the service life of the naval craft and thus increase the energy efficiency of alloy production. The corrosion test and post-heat treatment will be applied to the new alloys that we designed in order to optimize the manufacturing of the advanced alloys. In addition, further improvement of steel composition will be applied using the ICME (Integrated Computational Materials Engineering) models will be applied to further modify the processing of these new alloys for naval craft manufacturing.
Advisor: Wei Xiong, mechanical engineering and materials science

Electrically Reconfigurable Phase-Change Optics
The goal of this project is to characterize the thermal dynamics of an electrically controlled phase change pixel and compare the experimentally measured heating and cooling times against COMSOL simulations. This project will involve the design and construction of an electro-optical probe station for optical device testing.
Advisor: Nathan Youngblood, Electrical and Computer Engineering

Low-Energy Computing with Photonic Integrated Circuits
The goal of this project is to develop an experimental framework for controlling and measuring all-optical matrix-matrix multiply units which can achieve very high bandwidth and ultra-low energy computations. This project will involve the design, construction, and testing of a 16-channel PCB which controls electro-optic photonic components with high precision via a PC interface.
Advisor: Nathan Youngblood, Electrical and Computer Engineering

Machine Learning for Metal Additive Manufacturing Data Analytics
Laser Powder Bed Fusion based Additive manufacturing (AM) is a widely-used metal 3D printing method to fabricate complex-shaped metal components for various applications. Yet, effective process modeling and control is still needed to realize sustainable metal AM that features optimized energy and material usage and reduced defected products. This project will analyze big experimental data (including in-situ sensing data and ex-situ characterization data) and develop a machine learning based correlation model of “Process-Structure-Property”, which can help enhance the efficiency and yield of metal AM.
Advisor: Xiayun Zhao, Mechanical Engineering and Materials Science

Develop a novel multi-material 3D printing system
Conventional multi-material 3D printing technologies tend to consume more than necessary materials due to the constant material switchover and in-between cleanup. Towards a sustainable multi-material manufacturing, the goal of this project is to develop a novel multi-material photopolymerization based 3D printer with an in-situ monitoring system that could unravel the process dynamics and aid process improvement. The newly developed 3D printing system will eliminate the need for frequent residual material washing between each resin vat changeover, thereby reducing water and chemicals usage as well as increasing the manufacturing throughput.
Advisor: Xiayun Zhao, Mechanical Engineering and Materials Science