University of Pittsburgh
Mascaro Center for Sustainable Innovation

2023 Undergraduate Summer Research Project Descriptions

Application Link: bit.ly/2023urp
Applications Due: February 17, 2023
Program Period: May 8 – July 28, 2023

Forging Sustainable Responses to Landslide Hazards in Southwest Pennsylvania
Southwest Pennsylvania experiences widespread landsliding, requiring substantial effort/resource to protect built and natural infrastructure. However, data collections are spotty, limiting an informed, comprehensive response. This project provides opportunities to work with a dynamic research team to gather and organize data in support of development of data-driven responses to this regional challenge.
Advisor: Daniel Bain, Geology and Environmental Science

Functional Magnetic Materials for Energy Efficient Magnetocaloric Cooling
Magnetocaloric materials have been identified and used for solid-state cooling application that reduce energy consumption by up to 30% compared to standard vapor-cycle cooling technology. This summer project will focus on new compositions and processing approaches for magnetocaloric materials that will use cheaper and more readily available materials while providing similar efficiency gains when used in magnetocaloric cooling applications.
Advisor: Markus Chmielus, Mechanical Engineering and Materials Science

Reusable, Sterilizable, and Antimicrobial Filtration Using Binder-Jet 3D Printed Porous Metal Structures
Motivated by the COVID-19 pandemic, this project seeks to further refine our research on reusable and sterilizable 3D printed porous structures for effective filtration at the microscale. The project will consider filtration efficiency and anisotropic permeability/tortuosity using micro-computed tomography to design reusable and effective filtration systems.
Advisor: Markus Chmielus, Mechanical Engineering and Materials Science

Toward the transport of micro-plastics surface gravity waves
Micro-plastics can be carried by surface gravity waves in lakes and oceans. This summer, the student will use experiments to study how they are transported in surface gravity waves.
Advisor: Lei Fang, Civil and Environmental Engineering

Toward the two-way coupling of swimmer and surface gravity waves
Swimmers like protozoa and zooplankton are ubiquitous in lakes and oceans, and the swimmers are in the surface gravity waves. There is a two-way coupling between swimmers and surface gravity waves. We will use experiments to reveal the two-way coupling between the swimmers and surface gravity waves.
Advisor: Lei Fang, Civil and Environmental Engineering

Urban Permaculture
Student will learn the concepts of permaculture at an urban community farm in Garfield. Tasks will include land restoration design and implementation, food distribution at the Valley View Church Food Pantry, community garden participant management, and assisting with educational tours and project leadership.
Advisor: Corey Flynn, Physical Therapy
Kevin Bell, Bioengineering

Gradient Biopolymers for Benign Packaging
This project will focus on creating and characterizing a series of biopolymers to replace conventional, petroleum-based polymer packaging. The construct includes reversible crosslinks, and the student working on this project will investigate physical and thermal properties of the materials along with its triggerable degradation.
Advisors: Susan Fullerton, Chemical and Petroleum Engineering

Energy-efficient processors, sensors, and systems for space-based sensing and computing
The focus of this research opportunity is to study and contribute to a topic in advanced computer architectures, apps, sensors, networks, systems, and/or services, often in the context of resource constraints and environmental hazards, with the goal of maximizing performance, energy-efficiency, and resilience. Students will learn and employ selected concepts, methods, and technologies in parallel, reconfigurable, dependable, and/or distributed computing, by working on a research task for next-generation spacecraft, autonomous systems, or supercomputers, in the NSF Center for Space, High-performance, and Resilient Computing (SHREC) headquartered in the ECE Department at Pitt.
Advisors: Alan George, Electrical and Computer Engineering

Human Flourishing in the Era of Climate Transformation
As a result of the climate crisis, hundreds of millions of people worldwide face the disappearance of their homes, lives, and livelihoods; and it is therefore urgent to advocate affirmatively for social change that supports dignified and flourishing existence in an era of radical climate transformation while also commemorating the losses that are occurring. Michael Goodhart (Political Science) and Ruth Mostern (History) seek summer research students to assist with either or both of the following tasks:

- Research and planning for a book and a website of personal reflections (from local youth and global experts alike) that chronicle the cataclysmic and unsettling changes that we are now living through;
- Preparing a bibliography and syllabus about the degrowth movement, whose proponents seek to reduce global consumption and production in order to focus on wellbeing rather than GNP as a key measure of prosperity.

Advisor: Michael Goodhart, Political Science
Ruth Mostern, History

Testing algorithms for electric power grid operation
The introduction of renewables into the electric grid has made day-to-day operational decisions more difficult. Operators must plan for more contingencies due to fluctuations in renewable energy inputs. This project will involve benchmarking new algorithms for electric power grid operation and analyzing their performance.
Advisor: Oliver Hinder, Industrial Engineering

Bond energy analyses of nanocarbons for sustainable medical devices
The student will use computational quantum chemistry methods developed in Prof. Keith's lab to analyze nanocarbon models to assess reaction mechanisms and descriptors for their use in medical applications. The scope of the project will depend on ongoing collaborations with other researchers in the schools of engineering, arts & sciences, and medicine.
Advisor: John Keith, Chemical and Petroleum Engineering

Increasing Hosting Capacity through Distributed Control Methodologies
The US is transitioning to a grid which relies less on fossil fuels and more on renewable energy technologies. However, with this transition comes many challenges. One of the most abundant sources of renewable energy that we have at our disposal is photovoltaic (PV) solar energy from the sun. However, when PV is increased too much, the grid will experience problematic issues such as overvoltages and energy backflow. When this happens, this prevents us from taking advantage of all the available PV energy. In this research project, we will work in collaboration with the Electric Power Research Institute (EPRI) to thoroughly model electrical networks and determine their solar hosting capacity. In addition, we will explore techniques to increase the grid's solar hosting capacity using distributed control. Finally, we will map this study to the hosting of other resources (and loads), such as battery energy storage systems and electric vehicles. Students should have strong analytical skills, programming skills, and be willing to work with unfamiliar software packages. EPRI's Power Delivery and Utilization Sector:
https://www.epri.com/portfolio/sector/pdu
Advisor: Bob 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. Several of our previous summer fellows have been co-authors on manuscripts describing their work.
Advisor: Justin Kitzes, Biological Sciences

Tracking migration of monarch butterflies with the world's smallest computer
Each fall, millions of monarch butterflies across the U.S. and Canada migrate up to 4,000 km to overwinter in central Mexico, but the number of monarchs completing the journey has dramatically declined in the past decades, coincident with the decreased availability of their milkweed host plant. In this research project, a student will contribute to developing a miniature sensing system mountable on a monarch butterfly, which can be a key to the understanding of habitat use during migratory flight and dependence on weather conditions.
Advisor: In Hee Lee, Electrical and Computer Engineering

Developing Speculative Inference to Increase Energy-Efficiency of IoT Systems
Speculative inference is an optimization technique that initiates the processing pipeline intelligently without waiting for all inputs. This project will develop and examine the feasibility of using speculative inference that adapts to dynamic context, achieves high inference accuracy, and reduces delay and energy consumption of the system. Students will develop machine learning algorithms and will be exposed to programming frameworks.
Advisor: Stephen Lee, School of Computing and Information

Performance and Energy Impact of Deep Learning Models on Heterogenous Devices
This project will investigate the carbon footprint of deep learning models and how we account for device heterogeneity. Students will develop simulation models and explore various energy and carbon models to measure energy consumption and carbon emissions. Furthermore, the study will explore techniques that use dynamic voltage and frequency scaling (DVFS) on performance and energy.
Advisor: Stephen Lee, School of Computing and Information

Antireflective Coatings and Surfaces for Concentrated Solar
Antireflection coatings and surfaces may benefit concentrated solar, where light reflected from the surfaces of lenses or top of solar lead to losses. This project seeks to understand how concentrated solar systems can be made more efficient with new types of nanostructured glass that provides for not only low reflection across a wide variety of wavelengths, but a wide variety of light incidence angles.
Advisor: Paul Leu, Industrial Engineering

Recycling of Solar Panels
Solar energy is one of the world's fastest growing industries: solar installations have grown by 40 percent every year for the past decade, and the technology behind them has exploded along with it. However, over 90% of solar panels are disposed of in landfills currently. This project seeks to understand how we can improve the recycling of solar panels by separating and removing aluminum, glass, and other materials from solar panels.
Advisor: Paul Leu, Industrial Engineering

CyberWater2 -- A sustainable data/model integration framework
Natural hazards, such as coastal and inland flooding caused by Hurricanes and severe drought and its associated wildfire, have been occurring with unprecedented frequency induced by climate changes. To mitigate these potential disasters, CyberWater2, to be built on top of CyberWater, will develop a collaboration-centric cyberinfrastructure for scientific and engineering communities to solve complex scientific modeling problems efficiently, accurately and in-depth and to facilitate collaboration across disciplines, platforms, organizations, and geographic boundaries. The student will learn how to develop part of the CyberWater2 system, test and evaluate different features of the system, develop use cases, and identify limitations of the system.
Advisor: Xu Liang, Civil and Environmental Engineering

ESG related metrics in management compensation schemes
One interesting issue is that many firms are incorporating ESG related metrics into their management compensation scheme. The student will review and collect information about what and how ESG related metrics are used in management compensation from proxy statements. This research will be reviewed with our PhD students, the CSB staff, and Prof. Ma.
Advisor: Mark Ma, Business

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Decarbonizing Chemistry with Renewable Electrons
Our lab is looking for a summer student to help us build the next generation of catalysts and chemical reactors that can regenerate useful fuels and chemicals from nothing but seawater, renewable electricity, and trash!
Advisor: James McKone, Chemical and Petroleum Engineering

Hardware Development for Really Big Batteries
We are looking for someone to join our team that is developing smart hardware for a new type of battery that uses liquids to store electric charge. Bring your wrench set - this project is perfect for anyone who got into engineering to make and build stuff.
Advisor: James McKone, Chemical and Petroleum Engineering

Applying Principles of Clinical Psychology to the Climate Crisis
Join a newly funded project focused on applying principles of clinical psychology to climate emotion, cognitions, and behavior. The project can be tailored to the interests and/or subject area expertise of the student, but possible contributions include investigating the impacts of climate change on mental health or conducting cross-disciplinary research into individual behavior that most impacts climate change and what motivates people to reduce (or not reduce) those behaviors.
Advisor: Kirsten McKone, Psychology

Generating knowledge graphs to reduce combinatorial complexity of data-driven methods
This project will focus on using artificial intelligence methods for knowledge representation learning, causality and reasoning on knowledge to reduce the combinatorial complexity faced by machine learning methods and neural network-based methods. The scope of applications for the methods that will be developed is broad, from medicine to economy, agriculture, or power systems. The first application where we will use the developed methods is automated generation of receptor candidates for synthetic biology.
Advisor: Natasa Miskov-Zivanov, Electrical and Computer Engineering

Resolving contradictions in multimodal data
This project will use artificial intelligence methods such as natural language processing, knowledge representation learning, causality and reasoning on knowledge, as well as stochastic simulation and statistical hypothesis testing to infer explanations or suggest resolution for contradictions in multimodal data. We will explore contradictions between interaction networks inferred from cancer data and the knowledge available in published literature.
Advisor: Natasa Miskov-Zivanov, Electrical and Computer Engineering

Nanocrystalline Soft Magnetic Alloys for Electric Vehicle and Power Grid Applications
New nanocrystalline soft magnetic alloys will be synthesized and processed under a range of conditions to tailor the microstructure and optimize magnetic properties. These alloys are of interest for electric power conversion in electric vehicle, space exploration, and electric power grid applications. Students will gain hands on experience with alloy processing and characterization techniques in an interdisciplinary laboratory environment.
Advisor: Paul Ohodnicki, Mechanical Engineering and Materials Science

Photonic Nanocomposite Thin Films and Sensors for Energy Infrastructure Sensing
Nanostructured optical thin films will be synthesized having tailored optical properties for sensing applications in a range of energy applications including batteries, transformers, fuel cells, pipelines, etc. Optical sensors will be fabricated and tested in various relevant operational conditions in collaboration with an interdisciplinary team of materials scientists and electrical engineers.
Advisor: Paul Ohodnicki, Mechanical Engineering and Materials Science

Calibrating null models of social connectivity across the US population
Social networks form a critical substrate for adoption of innovative technologies, spread of healthy behavior, and democratic engagement but are also used to target vulnerable communities with false and misleading content that sow discord and mistrust, e.g., spreading vaccine misinformation and violent conspiratorial contents that disrupted our public health and national security during the pandemic. To better understand and study such vulnerabilities on a national scale, we use large-scale social network data about the U.S. population to calibrate random generative models of social connectivity across demographic groups in the U.S. The undergraduate researcher will perform statistical analysis of large-scale network connectivity data and will gain experience with model calibration, cluster computing and model evaluation.
Advisor: Amin Rahimian, Industrial Engineering

Modeling democratic resiliency of civic networks and evaluating policy interventions against civic disengagement and social unraveling
The unprecedented turnover of election officials across the US has raised concerns about the integrity of future elections and democratic resiliency. We provide an analytic model for this social unraveling and propose policy interventions to mitigate it. The undergraduate researcher will build simulation models of civic networks and their engagements with the public, as well as use the simulation model to evaluate the outcome of various interventions and allocation strategies on the network.
Advisor: Amin Rahimian, Industrial Engineering

Global Projects in the Engineering Curriculum
More than 240 senior students at the Chemical Engineering Department have developed 45 global projects over the course of the last four years. The impressive amount of data on problem identification, foreign partner contacts, strategies, analysis and proposed solutions, offer a tremendous potential to organize the structure of this innovative practice in engineering curriculum and elaborate a roadmap for further development to expand the impact on global sustainability.
Advisor: Joaquin Rodriguez, Chemical and Petroleum Engineering

Green Engineering and Sustainability
The development of a new elective course in green engineering and sustainability looks for exemplar sustainable project templates to be offered as models to develop course projects. The project will cover all the characteristic features of realistic projects in sustainability from conceptual design to practical solutions, including economic and strategic evaluations.
Advisor: Joaquin Rodriguez, Chemical and Petroleum Engineering

Imagining a New Paradigm for Cleaning Water Using Nanobubbles
We take advantage of the properties of everyday bubbles to clean, sift, protect, and deposit chemicals in applications such as medicine, manufacturing, food, and industry. Nanobubbles possess unique properties that allow them to stay in solution longer, increase mass transfer, and facilitate electrostatic interactions. Could there be an option to provide clean water for cheaper, without large filters and expensive reagents? This project will explore using Nanobubbles as a sustainable method for cleaning surface water. From plastics to contaminants of emerging concern, to biowaste, you'll evaluate the potential for Nanobubbles to separate and oxidize contaminants. Students will gain exposure to micro-fluidics, analytical chemistry, and environmental engineering treatment concepts.
Advisor: David Sanchez, Civil and Environmental Engineering

Using Microbial Fuel Cells to Generate Electricity from Wastewater using Biofilms
The goal of this project is to use microbial fuel cells to generate electricity from biofilms and wastewater. The project will focus on selectively adapting electrode materials to grow biofilms in 3-D printed microfluidic chambers that metabolize wastewater and emerging contaminants of concern. Additional aims will focus on optimizing parameters (growth substrate, material morphology, electrochemical activation). All disciplines are welcomed to apply.
Advisor: David Sanchez, Civil and Environmental Engineering

Developing Climate Leaders
This project will build on the work of 2022 MCSI Summer Research Fellow Allyson Frantz, whose research identified five characteristics of effective leadership on climate change. Through this year's project, the Summer Research Fellow will partner with GSPIA's Johnson Institute for Responsible Leadership to develop learning modules to teach these skills to students and other aspiring climate leaders. Modules may include online content that students can work through individually and teaching guides that faculty can integrate into course materials.
Advisor: Julia Santucci, Graduate School of Public and International Affairs

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Implementing Sustainable Development Goals in Pittsburgh
Pittsburgh's Human Rights City Alliance works with Pitt faculty, community organizations and Pittsburgh public officials to bring a human rights framework to city policy and community life. The UN Sustainable Development Goals (SDGs) provide one avenue for achieving this. In 2020 the City of Pittsburgh issued its first Voluntary Local Review (VLR). Since that time, other cities have developed models for strengthening local implementation of the SDGs, and there are a number of good models of best practices from which our city can draw to improve on this initial effort. This project will engage students in research to review lessons from other cities as we work with Pittsburgh community leaders and public officials to improve the city's efforts to promote equitable development and community resilience.
Advisor: Jackie Smith, Sociology

Validation of Google Eco-friendly routing method
This project will give students an opportunity to validate Google's, recently introduced, Eco-friendly method where drivers are given the best route not in terms of shortest time to their destination but in terms of the lowest impact on the environment (by suggesting a route which leads to lowest fuel/energy consumption). Students will compare Google's results, for a selected number of routes, to data from a set of highly calibrated and validated microsimulation models to test validity of the proposed routing method. The study and results are intended to be submitted for presentation at the 2023 Transportation Research Board conference and the associated journal.
Advisor: Aleksandar Stevanovic, Civil and Environmental Engineering

Practical optimization of traffic signals to reduce fuel consumption and vehicular emissions
This project will give students an opportunity to investigate impact of various stop penalties (e.g. how many seconds of delay is each vehicular stop worth, from the perspective of consumed fuel) on optimization of traffic signals. Students will use one of the contemporary practical signal optimization tools to test how various stop penalties affect the quality of signal timing plans, which will be measured through associated fuel consumption based on outputs of highly calibrated and validated microsimulation model. The study and results are intended to be submitted for presentation at the 2023 Transportation Research Board conference and the associated journal.
Advisor: Aleksandar Stevanovic, Civil and Environmental Engineering

Environmental Inequality and Disasters Research
This project examines the social, economic, and political determinants and outcomes of disaster responsiveness in the United States. We seek to understand how disasters and disaster recoveries affect people's lives, opinions, and behaviors. Centrally, we examine the underlying processes of disaster resource allocations, the means by which disaster recoveries can be more equitable, and how communities can better prepare for disasters and mitigate their complex impacts.
Advisor: Fernando Tormos-Aponte, Sociology

A Loopy Way to Hydrogen
Hydrogen is a key component in our path towards decarbonizing energy and the next generation of industrial processes. However, production of hydrogen itself is currently a carbon-intensive process where in particular the (typically required) purification step is energy intensive and costly. We are exploring a novel pathway that enables utilization of very low purity hydrogen for chemical processing, based on an efficient and flexible technology called "chemical looping".
Advisor: Götz Veser, Chemical and Petroleum Engineering

Towards Circular Use of Thermoplastic Urethanes
Thermoplastic polyurethanes (TPU) are ubiquitous in everyday life, from automobile parts over medical equipment to footwear and cell phone cases. Yet, like most "plastic waste", at the end of their use life, most TPU products end up in landfills or, even worse, in the environment. In this project, we are exploring a route for chemical decomposition of TPU waste into its constituent components which can be fed back into the original production process and hence enable truly circular use of TPU.
Advisor: Götz Veser, Chemical and Petroleum Engineering

Design spinel ferrite magnetic adsorbents for water purification
In this project, advanced computational 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

Biological Recovery of Critical Metals from Electronic Waste
Recovering high-quality metals from waste is of great importance to improve the metal circular economy and ensure a robust and sustainable metal supply. This project aims to engineer microorganisms to selectively concentrate and recover metals from electronic waste leachate.
Advisor: Meng Wang, Civil and Environmental Engineering

Co-localized Enzymes for Enhanced Biodegradation of Environmental Contaminants
Biodegradation is a sustainable and cost- and energy-saving approach to removing contaminants from waste streams and cleaning up contaminated environments. In this project, we will explore the feasibility of co-localizing enzymes to improve biodegradation efficiency.
Advisor: Meng Wang, Civil and Environmental Engineering

Forest Carbon Credit Programs: Who Participates and What are the Effects on Forests?
In collaboration with the American Forest Foundation, this project will study its family forest carbon program. The study will work with satellite data on vegetation to discover the effects of the carbon credit program on forests.
Advisor: Jeremy Weber, Graduate School of Public and International Affairs

Design of high-performance composite materials for sustainable structural applications
This project directly performs the new composite development, which is critical to improving the service life of engineering components for increased energy efficiency. The study will focus on materials design for metal-metal and metal-ceramic composites. Further improvement of alloy composition for the specific sintering heat treatment during composite manufacturing will be accomplished using fundamental materials modeling and high-throughput experiments.
Advisor: Wei Xiong, Mechanical Engineering and Materials Science

Manufacturing of functionally graded alloys using 3D printing for enhanced energy sustainability
The students working on this project will learn the techniques regarding functionally graded alloy build and study process-structure-property relationships in additive manufacturing, including post-heat treatment. The materials will be used in repairing and manufacturing critical power plant components. Some critical materials design models will be developed through this project.
Advisor: Wei Xiong, Mechanical Engineering and Materials Science

Developing Electrical Interfaces for Phototonic A.I. Hardware
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 multi-channel PCB which interfaces with and controls electro-optic photonic components with high precision via a PC interface.
Advisor: Nathan Youngblood, Electrical and Computer Engineering

Novel 3D Printing for Efficient Composites Manufacturing
Ceramic matrix composites (CMCs) have broad applications in critical industries such as aerospace and automobile. Traditional CMCs manufacturing processes involve multiple sequential steps and processes which are time-consuming and energy-consuming. The objective of this project is to develop a novel 3D printing system that can streamline the fiber deposition and matrix printing processes to print high-performance CMCs.
Advisor: Xiayun Zhao, Mechanical Engineering and Materials Science

Sustainable photopolymer 3D printing

Despite the current and potential applications of photopolymer 3D printing, there is a lack of research on eco-/bio-friendly photo resins and a limited understanding about their printability and potential applications. The objective of this project is to develop bio-based photo resins derived from renewable resources (e.g., vegetable oils and starch) and demonstrate versatile applications of these sustainable materials such as sensors and microfluidic bio-chips. The developed 3D printable photo resins will serve as green alternatives for the fossil-based acrylates and epoxides used in current photopolymer 3D printing.

Advisor: Xiayun Zhao, Mechanical Engineering and Materials Science