Vertically Integrated Projects (VIP) Program

Information Packet

Fall Quarter 2025-2026

Thank you for your interest in the Vertically Integrated Projects (VIP) Program at Drexel University!

VIP team members work as part of a multidisciplinary group of undergraduate students, graduate students, research staff, and faculty members to tackle novel research and design problems around a theme. Undergraduate students that join VIP teams earn academic credit for their participation in design/discovery efforts that assist faculty and graduate students with research and development issues in their areas of expertise.

VIP teams are:

- Multidisciplinary - drawing students from all disciplines on campus;
- Vertically-integrated - maintaining a mix of freshman through PhD students each academic term;
- Long-term - each undergraduate student may participate in a project for up to three years and each graduate student may participate for the duration of their graduate career.

The continuity, technical depth, and disciplinary breadth of these teams are intended to:

- Provide the time and context necessary for students to learn and practice many different professional skills, make substantial technical contributions to the team project(s), and experience many different roles on a large, multidisciplinary design/discovery team.
- Support long-term interaction between the graduate and undergraduate students on the team. The graduate students mentor the undergraduates as they work on the design/discovery projects embedded in the graduate students' research.
- Enable the completion of large-scale design/discovery projects that are of significant benefit to faculty members' research programs.

In the following pages you will find descriptions of the following VIP teams that are recruiting for the Fall Quarter of the 2025-2026 academic year:

- Artificial Intelligence and Robotics for Nondestructive Evaluation
- Astroparticle Physics in Extreme Locations
- Circular Cities: Assessing, predicting, and tracking building material stocks and flows from urban areas
- Co-Design of Spiking BERT
- Cognitive Neuroengineering for the Brain and Mind
- Consortium for Climate Risks in the Urban Northeast (CCRUN) Climate and Sustainability Research Team (CSRT)
- Coordination and Planning for Multi-Robot Systems
- Designing Smart and Healthy Transportation Systems
- Designing Sustainable Intelligent Transportation Systems
- Development of biomaterial-based nanofiber yarns and textiles for health applications
- Neuroergonomics and Neuroengineering for Brain Health and Performance Research
- Peace Engineering: Achieving the U.N Sustainable Development Goal #16
- Robotic Evaluation for Circular Lifecycle Assessment of Infrastructure Materials (RECLAIM)
- Robotics, Automation, and AI for Smart Agriculture
- Utilizing spatial data to support sustainable water management
- Vision Language Models for Autonomous Driving
- Wireless Systems for the Internet of Things

In order to participate in VIP, you must formally apply and be accepted to a specific team. To apply, please log into ForagerOne (www.drexel.edu/foragerone) and search for “VIP”. This will bring up all available open positions tagged as VIP projects. When submitting an application, please be sure to have uploaded an updated résumé to your ForagerOne profile and to include a statement regarding why you are interested in working on the team to which you are applying.

Please note that VIP team participation requires registration for the accompanying VIP course section. The number of credits required per quarter is flexible and will be determined on a case-by-case basis in consultation with the team's faculty mentor and a student's academic advisor; however, most VIP team members will register for a single credit per quarter. Long-term, sustained participation in the program (three or more quarters of working on a single team) is strongly encouraged and may be required in order for earned VIP credits to count towards degree requirements. More information will be provided to all applicants that are offered a position.

Should you have any questions about a particular team, please feel free to reach out to the team's faculty mentor(s). Any questions regarding the VIP program in general should be sent to Chad Morris via email at cam83@drexel.edu

We hope you'll take the time to consider this compelling new opportunity. We look forward to receiving your application!

Artificial Intelligence and Robotics for Nondestructive Evaluation

Drs. Arvin Ebrahimkhanlou (CAEE/MEM) – Faculty Mentors

GOALS

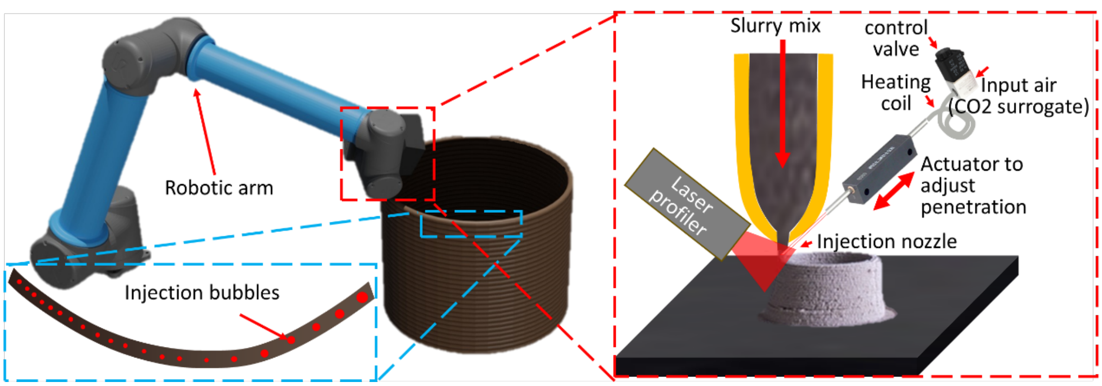
Recent advancements in artificial intelligence and robotics have created new opportunities for transforming how we evaluate and assess the condition of physical assets. Projects in this research theme leverage such opportunities to advance the field of nondestructive evaluation.

CURRENT PROJECTS

PROJECT 1: DESIGN AND MANUFACTURING OF A ROBOTIC NOZZLE FOR NONDESTRUCTIVE EVALUATION OF CO_2 INJECTION IN 3D PRINTED CONCRETE

The construction industry faces a significant challenge in achieving net-zero carbon emissions, contributing 8% of global carbon emissions. While concrete 3D printing offers material waste reduction by eliminating formwork, it paradoxically increases embodied carbon due to higher cement content. Although concrete can naturally absorb CO_2 through carbonization, this process is slow and limited to external surfaces. Once saturated, the external surfaces further inhibit additional CO_2 uptake, limiting the net-zero benefits. Existing CO_2 injection methods in prefabrication, while enhancing concrete properties, suffer from the limitations of slow absorption and CO_2 re-release, highlighting a critical need for innovative, more efficient carbon sequestration strategies in concrete.

This project focuses on designing and manufacturing an injection nozzle to investigate the feasibility of injection-based carbon sequestration in 3D printing of cementitious materials. The idea is to use a laser profiler to nondestructively track the geometry and defects (e.g., cracks) of 3D printed concrete as a function of the amount and patterns of CO_2 injections. To this end, the project will utilize an existing robotic arm and instead of actual CO_2 gas, will experiment with air bubbles as surrogates for CO_2 to ensure safety and a manageable timeline.



METHODS & TECHNOLOGIES

3D printing concrete, Robotics, Nondestructive evaluation, Mechanical design and manufacturing

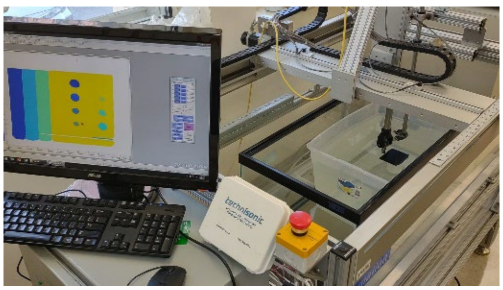
RESEARCH, DESIGN, & TECHNICAL ISSUES

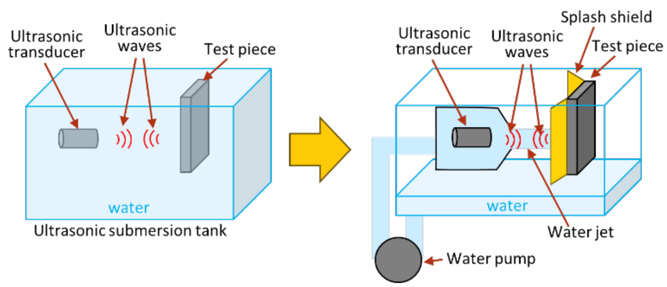
1) Computer-aided design (CAD) and manufacturing of the injection nuzzle.
2) Mechatronic implementation and integration with the robotic arm.
3) Sample generation with variable concrete mix, bubble sizes, spacing, injection depths, and temperatures.
4) Nondestructive evaluation (NDE) and time-dependent assessment of the prints. A laser surface profiler will be used to scan the geometry and map its defects, such as cracks.

PROJECT 2: DESIGN AND MANUFACTURING OF AN ULTRASONIC JET SYSTEM FOR BATTERY INSPECTION

Batteries are becoming increasingly prevalent due to the rise of electric vehicles, the growing need for renewable energy storage, and advancements in battery technology that have lowered costs and improved performance. Inspecting damaged batteries is vital for understanding their failure modes—including internal defects and material degradation—which is crucial information for designing safer, more reliable products and refining manufacturing processes. Ultrasonic inspection stands out as a fast and reliable non-destructive evaluation (NDE) method for assessing the internal structures of batteries. This technique offers key advantages over alternative approaches, such as X-ray imaging and destructive techniques like the microscopic analysis of sectioned battery components.

This project aims to enhance Drexel University's current ultrasonic inspection capabilities by modifying an existing ultrasonic tank to incorporate a squirting (water jet) ultrasonic system. The primary goal is to enable the NDE of internal battery structures to identify defects and damage effectively. While traditional ultrasonic submersion tanks can provide high-resolution three-dimensional scans of various materials' internal structures, submerging batteries for inspection is often prohibitive due to safety concerns. Therefore, this project seeks to eliminate the need for direct submersion, ensuring the batteries are protected throughout the inspection process.





METHODS & TECHNOLOGIES

Nondestructive Evaluation (NDE) - Squirting Ultrasonic Testing, Mechanical Design and Modification, 3D Printing, Machining, Sensing and Data Acquisition, Robotics

RESEARCH, DESIGN, & TECHNICAL ISSUES

1) Literature Review: Performing a literature review and comparing different NDE methods for inspection of batteries.
2) Design and Integration of Squirting Jet System: Developing and integrating a squirting ultrasonic water jet system into the existing tank system. This includes nozzle design, water flow control, and transducer placement.
3) Battery Protection: Designing and implementing effective measures to protect batteries from water ingress during the inspection process.
4) Ultrasonic Calibration: Selecting appropriate probes (frequency, aperture, focal distance), choosing the inspection mode (pulse-echo or through-transmission mode), setting ultrasonic gates, calibrating ultrasonic parameters (probe delay and wave velocity), and choosing scanning parameter (steps and speed) for effective penetration and reflection from internal battery structures.
5) Data Acquisition: Acquiring data from battery samples provided by Ohio University and characterizing internal defects.
6) Report Writing: Documenting the design and findings.

MAJORS & AREAS OF INTEREST

This VIP is interested in recruiting both undergraduate and graduate students from the following majors and areas of interest:

- Civil, Architectural, and Environmental Engineering: Concrete 3D Printing, Nondestructive evaluation, Robotics, Sustainability
- Mechanical Engineering and Mechanics: Mechanical design and manufacturing, Nondestructive evaluation, Robotics, Control, Mechatronics
- Electrical and Computer Engineering: Nondestructive evaluation, Robotics, Control, Mechatronics
- Computer Science: Artificial Intelligence, Computer Vision, Robotics, Automation
- Material Engineering: Nondestructive evaluation

MENTOR CONTACT INFORMATION

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Civil, Architectural, and Environmental Engineering

PARTNERS & SPONSORS

Potential for funding from Manufacturing PA Initiative

Astroparticle Physics in Extreme Locations

Dr. Christina Love (Physics) – Faculty Mentor

GOALS

Particles like cosmic rays and astrophysical neutrinos are produced throughout our Universe. This Astroparticle VIP team explores two main ways of detecting these particles: the IceCube Neutrino Observatory at the South Pole and the HERA collaboration using High Altitude Balloons (HAB). IceCube detects neutrinos using a massive array of detectors embedded in the Antarctic ice. Team members working on IceCube will specifically work with the citizen science project called Name that Neutrino. This project allows volunteers (members of the general public) to aid in data classification of events for IceCube. The HERA collaboration studies particles produced by cosmic ray air showers by using HAB to carry scientific instruments into the stratosphere.

Team members participating in Name that Neutrino will work on analyzing data, visualizing data for the next iteration, exploring ways to reach more volunteers, and actively participating in the forum talk pages to help volunteers.

Team members participating in the HERA HAB experiment will engage in all the stages of real-life research projects: literature searches, theory calculations and predictions, equipment design, prototype testing and development, logistics and deployment, data analysis, and project reporting. There should be a few opportunities to participate in the field deployment of devices on balloons.

The entire Astroparticle VIP team will focus on improving the experimental design for these two distinct detection methods to better understand the origins and properties of these elusive and astronomical particles.

METHODS & TECHNOLOGIES

Computer programming, citizen science, web development, hardware with particle detectors, literature searches, communication, surveys, social media

MAJORS & AREAS OF INTEREST

The Astroparticle VIP team needs a variety of skills:

- Physics and Math – astronomy, particle physics, data analysis, data visualization
- Computer Science – microprocessors for data collection for HAB, data analysis, data visualization
- Engineering – engineering payload design for HAB, data analysis, data visualization
- Education, Communication, and Sociology – design, assess, or deliver high school lessons
- Design Majors and English – explore ways to recruit volunteers through graphic design, animation, blog posts, etc
- Other students with a variety of interests are welcome to apply – this is a multidisciplinary project.

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

Collaborators: Richard Cairncross (Chemical and Biological Engineering); Alissa Sperling (Springside Chestnut Hill Academy); Naoko Kurahashi Neilson (Physics)

Funding received from:

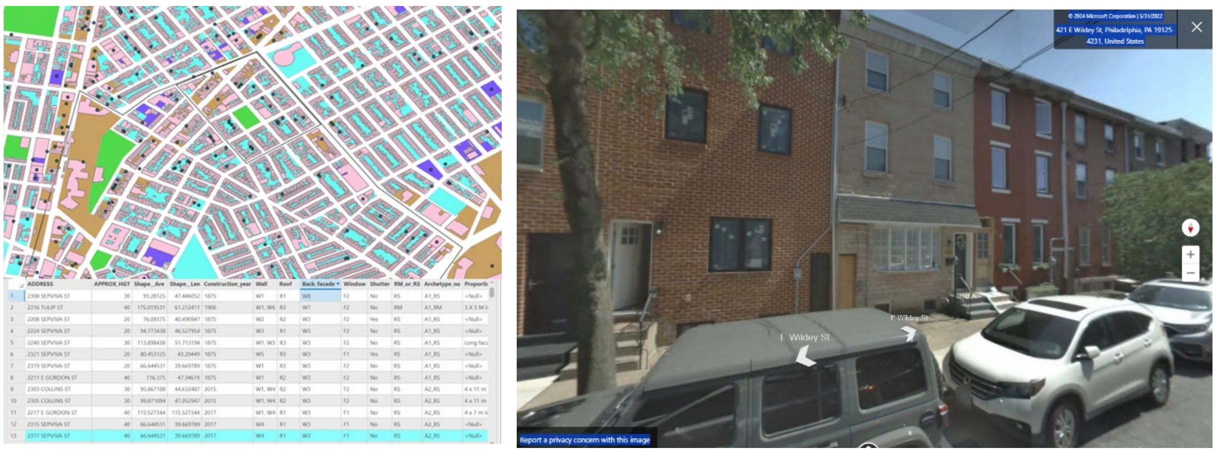
- NSF IceCube: https://www.nsf.gov/awardsearch/showAward?AWD_ID=2209445&HistoricalAwards=false
- Nationwide Eclipse Ballooning Project (NEPB): https://eclipse.montana.edu/
- Pennsylvania Space Grant Consortium: https://sites.psu.edu/paspacegrant/support/statewide-support/competitive-mini-grant-program/
- Drexel: College of Arts and Sciences Undergraduate Research Support (ASURS) Fund

Circular Cities: Assessing, predicting, and tracking building material stocks and flows from urban areas

Dr. Fernanda Cruz Rios (CAEE) – Faculty Mentor

GOALS

Cities are responsible for 75% of natural resource consumption and 70% of global greenhouse emissions. The circular economy has been increasingly discussed as a potential solution to climate change, resource scarcity, and pollution – problems that have been exacerbated by growing urbanization trends. In circular economy systems, products and services are traded in closed loops, and resources are recirculated into the Technosphere through sustainable strategies such as reuse, refurbishment, remanufacture, or recycling. “Circular cities” apply circular economy concepts in infrastructure, resources, goods, and services.



1 ArcGIS and Google Street View Fishtown, Philadelphia

This VIP team will focus on circular economy for city infrastructure; specifically, building envelope materials from buildings that have been demolished or will be demolished (or deconstructed) in the future. To reuse or recycle building materials, first we need to understand the quantity and types of materials that are and will be available in a city. Materials that are currently being used in a building are called “material stocks”, while materials that are arriving at the construction site or leaving the demolition site are called “material flows”. Assessing, predicting, and tracking building material stocks and flows is key to creating economic opportunities and public policy to incentivize the recirculation of building materials. **Team members will assist in the creation of an urban database for building material stocks and flows in Philadelphia, including quantity and type of materials and their respective environmental impacts for manufacturing and end-of-life treatment (e.g., reuse, recycling, incineration, disposal in landfills).** Throughout AY 24-25, teams will focus on residential buildings in the Fishtown neighborhood.

METHODS & TECHNOLOGIES

1. Spatial data collection (e.g., ArcGIS), photogrammetry (e.g., analysis and interpretation of photographic images from different sources)
2. Life cycle inventory data collection (collecting data on environmental impacts from different building materials)
3. Statistical data analysis
4. Machine learning algorithms (e.g., for predicting future material flows based on demolition trends)
5. Qualitative data collection and analysis (interviews and surveys with demolition and deconstruction contractors and experts)

RESEARCH, DESIGN, & TECHNICAL ISSUES

This VIP team will focus on collecting and preprocessing quantitative data from ArcGIS, City databases, building codes, life cycle inventory databases, and stakeholder surveys. Team members may also participate in collecting and analyzing qualitative data from stakeholder interviews. Undergraduate team members will work with graduate students and professors biweekly to work on developing the building material stocks database for Philadelphia and predicting current material flows in the City.

MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting undergraduate students from the following majors or areas of interest:

- Civil, Architectural, and Environmental Engineering – sustainable buildings and cities, circular economy, building envelope design, life cycle assessment, material flow analysis, urban metabolism, material reuse or recycling.
- Computer Engineering – big data, machine learning
- Architecture and urban studies – circular building design, circular cities
- Construction management – deconstruction and material reuse

Other students with a variety of interests are welcome to apply!

MENTOR CONTACT INFORMATION

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Civil, Architectural, and Environmental Engineering

PARTNERS & SPONSORS

None

Co-Design of Spiking BERT

Dr. Anup Das (ECE) – Faculty Mentor

GOALS

The convergence of transformer architectures like BERT with neuromorphic computing represents an opportunity for energy-efficient natural language processing. While traditional BERT implementations achieve remarkable performance in language understanding tasks, their computational intensity and memory requirements make them impractical for edge deployment and real-time applications. Spiking neural networks (SNNs) offer a promising alternative by mimicking brain-like processing patterns that naturally handle temporal information and enable ultra-low power consumption.

This VIP team will focus on co-designing spiking implementations of BERT architectures through hardware-software optimization. Our approach will integrate novel temporal attention mechanisms with event-driven processing, developing custom neuromorphic hardware accelerators alongside optimized software frameworks. The project advances beyond conventional approaches by creating end-to-end spiking transformer systems that maintain competitive accuracy while achieving orders-of-magnitude improvements in energy efficiency. Team members will develop an integrated neuromorphic language processing system including temporal attention mechanisms using spike-based computation, custom FPGA-based neuromorphic accelerators for transformer operations, software frameworks bridging conventional BERT models with spiking, and comprehensive evaluation for accuracy-efficiency trade-offs.

METHODS & TECHNOLOGIES

1. **Neuromorphic Computing**: Spiking neural network theory, temporal coding schemes, integrate-and-fire neuron models, and spike-timing-dependent plasticity (STDP).
2. **Transformer Architectures**: BERT model analysis, attention mechanism implementation, positional encoding, and pre-training strategies.
3. **Hardware-Software Co-Design**: SystemVerilog for neuromorphic accelerators, HLS (High-Level Synthesis), FPGA optimization, and custom instruction set architectures.
4. **Deep Learning Frameworks**: PyTorch, SpikingJelly, PYNN, custom CUDA kernels, and neuromorphic simulation environments.
5. **FPGA Development**: Xilinx Vivado/Vitis, timing optimization, resource utilization analysis, and hardware-software interface design.
6. **Natural Language Processing**: Tokenization, embedding techniques, fine-tuning strategies, and benchmark evaluation (GLUE, SuperGLUE).
7. **Performance Analysis**: Energy profiling, latency measurement, accuracy assessment, and hardware resource optimization.

MAJORS & AREAS OF INTEREST

This VIP team is interested in undergraduate students from the following majors or areas of interest:

- Computer Engineering – hardware-software co-design, FPGA development, computer architecture, embedded systems, parallel processing
- Electrical & Computer Engineering – digital design, neuromorphic engineering, signal processing, VLSI design, system-on-chip development
- Computer Science – machine learning, natural language processing, deep learning, software engineering, algorithm optimization
- Data Science – statistical learning, neural networks, language modeling, experimental design, performance analysis
- Mathematics & Applied Mathematics – linear algebra, optimization theory, probability theory, numerical methods, computational mathematics
- Cognitive Science – computational neuroscience, brain-inspired computing, cognitive modeling, perception and attention

Preferred skills: Prior experience with PyTorch or TensorFlow, Verilog/SystemVerilog, FPGA development, natural language processing, transformer models, Python programming, or neuromorphic computing. Students with strong interdisciplinary interests and passion for cutting-edge AI hardware are strongly encouraged to apply!

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

None

Cognitive Neuroengineering for the Brain and Mind

Drs. John Medaglia (PSY) & Gary Friedman (ECE) – Faculty Mentors

GOALS

Just like any other part of the body, brains are unique to the individual and change over time. Anatomical MRIs (magnetic resonance imaging) show very clear differences in the shape and position of different landmarks, lobes, etc. in different peoples' brains. But there are also many differences that are not evident from visual inspection of anatomical images. Using fMRI (functional MRI), we are able to see which areas become more or less activated during a certain task. This allows us to make a functional connection between a behavior or performance and regions of the brain. For example, fMRI has allowed us to associate the frontal areas of the brain with executive control, which is the ability to choose between options and make plans. Like anatomy, the location of these functional areas varies across individuals. Even more, functional areas are part of greater networks throughout the brain. These networks connect and exchange information in order to execute tasks. For example, the "frontoparietal control network" (FPCN) is a network that links frontal and posterior areas of the brain and is especially important in helping us to switch between different tasks based on the context of our environment or rules. Networks vary across individuals in the same way that functional areas do.

As described above, there are individual differences at many levels within the brain. i.e. at the anatomical, functional, and network levels. Our lab uses a combination of MRI, functional MRI, diffusion MRI (which maps brain connectivity), EEG, graph theory, and network control theory to create individual-level functional maps of a person's brain. We pair these maps with TMS (transcranial magnetic stimulation) and tDCS (transcranial direct current stimulation) to stimulate the brain in order to learn about how functional networks connect and to develop and inform treatments for brain disorders. TMS and tCDS are non-invasive brain stimulation technologies, meaning that they can influence how neurons fire, harmlessly, from outside the body. TMS achieves this through the application of strong magnetic fields and tCDS achieves this through direct low-intensity electrical currents. A unique advantage of brain stimulation allows us to make causal connections between brain activation and behavioral outcomes, which was previously only possible using invasive techniques or by studying those with brain damage due to injury.

However, TMS and tCDS are often used in treatments without any information about underlying neural circuits and network organization, i.e. using anatomical landmarks. Our lab uses the fMRI methods described above to create detailed and personalized functional networks to guide stimulation to test whether we can induce improved behavioral responses. Another aspect of targeting neural stimulation is synchronizing it to the activity in the relevant networks. Our lab uses Electroencephalography (EEG) to measure what happens in subjects' brains while they complete tasks. We use extremely fast "closed-loop" systems to deliver neural stimulation that can enhance or suppress brainwaves in the targeted networks. Together, personalized targeting in space ("where" in the brain) and in time (synchronizing with ongoing brain waves from functional networks) can help us to identify optimal stimulation strategies that lead to better treatment plans and better patient outcomes.

METHODS & TECHNOLOGIES

Many different methods and technologies are used at each step of our research. Our typical process is to design appropriate MRI tasks and scan sequences; bring the subject into the scanner; process their imaging data and create personalized stimulation targets; create cognitive/behavioral tasks that test the function of interest; noninvasively stimulate the subject at their personalized target and analyze their results. Some steps are more design-focused with an emphasis on cognitive psychology, some are more technically focused such as creating tasks and setting up equipment, some are more subject-focused, i.e. running sessions, and some are more programming-focused, such as neuroimaging data processing and analysis. In general, most of our time is spent doing processing and analysis on computers, and the rest is spent in-person running sessions. Experience with and interest in any of the following will be relevant to our research.

- Computer-guided behavioral testing of humans
- EEG (electroencephalography)
- MRI (magnetic resonance imaging)
- Transcranial magnetic stimulation (TMS)
- Transcranial direct current stimulation (tDCS)
- Statistical data analysis (Matlab, Python, R, etc.)
- Neural network models
- Any EEG or MRI preprocessing suite (FreeSurfer, SPSS, FSL, fMRI prep, EEGLab, ERPLab, FieldTrip, etc.)
- Using the Command Line
- Signal Processing
- Cloud Computing, Supercluster computing, Supercomputer computing (Azur, AWS, Google Cloud, University Clusters, regional sites) and knowledge of computing resources for research beyond Drexel
- Windows, Mac, and Linux operating systems
- Computer Hardware/Design, including adding hard drives, expansion cards, memory, etc., upgrading internal components, RAID configuration, and technical specifications such as cable shielding, data transfer rates and certifications, Monitor metrics such as ppi, refresh rate, viewing angle, motion artifacts, etc.

RESEARCH, DESIGN, & TECHNICAL ISSUES

In general, VIP team members will be involved in both running in-person research sessions and in analysis, processing, and design. The lab will work closely with incoming VIP students to understand their interests and goals and align their time and efforts with appropriate projects. At any given time, the lab has multiple ongoing projects in various stages of development.

MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and/or with a background and interest in the areas listed below.

- Electrical Engineering - EEG and MRI signal detection and processing, modeling of field penetration into the brain, neural network models, statistical signal processing
- Computer Engineering - software for behavioral tests, implementation of testing protocols over internet, neural network modeling, statistical signal processing
- Psychology - development of behavioral tests, interpretation of EEG data, development of TMS and TDCS protocols, neural network modeling
- Biomedical Engineering - EEG and MRI signal detection and processing, modeling of field penetration into the brain, neural network models, statistical signal processing
- Computer Science - software for behavioral tests, implementation of testing protocols over internet, neural network modeling, statistical signal processing

MENTOR CONTACT INFORMATION

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Professional Profile

PARTNERS & SPONSORS

None

Consortium for Climate Risks in the Urban Northeast (CCRUN) Climate and Sustainability Research Team (CSRT)

Drs. Franco Montalto (CAEE) & Patrick Gurian (CAEE)– Faculty Mentors

GOALS

We invite students interested in Resource Stewardship and Sustainability, Climate Change, Climate Resilience, and related topics to join the VIP Climate and Sustainability Research Team (CSRT). As part of the Consortium for Climate Risks in the Urban Northeast (CCRUN), Drexel undertakes stakeholder-driven, applied research that helps our external partners cope with and plan for climate change. Working under the supervision of a research team directed by Dr. Franco Montalto and Dr. Patrick Gurian, CSRT students will be involved in all aspects of this work, including data collection, data analysis, planning studies, modeling and simulation efforts, literature reviews, interviews, surveys, and planning and organization of meetings and convenings.

Climate resilient development simultaneously addresses human well-being, sustainability, and climate action goals. Our team is developing planning, policy, and infrastructure strategies that align the various sustainability, adaptation, and emissions reduction goals of our stakeholders. This work requires that engineers work with natural, social, and applied scientists, and public health experts. The objective is to explore the various intersections between sustainability, mitigation, adaptation, and equity goals, addressing topics such as the: 1) Emissions implications of various adaptation projects (e.g., low carbon adaptation); 2) Ecological implications of adaptation strategies; 3) Social/cultural/regional implications of coastal retreat; 4) Relationship between nature-based solutions and green gentrification; and 5) Enhancement of urban land-based ecosystem services through decentralization.

METHODS & TECHNOLOGIES

Team members will have the opportunity to tackle real-world projects and create deliverables for these real-world projects, including communication & outreach plans; data tools, maps, information; decision support tools; publications (book, peer-reviewed publication, and/or technical report); presentations; white papers; academic theses/dissertations; and methodologies/approaches.

RESEARCH, DESIGN, & TECHNICAL ISSUES

Currently, the faculty mentors and research coordinator for this team are looking for team members interested in:

1. Building electrification. Heat pumps offer the prospect of sustainably heating and cooling buildings. Ongoing work has identified capital costs as a substantial barrier to their market competitiveness. This work seeks to identify a set of active and passive solar features which can reduce the required capital costs of heat pumps and make them market competitive. Researchers are working with SketchUp, OpenStudio, and EnergyPlus, a set of powerful tools to develop sustainable buildings. However, these programs have a notoriously difficult learning curve. In the process of training researchers on these tools, the project is working to codify and simply the training process. The outputs of the project are both the specific design options to maximize heat pump performance and a vetted training procedure allowing novices to master these software packages, thereby democratizing access to a powerful set of tools for sustainable design.

MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and/or with a background and interest in the following areas:

- Infrastructure and the built environment
- Nature-based strategies / green infrastructure
- Water, energy, waste
- Computer simulations
- Planning and urban design
- Other related topics

MENTOR CONTACT INFORMATION

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Dr. Patrick Gurian
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PARTNERS & SPONSORS

This work is sponsored by the Consortium for Climate Risks in the Urban Northeast (CCRUN) and the National Oceanic and Atmospheric Administration (NOAA) Climate Adaptation Partnerships (CAP) / Regional Integrated Sciences and Assessments (RISA) program

Coordination and Planning for Multi-Robot Systems

Dr. Lifeng Zhou (ECE) – Faculty Mentor

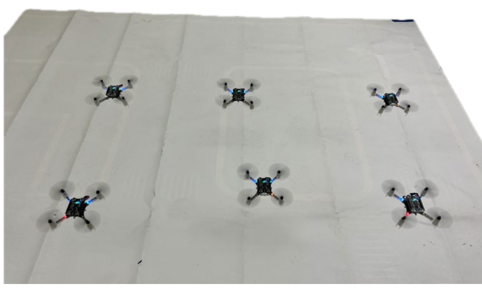
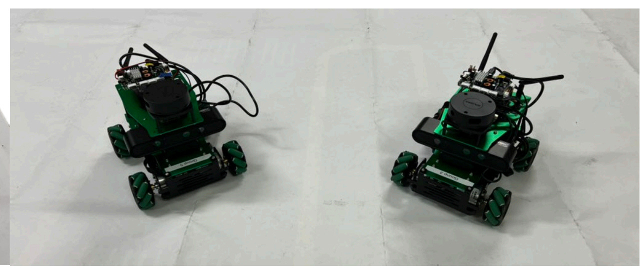
GOALS

Robots continue to get smaller, faster, and cheaper. Robots today are equipped with sophisticated computing, communication, and sensing resources. It is becoming increasingly essential to advance robotics systems and algorithms that make full use of the robots' capabilities. The goal of this VIP team is to develop novel robotics systems and advanced coordination and planning algorithms for the resilient and long-term operation of robots in tasks such as environmental monitoring, search and recuse, target tracking, surveillance, and reconnaissance. VIP team members will work with professors and Ph.D. students and have regular meetings to discuss progress. There will be opportunities for publications at top robotics venues.

CURRENT PROJECTS

PROJECT 1: HETEROGENEOUS MULTI-ROBOT TARGET TRACKING

This project focuses on developing a multi-robot target tracking system and designing coordination algorithms that enable drones to actively track dynamic ground robots. The project aims to enhance real-time tracking efficiency by optimizing drone collaboration, path planning, and target adaptation in dynamic environments

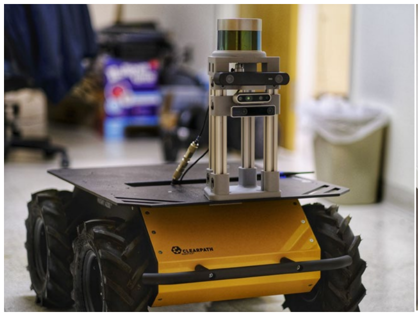



RESEARCH, DESIGN, & TECHNICAL ISSUES

1. Develop a Multi-Robot Target Tracking System – Create a system where multiple drones act as trackers and multiple ground robots serve as dynamic targets, enabling real-time monitoring and pursuit.
2. AI-Powered Target Detection – Equip each drone with an AI-driven camera to detect and track ground robots accurately in varying environments.
3. Advanced AI for Target Recognition – Implement AI techniques such as Vision-Language Models (VLMs), YOLO, or DETR to recognize, classify, and track targets efficiently.
4. Multi-Drone Coordination Algorithms – Design intelligent coordination algorithms that enable drones to share perception data, communicate in real-time, and dynamically assign tracking responsibilities for optimized performance.

PROJECT 2: COORDINATION OF HETEROGENEOUS ROBOTICS SYSTEMS

This project focuses on the coordination between a drone and a rover for outdoor information gathering. The perceptions of the drone and rover can complement each other for better data collection. In addition, when the battery of the drone is out of power, the rover should rendezvous with the drone to charge the drone.




RESEARCH, DESIGN, & TECHNICAL ISSUES

1. Developing a heterogeneous robotics system composed of a drone and a rover
2. Autonomous landing of the drone on the rover (the drone can be ferried by the rover)
3. Autonomous drone charging by the rover
4. Autonomous navigation of the rover using a Lidar, a camera, etc.
5. Area monitoring, coverage, exploration, target tracking of the drone using a downward facing camera
6. Real-time communication and information sharing between the drone and the rover
7. Joint perception of the drone and rover

METHODS & TECHNOLOGIES

Robotics system design, unmanned aerial and ground vehicles, multi-robot coordination and communication, planning and control, perception and deep learning, reinforcement learning, GNNs, LLMs, robotics algorithm design, sensing techniques (Lidar, camera, radar, etc.).

MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and/or with a background and interest in the areas listed below.

- Electrical & Computer Engineering - coordination and control, motion planning, perception (Lidar, camera, etc.), LLMs, VLMs, computer vision, deep learning, reinforcement learning, robot communication, system design
- Computer Science - LLMs, VLMs, perception, computer vision, deep learning, reinforcement learning, algorithm design and analysis
- Mechanical Engineering - computer aid design (CAD) software experience, sensor design, system design, structure design

APPLICATION PREREQUISITES

Prior to applying for a position on this team, prospective team members are asked to please install the Linux-Ubuntu & Robot Operating System (ROS) on their computer and go through the ROS tutorials (ROS1: http://wiki.ros.org/noetic or ROS2: https://docs.ros.org/en/humble/index.html). Prospective team members should prepare a video of the velocity control of a turtlebot in the ROS-Gazebo simulator and provide a link to this video when reaching out on ForagerOne to apply for the team.

If needed, a docker package with all the instructions for both ROS 1/2 which allows using Rviz, Gazebo, etc. is available at: https://github.com/Zhourobotics/ros2-docker-dev Alternatively, this software can also be utilized using a virtual machine to install Linux and ROS.

For Project 1: Try out mapping and wall-following of a Crazyflie drone in ROS-Gazebo simulator by following https://www.bitcraze.io/2024/09/crazyflies-adventures-with-ros-2-and-gazebo/ and record a video. Try out camera calibration: https://docs.opencv.org/4.x/dc/dbb/tutorial_py_calibration.html and document your findings. Please provide a link to this video when reaching out on ForagerOne to apply for the team.

For Project 2: Implement the autonomous navigation of a HUKSY robot in the ROS-Gazebo simulator (similar to this: https://www.youtube.com/watch?v=F5OiuIkqxcc) and record a video. Please provide a link to this video when reaching out on ForagerOne to apply for the team. Please also provide a demonstration of your skills in CAD design (Fusion 360 or SOLIDWORKS).

Please note that participation on this VIP team requires use of many robot hardware and software tools, which can take significant time to learn and build familiarity with; therefore, it is NOT recommended to apply for this team if one doesn't have enough time to commit to this effort (such as having a heavy courseload or participating in co-op in the same quarter). Prospective team members should indicate how much time they can commit to the team when reaching out on ForagerOne to apply for the team.

MENTOR CONTACT INFORMATION

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Drexel Zhou Robotics Lab

PARTNERS & SPONSORS

Distributed and Collaborative Intelligent Systems and Technology Collaborative Research Alliance (CRA)

Assure - THE FAA's Center of Excellence for UAS Research

Designing Smart and Healthy Transportation Systems

Drs. Zhiwei Chen (CAEE), Shannon Capps (CAEE), Gina Lovasi (Epidemiology and Biostatistics) – Faculty Mentors
Benjamin Gruswitz, Amy Verbofsky, Sean Greene – Industry Mentors

GOALS

The goals of this team are: (1) to develop a systematic health impact assessment model for transportation systems that can directly be used by our community partner, Delaware Valley Regional Planning Commission (DVRPC), in their regional planning activities and (2) to design and implement autonomous modular vehicles.


Autonomous modular vehicle technology enables vehicles to physically dock and undock to form train-like platoons while in motion. These platoons improve passenger travel experience and lower vehicle operational cost in transportation systems. The focus of this project is on designing and implementing such platoons using reduced-scaled autonomous racing vehicles called F1TENTH. Our goal is to design and optimize the docking process of multiple autonomous modular vehicles that aim to form a platoon by integrating real-time trajectory planning and control methods into F1tenth Robot. The resulting systems will be evaluated for their energy efficiency, stability, and scalability within a smart city environment.

Together, these activities will produce actionable information that communities can leverage to design smart and healthy transportation systems.

METHODS & TECHNOLOGIES

Team members interested in health impact modeling for transportation systems will utilize a number of methods and technologies, including literature research, expert interviews, data analytics, and computer programming (R, Python, or more complex atmospheric models) and will build domain knowledge in transportation engineering, atmospheric chemistry, and public health.

Team members interested in the autonomous modular vehicle project will utilize:

- **Dynamic Optimization**: Develop closed-form analytical solutions for optimal docking trajectory planning.
- **Docking Control Algorithms**: Implement and test real-time autonomous docking maneuvers in dynamic environments.
- **System Implementation**: Build two F1TENTH robots from scratch, equipped with 2D LiDAR and stereo vision.
- **Smart City Deployment**: Integrate the docking system into a scaled smart city environment for evaluation.

RESEARCH, DESIGN, & TECHNICAL ISSUES

For the team's health impact modeling goal, specific technical challenges include identifying transportation-related health impact metrics and health impact modeling frameworks (e.g., ITHIM); for each framework, specifying the modeling details, assumptions, advantages, disadvantages, implementation requirements (e.g., data, computation resources), and current usage in practice; presenting the results to DVRPC; developing a roadmap to a systematic health impact assessment framework for transportation systems based on DVRPC's inputs; and preparing a technical memorandum to implement the roadmap.

For the team's autonomous modular vehicle goal, specific technical challenges include:

- Deriving and validating analytical solutions for time-optimal docking under dynamic constraints.
- Ensuring robust perception for precise docking alignment using LiDAR and stereo vision sensors.
- Coordinating motion between multiple robots in real time with minimal communication delays.
- Integrating robots within a smart city testbed.

MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting undergraduate and graduate students from a variety of majors including but are not limited to:

- Civil Engineering – transportation systems, infrastructure, GIS
- Environmental Engineering, Environmental Science – air pollution, geospatial data analysis, perception and sensor fusion, embedded systems and real-time computing
- Electrical and Computer Engineering – hardware, control, wireless communication, optimization, multi-robot systems
- Mechanical Engineering – hardware, control, optimization, multi-robot systems
- Public Health – health impacts of transportation, health policy
- Public Policy – transportation and health policies, planning
- Computer Science – big data, machine learning, perception and sensor fusion, embedded systems and real-time computing
- Sociology – societal impacts of transportation systems
- Other students with a variety of interests are welcome to apply – this is a multidisciplinary project!

MENTOR CONTACT INFORMATION

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Connected and Automated Mobility Lab

Dr. Shannon Capps
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Atmospheric Modeling Group

Dr. Gina Lovasi
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Urban Health Collaborative

PARTNERS & SPONSORS

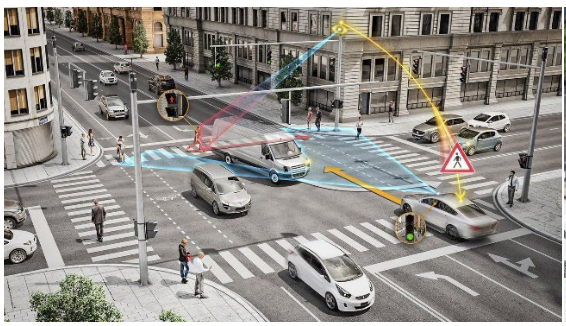
Delaware Valley Regional Planning Commission

Designing Sustainable Intelligent Transportation Systems

Dr. Liang Zhang (ELS) – Faculty Mentor

GOALS

An Intelligent Transportation System (ITS) is a system in which real-time data is gathered and used to inform automated decisions regarding the function of traffic-related infrastructure and hardware. Although traffic communications have traditionally been hardwired, cities are increasingly looking to wireless networks for such communications. Challenges, however, could arise when adapting these sectors to smart cities. For instance, the traffic signal system could enter a failsafe mode (a blinking red light) if the communication between sensors and traffic signals fails. Natural events or malicious human actions (e.g., extreme weather or cyber-attacks) could create unsafe driving conditions or system congestion, trapping people in an affected area. Consequently, stability and reliability should be addressed when developing such systems. In addition, the rising number of vehicles and congestion have highlighted environmental impacts. Sustainability, as a result, should also be considered.



Our team will focus on designing a self-organizing traffic signal control system to increase the stability and reliability of smart cities. This system operates as a self-organizing system which aims to automatically adapt and optimize signal control based on real-time traffic conditions despite system failure and human intervention. In addition, vehicle emissions due to vehicle delays during traffic operations will also be addressed. Team members will have the opportunity for publications at top systems engineering, engineering management and transportation engineering venues, such as INFORMS, ASEM, and TRB.

METHODS & TECHNOLOGIES

1. Basic traffic flow theory, traffic control methods, and vehicle emission measures.
2. Machine learning algorithms (deep learning, reinforcement learning, classification methods, etc.).
3. Resource allocation problems.
4. Fairness index and equity measures.
5. Traffic simulation software (SUMO and VISSIM), operations research software (Arena), programming language (Python and MATLAB).

RESEARCH, DESIGN, & TECHNICAL ISSUES

This VIP team will mainly focus on hands on experiments, field research at signalized intersections, and writing research papers. Undergraduate students will work with graduate students and professors biweekly to participate in the following activities: 1) literature review; 2) conduct field research at signalized intersections; 3) establish simulation environments using SUMO or VISSIM and Python; and 4) data analytics.

MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate students from the following majors and/or with a background and interest in the areas listed below.

- Civil, Architectural and Environmental Engineering – transportation systems, infrastructure, GIS, air pollution, data analysis.
- Systems Engineering – optimization, operations research, queue theory, game theory, graph theory.
- Computer Engineering – big data, machine learning.
- Sociology – societal impacts of smart cities.

Other students with a variety of interests are welcome to apply to this multidisciplinary project!

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

None

Development of biomaterial-based nanofiber yarns and textiles for health applications

Dr. Caroline Schauer (MSE), Dr. Christopher Rodell (BME), Genevieve Dion (Westphal) – Faculty Mentors

GOALS

Functional textiles are knitted materials with capabilities such as energy storage, biosensing, tissue engineering, implantable devices, or drug delivery. Traditional textiles have garnered interest for broader applications in recent years due to their hierarchical structure and flexibility. Nanofibers in textiles are enticing for functional textiles as the functionality and properties of the fibers can be controlled from the nanoscale to the macroscale level through the incorporation of active materials within the nanofibers. The Natural Materials and Polymer Processing lab led by Dr. Caroline Schauer has developed a nanoyarn machine that can produce continuous yarns from nanofibers from diverse materials. The nanofibers provide increased surface area that is advantageous to improve sensitivity for biosensing and increase the number of conductive pathways for energy storage applications. In addition to material properties and functionality, mechanical properties are important in transforming nanoyarns into 3D structures. The current goals of this VIP project are to standardize and qualify a modified ASTM method for traditional textiles, to apply this method to nanoyarns, and, lastly, to transform these nanoyarns into a 3D structure for biomedical applications.

METHODS & TECHNOLOGIES

This VIP team will be utilizing a uniaxial tensile tester to establish a modified ASTM standard for measuring the mechanical properties of commercial yarns and nanofiber yarns. Additionally, the team will utilize traditional textile manufacturing methods such as plying, twisting, weaving, and knitting to transform biomaterial-based nanoyarns into 3D structures for heart patch applications.

RESEARCH, DESIGN, & TECHNICAL ISSUES

This VIP will address the following challenges:

- Development of a standard procedure for mechanical testing of commercial yarns, which can be applied to any material type or fineness.
- Application of established standard procedure for mechanical testing on biobased nanoyarns.
- Investigation of transforming the nanoyarns into a 3D structure for biomedical heart patch applications.

MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting undergraduate students from the following majors and/or with a background and interest in the areas listed below:

- Material Science & Engineering- Electrospinning, polymer science, mechanical testing
- Textile Engineering/Manufacturing- commercial textile manufacturing methods, 3D printing
- Biomedical Engineering- tissue engineering scaffolds, cardiovascular patches

MENTOR CONTACT INFORMATION

Materials Science & Engineering
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Biomedical Engineering
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Center for Functional Fabrics
Prof. Genevieve Dion
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PARTNERS & SPONSORS

None

Neuroergonomics and Neuroengineering for Brain Health and Performance Research

Dr. Hasan Ayaz (BMES)– Faculty Mentor

GOALS

Our lab studies the human brain in real-world settings using wearable neurotechnologies and computational methods. We investigate brain function across the lifespan, from children to older adults, and across both healthy and clinical populations.

As part of this VIP team, members will contribute to projects that combine wearable neuroimaging, Brain-Computer Interfaces (BCIs), physiological monitoring, and eye tracking systems. These technologies are developed with the goal of improving human health, accessibility, and performance in everyday life.

- **Project Area #1**: Brain-Computer Interfaces (BCIs): Team members will help design mobile, non-invasive BCIs (using EEG and fNIRS) that allow people to control devices with their brain activity. Applications include accessibility for patients with conditions such as ALS, healthcare technologies, and human–machine teaming in real-world environments.

  BCIs translate neural activity into real-time control signals for computers, robots, and other external systems. Our work focuses on mobile, non-invasive BCIs (using EEG and fNIRS) that can be used outside the laboratory and with clinical populations such as ALS patients. We aim to design systems that adapt to users in real-world environments and support applications in accessibility, healthcare, and human–machine teaming.
- **Project Area #2**: AI-Enhanced Brain Signal Processing and Analysis: Team members will apply machine learning and deep learning methods to EEG, fNIRS, and eye-tracking data. Projects include developing real-time decoding models, creating algorithms for artifact removal and signal enhancement, and fusing multiple data sources to better understand human cognition and behavior.

  Advances in artificial intelligence are transforming how we process and interpret neural data. In this project area, we focus on developing and applying machine learning and deep learning methods to extract meaningful patterns from complex, noisy brain signals such as EEG and fNIRS. Team members will work on creating models for real-time signal decoding, cognitive state classification, and adaptive feedback to improve the performance of BCIs and neuroergonomic applications. Beyond classification, AI techniques will be used to enhance artifact removal, feature extraction, and multimodal data fusion (combining brain, eye tracking, and physiological signals). The overarching goal is to build robust and generalizable algorithms that can operate effectively in real-world environments, enabling neurotechnologies that are both accurate and accessible.
- **Project Area #3**: Scalable Physiological Monitoring / Eye Tracking: Team members will develop and test affordable, camera-based eye tracking and ultra-low-cost physiological systems that monitor large number of humans simultaneously and continuously during collaborative work. These systems provide new opportunities for research and clinical use for teamwork and cooperation, and can be integrated with BCIs for multi-modal human–technology interaction.

  Eye movements reveal attention, cognitive load, and decision-making. Traditional eye trackers are expensive and limited in accessibility. Our lab is utilizing camera-based eye tracking technologies that are affordable, scalable, and deployable on standard devices (e.g., webcams, tablets). These tools open up opportunities for broad research and clinical use, as well as integration with BCIs to create multi-modal human–technology interaction systems.

Together, these efforts aim to enhance human performance, health, and well-being, and to create neuroadaptive technologies that respond intelligently to the user’s brain and behavior in real-world settings.

METHODS & TECHNOLOGIES

The team's research integrates cognitive science, electrical engineering, computer engineering, biomedical engineering, and computer science. Members will gain exposure to:

- **Electroencephalography (EEG)** and **functional near-infrared spectroscopy (fNIRS)** for brain monitoring
- **Brain-Computer Interface design** for real-time neural decoding and adaptive feedback
- **Eye tracking methods** using both commercial and novel camera-based systems
- **Physiological sensing** approaches for cardiac activity (heart rate), skin response (electrodermal), etc.
- **Machine learning and AI methods** for neural and signal processing and behavioral data analysis
- **Signal processing pipelines** for EEG, fNIRS, physiological signals and eye-tracking data
- **Software development** for neurotechnology prototypes, user interfaces, and experimental paradigms
- **Human-subject experiments** in cognitive neuroscience and neuroergonomics

Depending on their skills and interests, team members may focus more on system design, programming, data analysis, or experimental research with human participants.

MAJORS & AREAS OF INTEREST

This VIP Team is seeking both undergraduate and graduate students with diverse skill sets and interests, including but not limited to:

- Electrical Engineering – signal acquisition, signal processing, hardware interfaces
- Computer Science / Computer Engineering – software architecture, machine learning, computer vision for eye tracking
- Psychology / Cognitive Science – experimental design, cognitive testing, human–technology interaction
- Data Science / Applied Mathematics – computational modeling, neural and behavioral data analysis
- Biomedical Engineering – neuroimaging, BCI, neurotechnology

MENTOR CONTACT INFORMATION

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Neuroergonomics and Neuroengineering Lab

PARTNERS & SPONSORS

None

Peace Engineering: Achieving the U.N Sustainable Development Goal #16

Drs. Joseph Hughes (CAEE/ELS), Mira Olson (CAEE/ELS), and James Tangorra (MEM/ELS) – Faculty Mentors

GOALS

The research theme of this VIP is focused on challenges presented by the *U.N. Sustainable Development Goal (SDG) # 16*:

Promote peaceful and inclusive societies for sustainable development,
provide access to justice for all, and
build effective, accountable, and inclusive institutions at all levels.

A number of significant underlying challenges present roadblocks to achieving SDG 16. War, direct violence, structural violence, and cultural violence all represent barriers to sustainability. They are destructive forces (180° opposite of efforts to be constructive and advance sustainability) and are recognizable to anyone. Peace, however, does not possess a shared understanding and creating peaceful societies becomes a complicated and elusive social aspiration. SDG #16 aims at challenges that are least the understood of all the SDGs and known to be fundamental to achieving sustainability.

The U.N, has identified a number of structural roadblocks to achieving SDG #16 including: Conflict and Insecurity, Weak Institutions and Governance, Inequality and Exclusion, and Access to Justice. Tackling these underlying issues is critical for creating the foundation for peace – locally, in conflict regions, and globally. The long-term focus of our research efforts is the development of decision support tools using emerging technologies (i.e., machine learning, AI, and Geo-AI, remote and/or autonomous systems, and visualization) to aid peace practitioners and community organizations in addressing these, and other, structural challenges more effectively.

METHODS & TECHNOLOGIES

As a topic to provide real world context in AY 24-25, we will leverage ongoing work led by Professor Hughes with A) the U.S.-Ukraine Foundation Task Force on Reimagining and Reconstruction of Ukraine and B) Jumpstarting Hope in Gaza with the Arava Institute. These challenges present a number of complex research questions all directed at a better future for recovery after unthinkable destruction and loss of life. The Fall Term of AY 24-25 will be the inaugural term for VIP Group. Early efforts will focus on developing research capacity, building technological skills, and establishing a Peace Engineering team culture that will be foundational for teams to build on for in future terms. hroughout AY 24-25, teams will follow developments in Ukraine/Gaza while building IT and systems modeling capability that provides for enhanced decision support towards both a durable and an enduring peace.

RESEARCH, DESIGN, & TECHNICAL ISSUES

Foundational computational tools that will be used in this VIP program will be Geospatial Information Systems (GIS) and Systems Modeling. Specifically, we will develop ArcGIS (a cloud-based mapping and analysis software used to map information in a geospatial layered data system that allows for analysis and collaboration) and Stella Online (a web-based modeling tool for dynamic modeling, policy analysis, and strategy development) as platforms to develop skills in AY 24-25.

Beginning on Day 1 of the Fall term, teams will engage in the development of Peace Data Ontology[1] (PDO). Of particular interest will be the ability to link information obtained in community-based research (e.g., interviews, surveys, etc.) with sensor-based (remote sensing, IoT, arial/satellite imagery, etc.) approaches. No accepted approaches currently exist to combine digital-derived data with survey-based information to create large scale "peace outcomes" data sets. Engaging in the development of PDO is highly interdisciplinary and presents a significant challenge including fields of peace and diplomacy, peace studies, peace engineering, peacebuilding, and in some cases spirituality. Adding complexity and nuance

[1] An ontology provides the map that links together data and meaning by defining what is meaningful.

to PDO is needed for both objective terms used in SDG #16 “peace” and “inclusivity” since both have local and/or cultural variation.

MAJORS & AREAS OF INTEREST

Peace, inclusivity, and sustainability can be advanced by all interested students. This VIP team will promote convergence across disciplines and welcomes students ranging from freshman to doctoral candidates, in any major, and with/without other learned skills (i.e., Coop, independent research, etc.). Examples of personal interest related to this effort include, but are not limited to:

- Sustainability
- Peace
- Justice
- Health
- Environment
- Computing
- Data Science
- Psychology, sociology, anthropology
- Economics and business
- Religion and/or Peace Studies

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

None

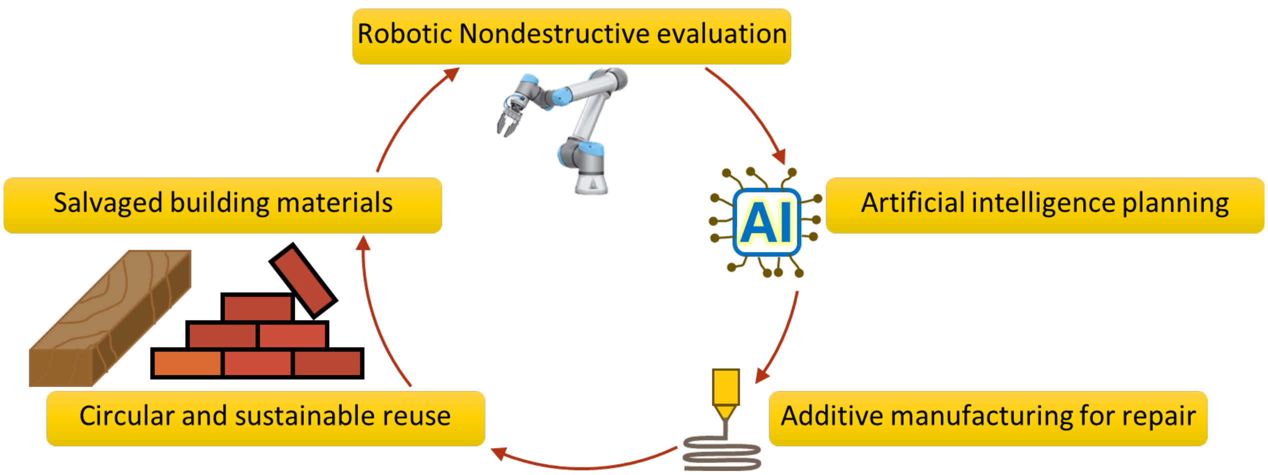
Robotic Evaluation for Circular Lifecycle Assessment of Infrastructure Materials (RECLAIM)

Drs. Arvin Ebrahimkhanlou (CAEE/MEM) & Fernanda Cruz Rios (CAEE) – Faculty Mentors

GOALS

In the U.S., construction and demolition waste is more than twice the volume of municipal solid waste, with approximately 90% originating from demolition activities. Every year, large volumes of potentially reusable materials from building demolitions are lost due to a lack of sorting, assessment, and reuse infrastructure. Recent research by Drexel's CIRCLE lab found that, in Philadelphia houses, the materials with the largest environmental benefits from reuse are also the materials that are more feasible to deconstruct and salvage from older buildings: brick and lumber.

This team aims to evaluate building materials recovered from old buildings without damaging them, using nondestructive evaluations. The goal is to find the best ways to repair and reuse these materials to reduce demolition waste, carbon emissions, and other environmental impacts at the end of a building's life. By applying circular economy principles – such as extending material lifespans, designing for reuse, and closing material loops – the project supports sustainability in the built environment. A key challenge is that sorting and testing old materials can be costly and labor-intensive. To address this, the project builds on the expertise of the ARVIN lab to use robotics, artificial intelligence (AI), and additive manufacturing (3D printing) to automate material assessment, repair, and reuse.



METHODS & TECHNOLOGIES

Nondestructive evaluation, Load testing, Environmental testing, Robotics, Artificial intelligence, Machine learning, Building information modeling, Life cycle assessment

RESEARCH, DESIGN, & TECHNICAL ISSUES

1) Nondestructive evaluation (NDE) as well as destructive load and environmental tests will be performed in the laboratory on building materials salvaged from old buildings in Philadelphia (e.g., bricks, wood beams, plaster panels, etc.).
2) Machine learning will be used to correlate the results of NDE and destructive tests and estimate the structural properties of the salvaged materials.
3) Environmental Life Cycle Assessment (LCA) will be used to quantify the environmental costs and benefits associated with recovering, testing, and reusing the materials.
4) A robotic arm will be programmed to automate the repetitive task of performing NDE on large quantities of building materials, and the process costs will be quantified.

5) Artificial intelligence (AI) and building information modeling (BIM) will be used to find the optimal and individualized reuse plan for each unit of recovered building materials.
6) Advanced manufacturing methods will be deployed to implement the repair plan and enhance the properties of each recovered unit for their future reuse.

MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and areas of interest:

- Civil, Architectural, and Environmental Engineering: Digital twins, Sustainability, Circular economy, Life cycle assessment, Material reuse or recycling, Nondestructive evaluation, Artificial intelligence, Robotics.
- Mechanical Engineering and Mechanics: Nondestructive evaluation, Robotics, Artificial intelligence
- Electrical and Computer Engineering: Nondestructive evaluation, Robotics, Artificial intelligence
- Computer Science: Robotics and Artificial Intelligence

MENTOR CONTACT INFORMATION

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Civil, Architectural, and Environmental Engineering

Dr. Fernanda Cruz Rios
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Civil, Architectural, and Environmental Engineering

PARTNERS & SPONSORS

Potential for funding from Manufacturing PA Initiative

Robotics, Automation, and AI for Smart Agriculture

Dr. Lifeng Zhou (ECE) – Faculty Mentor

GOALS

This VIP team explores the integration of robotics, automation, and AI in modern agriculture, focusing on two key applications:

1. AI-driven robotic arms for intelligent packaging and autonomous soil sampling systems: VIP team members will learn how AI enhances robotic manipulation for efficient sorting and packaging of agricultural products, optimizing speed and precision
2. The design and implementation of autonomous soil sampling systems: VIP team members will gain the knowledge to develop robotic solutions for precision agriculture.

Through hands-on projects and real-world case studies, team members will gain practical expertise in AI-driven automation for agricultural efficiency and sustainability.

CURRENT PROJECTS

PROJECT 1: AI-DRIVEN ROBOTIC ARM FOR INTELLIGENT PACKAGEING OF AGRICULTURAL PRODUCTS

As agriculture embraces automation, AI-powered robotic arms are revolutionizing the packaging process, improving efficiency, precision, and adaptability. This project explores the integration of robotic manipulation, computer vision, and AI-driven decision-making to automate the packaging of agricultural products such as fruits, vegetables, and grains.

VIP team members will explore how AI enhances robotic perception and control, enabling robotic arms to identify, sort, and package agricultural products while adapting to variations in size, shape, and texture. By programming and deploying AI-powered robotic solutions, team members will gain hands-on experience in developing smart, autonomous packaging systems for modern agricultural industries. Additionally, they will work with professors and Ph.D. students and have regular meetings to discuss progress. There will be opportunities for publications in top robotics and AI venues.

RESEARCH, DESIGN, & TECHNICAL ISSUES

1. Camera Integration for Object Detection – Mount a camera on the robotic arm to enable real-time product identification and classification for efficient packaging.
2. Custom CAD-Designed Gripper – Design a specialized gripper for secure and delicate handling of a specific agricultural product.
3. AI-Powered Packaging Control – Train an AI model to map camera observations to robotic actions, enabling adaptive and efficient packaging.

METHODS & TECHNOLOGIES

Vision-language-action (VLA) model, robot kinematics, motion planning, AI-based object detection, force control for delicate handling, and real-time optimization for packaging.

PROJECT 2: AUTONOMOUS SOIL-SAMPLING SYSTEM

This project aims to develop an autonomous robotic system for precise soil sampling from agricultural fields to enable accurate soil health monitoring. The robotic system will autonomously navigate fields and collect geo-referenced soil samples at predefined depths for further analysis. The autonomous robotic system should perform automatic, consistent, efficient, and precise soil sampling across large agricultural fields, which will lead to large-scale soil sampling and accurate soil health assessments. The VIP team members will work with professors and Ph.D. students and have regular meetings to discuss progress. There will be opportunities for publications in top robotics and AI venues.

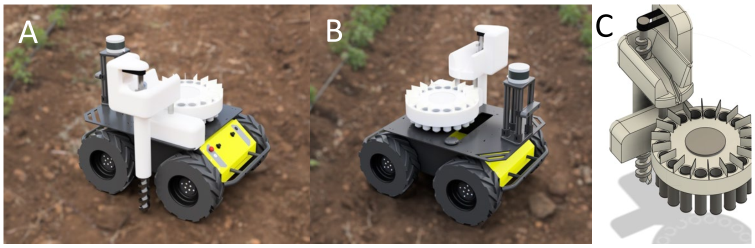

Fig 1: The ground robot and soil sampling system.

RESEARCH, DESIGN, & TECHNICAL ISSUES

1. Build an autonomous soling sampling system.
2. Equip the ground robot (HUSKY) with RTK-GPS for precise geo-localization.
3. Equip the system with a soil sampling drill, a slice coated with Teflon, a shaker motor, a motorized sampling wheel with absolute position encoders, etc.
4. Develop autonomous navigation algorithms via GPS or LiDAR/camera and precise sampling/planning/control algorithms

METHODS & TECHNOLOGIES

Robotics system design, path planning, motor control, sensing techniques (RTK-GPS, LiDAR, camera).

MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and/or with a background and interest in the areas listed below.

- Electrical & Computer Engineering – motion planning, robotic arm and gripper control, path planning, motor control, RTK-GPS, robot communication, system design, autonomous navigation, localization and mapping
- Computer Science - vision-language-action, perception, motion planning, autonomous navigation, reinforcement learning
- Mechanical Engineering – robot kinematics, sampling system design, structure design, computer aid design (CAD) software experience

APPLICATION PREREQUISITES

Prior to applying for a position on this team, prospective team members are asked to please install the Linux-Ubuntu & Robot Operating System (ROS) on their computer and go through the ROS tutorials (ROS1: http://wiki.ros.org/noetic or ROS2: https://docs.ros.org/en/humble/index.html). Prospective team members should prepare a video of the velocity control of a turtlebot in the ROS-Gazebo simulator and provide a link to this video when reaching out on ForagerOne to apply for the team.

If needed, a docker package with all the instructions for both ROS 1/2 which allows using Rviz, Gazebo, etc. is available at: https://github.com/Zhourobotics/ros2-docker-dev Alternatively, this software can also be utilized using a virtual machine to install Linux and ROS.

For Project 1

1. Follow the Open Platform tutorial for the FR5 robot arm at https://fair-documentation.readthedocs.io/en/latest/ROSGuide/index.html and create a ROS package for it. Document your findings and questions.
2. Try out LeRobot simulation: https://github.com/huggingface/lerobot and PI simulation: https://github.com/Physical-Intelligence/openpi. Document your findings and questions.
3. If you are not a fan of ROS programming, you must demonstrate strong skills in CAD design (Fusion 360 or SOLIDWORKS).

For Project 2

1. If you plan to work on autonomous navigation of the HUSKY robot, implement the autonomous navigation of a HUKSY robot in the ROS-Gazebo simulator (similar to this: https://www.youtube.com/watch?v=F5OiuIkqxcc) and record a video.
2. If you plan to work on the design and control of the soil sampling system, you must demonstrate strong skills in CAD design, embedded system programming, DSP, circuit design, etc.

Please provide links to the materials prepared from the above when reaching out on ForagerOne to apply for the team.

Please note that participation on this VIP team requires use of many robot hardware and software tools, which can take significant time to learn and build familiarity with; therefore, it is NOT recommended to apply for this team if one doesn't have enough time to commit to this effort (such as having a heavy courseload or participating in co-op in the same quarter). Prospective team members should indicate how much time they can commit to the team when reaching out on ForagerOne to apply for the team.

MENTOR CONTACT INFORMATION

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Drexel Zhou Robotics Lab

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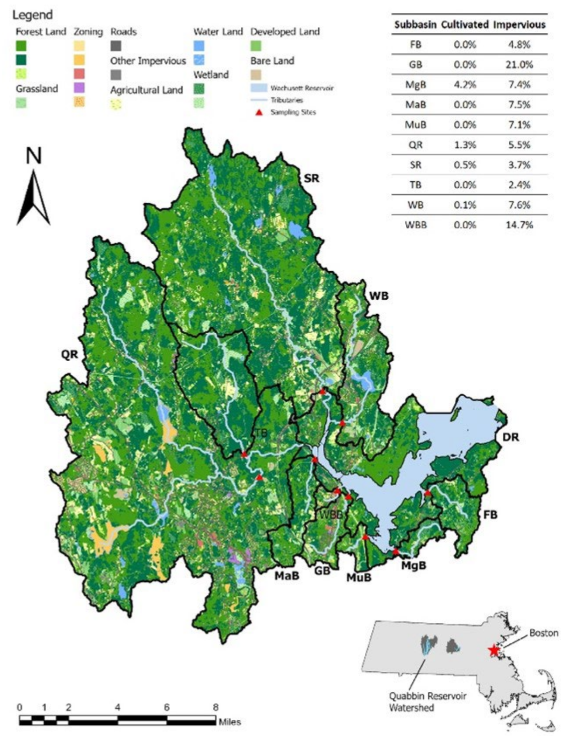
Drexel College of Engineering Longsview Faculty Award

Utilizing spatial data to support sustainable water management

Dr. Amanda Carneiro Marques (CAEE) – Faculty Mentor

GOALS

Protection of waterbodies used for drinking water supply systems includes the assessment of constituent delivery within sensitive timeframes and areas of water supply watersheds in face of changes caused by land use, human practices, and climate patterns. Often, the type of land use/land cover plays a significant role in determining nutrient and sediment loading patterns to water resources. Improvements in land use planning and protection programs aim to control nonpoint source contributions. Studies have demonstrated the impact of watershed protection components to understand how programs can be balanced, effective, and sustainable.



Land use/land cover map of a drinking water supply watershed with altered drainage landscaped percentages showed by subwatershed created using ArcGIS (Marques et al, 2024)

This VIP team will focus on using Geographic Information Systems and Machine Learning to elucidate how changes in land use/land cover affect water quality trends and climate change impacts in environmental systems. The team's first major project will aim at identifying, assessing, and predicting major drivers of water pollution. This project will involve learning ArcGIS Pro as a tool to process and analyze spatial data. Additionally, it will provide an understanding of GIS principles and practices and an overview of spatial data analyses and computer systems. This project is designed to encourage team members to think more broadly about the use of spatial technologies, practices, and models and how they influence communities and the environment. Team members will gain experience working with spatial data and using spatial analysis tools to answer research questions integrating water quality and quantity assessments. The team will also assess how changes in land use/land cover affect water quality trends, including identifying the main drivers of pollutants in freshwater. Furthermore, team members will support key aspects of this research by learning how to process environmental datasets and climate records, and preparing datasets for exploratory and predictive analysis. They will gain hands-on experience with Python for data processing, ArcGIS Pro for spatial mapping, and learn the basics of supervised machine learning (e.g., Random Forest, XGBoost) for environmental modeling.

METHODS & TECHNOLOGIES

1. Spatial data collection (e.g., ArcGIS)
2. Statistical data analysis (e.g., to assess water quality trends)
3. Machine learning algorithms (e.g., to identify major drivers of water pollution)

RESEARCH, DESIGN, & TECHNICAL ISSUES

This VIP team will focus on collecting and preprocessing data from ArcGIS. Team members will learn how to use tools in ArcGIS Pro for spatial data analysis; understand what types of spatial data are available and how to access/download data from publicly available sources; investigate the impacts of changes in land use/land cover for water quality patterns; and assess the impacts of those changes for water management by using these tools to support the development of effective mitigation strategies.

Team members will also learn how to compile spatial and tabular data across multiple datasets (USGS, NOAA, EPA, state agencies). Tasks may include processing water quality datasets, land cover and climate data, conducting seasonal trend analysis, elucidating spatial patterns and building a water quality index, and assisting with training and evaluating machine learning models. This project will give team members exposure to real-world environmental data challenges, interdisciplinary research, and a better understanding of sustainable watershed planning.

MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting undergraduate students from the following majors or areas of interest:

- Civil, Architectural, and Environmental Engineering – water resources; water planning and management; water quality; stormwater management; urban flooding; environmental systems; watershed management; hydraulic modeling; sustainable systems
- Computer Engineering – big data, machine learning

Other students with a variety of interests are welcome to apply!

MENTOR CONTACT INFORMATION

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Water, Sustainability, and Climate Research Group

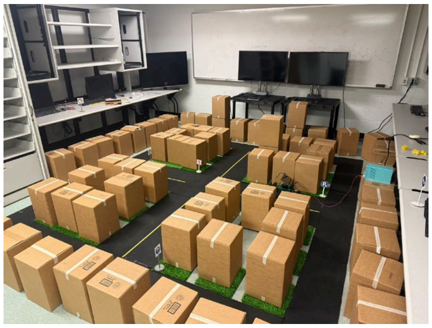
PARTNERS & SPONSORS

Massachusetts Department of Conservation and Recreation
Philadelphia Water Department
Pennsylvania Water Resources Research Center

Vision Language Models for Autonomous Driving

Dr. Lifeng Zhou (ECE) – Faculty Mentor

GOALS



As autonomous systems continue to evolve, the integration of vision-language models (VLMs) is revolutionizing how autonomous cars perceive, reason, and act in dynamic environments. This course explores the intersection of computer vision, natural language processing, and robotic control, focusing on how multi-modal AI models can enhance decision-making in autonomous robot cars.

VIP team members will gain hands-on experience with state-of-the-art vision-language models (e.g., GPT-4V, Flamingo, BLIP, LLaVA) and their applications in scene understanding, trajectory planning, and real-time control. Through simulations and real-world case studies, the team will examine how these models interpret visual inputs, follow natural language commands, and make autonomous decisions in complex scenarios. Undergraduate team members will work with professors and Ph.D. students and have regular meetings to discuss progress. There will be opportunities for publications in top robotics and AI venues.

METHODS & TECHNOLOGIES

Vision-language models (VLMs), motion planning and control for AVs, multi-modal perception (Lidar, camera, microphone, etc.).

RESEARCH, DESIGN, & TECHNICAL ISSUES

1. Implement and fine-tune small VLMs for real-time perception
2. Motion planning and control of AVs

MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and/or with a background and interest in the areas listed below.

- Electrical & Computer Engineering, Computer Science, and Mechanical Engineering – VLMs, motion planning and control, robot perception (Lidar, camera, microphone, etc.).

APPLICATION PREREQUISITES

Prior to applying for a position on this team, prospective team members are asked to please install the Linux-Ubuntu & Robot Operating System (ROS) on their computer and go through the ROS tutorials (ROS1: http://wiki.ros.org/noetic or ROS2: https://docs.ros.org/en/humble/index.html).

If needed, a docker package with all the instructions for both ROS 1/2 which allows using Rviz, Gazebo, etc. is available at: https://github.com/Zhourobotics/ros2-docker-dev Alternatively, this software can also be utilized using a virtual machine to install Linux and ROS.

Prospective team members should:

1. Implement the autonomous navigation of Turtlebot in the ROS-Gazebo simulator, similar to this: https://www.youtube.com/watch?v=lW-c88vxLRE and record a video.
2. Go through the tutorials (Chapters 8, 11, 12, 14, 15, 16) of ROSMASTER R2: http://www.yahboom.net/study/ROSMASTER-R2. This is the robot car the team will use in the lab. Document your findings and questions.
3. Try out some small VLMs: https://huggingface.co/blog/paligemma. Document your findings and questions.

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Drexel College of Engineering Carleone Faculty Award

Wireless Systems for the Internet of Things

Dr. Kapil Dandekar (ECE) – Faculty Mentor

GOALS

The future Internet of Things (IoT) will consist of a large number of wireless devices and sensors with profound implications for the economy and society. The Drexel Wireless Systems Lab (DWSL) is focused on developing new experimental wireless transceivers and sensors for future IoT networks. These systems require a wide variety of protocols (wireless local area networks, radio frequency identification, Zigbee, Low-power wide area networks, real-time localization systems, etc.) which can be implemented using flexible software defined radios (SDR) in DWSL. Target applications include: applications of radio frequency identification (RFID), wearable transceivers for biomedical sensing, smart grid and smart city infrastructure, effective omni-channel retailing, real-time localization, collaborative intelligent radio networks.

METHODS & TECHNOLOGIES

Software defined radio, wireless communications and networking, signal processing, machine learning, antenna and wireless transceiver design, augmented reality, cybersecurity, unmanned aerial vehicles

RESEARCH, DESIGN, & TECHNICAL ISSUES

Using RFID and sensors for biomedical sensing and real-time localization, wireless networks and sensors for smart infrastructure applications enabling a smart and connected omni-channel approach in retail environments, software defined radio for collaborative intelligent radio design, research and education with competition-based radio networks, cybersecurity for wireless networks, unmanned aerial vehicle communications and sensing

MAJORS & AREAS OF INTEREST

This VIP team is interested in recruiting both undergraduate and graduate students from the following majors and/or with a background and interest in the areas listed below.

- Electrical & Computer Engineering - wireless communications and networks, signal processing, machine learning
- Computer Science - software defined radio, machine learning, game design and visualization, cybersecurity
- Sociology - human factors and technology adoption
- Business - business analytics, marketing, decision sciences
- Economics - smart CRM; customer experience; and optimization of employee, inventory, and store layouts

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Currently in discussions with Comcast machineQ, Impinj, and Centrak