Vertically Integrated Projects (VIP) Program

Information Packet

Summer Quarter 2024-2025

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 Summer Quarter of the 2024-2025 academic year:

- Artificial Intelligence and Robotics for Nondestructive Evaluation
- Astroparticle Physics in Extreme Locations
- Cognitive Neuroengineering for the Brain and Mind
- Coordination and Planning for Multi-Robot Systems
- Development of biomaterial-based nanofiber yarns and textiles for health applications
- Robotic Evaluation for Circular Lifecycle Assessment of Infrastructure Materials (RECLAIM)
- Robotics, Automation, and AI for Smart Agriculture
- 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

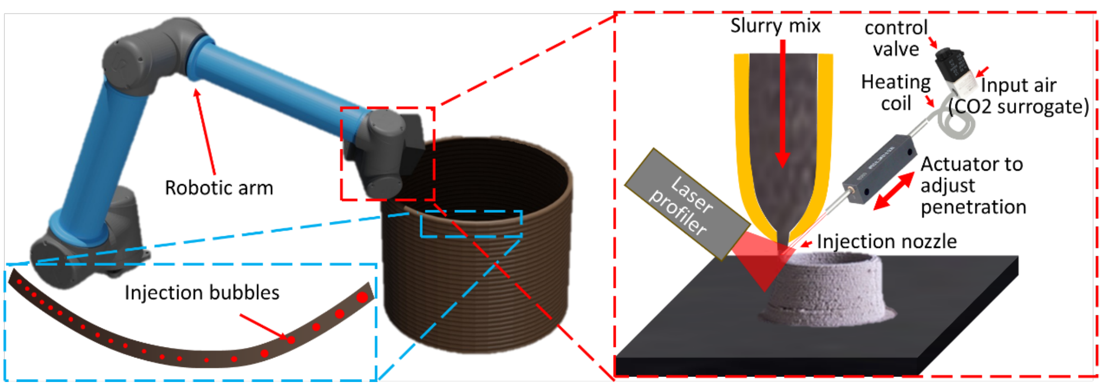
Recent advancements in artificial intelligence and robotics have created new opportunities for transforming how we evaluate and assess the condition of physical assets. Projects in this research theme leverage such opportunities to advance the field of nondestructive evaluation.

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

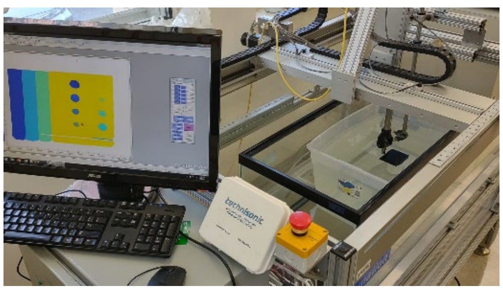
RESEARCH, DESIGN, & TECHNICAL ISSUES

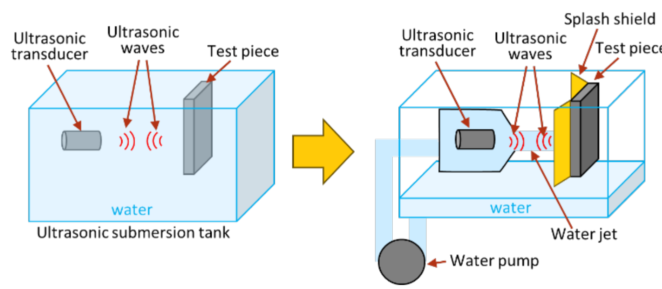
1) Computer-aided design (CAD) and manufacturing of the injection nuzzle.
2) Mechatronic implementation and integration with the robotic arm.
3) Sample generation with variable concrete mix, bubble sizes, spacing, injection depths, and temperatures.
4) Nondestructive evaluation (NDE) and time-dependent 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

Dr. Christina Love
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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

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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Cognitive Neuroengineering & Wellbeing Laboratory

Dr. Gary Friedman
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Professional Profile

PARTNERS & SPONSORS

None

Coordination and Planning for Multi-Robot Systems

Dr. Lifeng Zhou (ECE) – Faculty Mentor

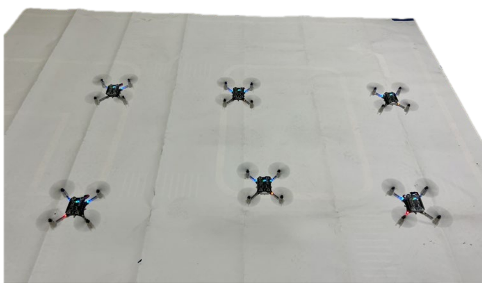
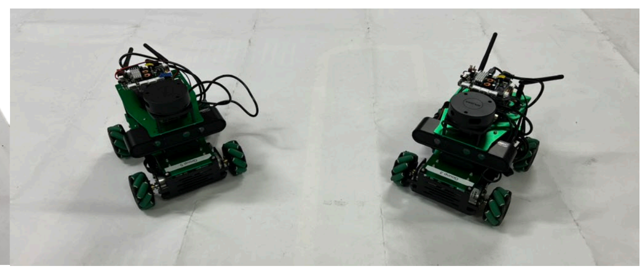
GOALS

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

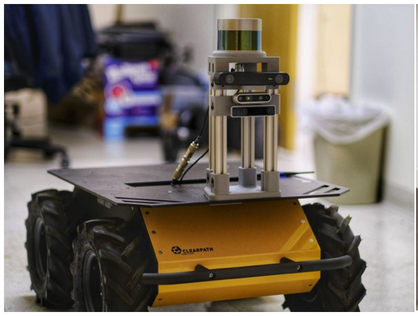



RESEARCH, DESIGN, & TECHNICAL ISSUES

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

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	Biomedical Engineering	Center for Functional Fabrics
Prof. Caroline Schauer	Prof. Christopher Rodell	Prof. Genevieve Dion
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PARTNERS & SPONSORS

None

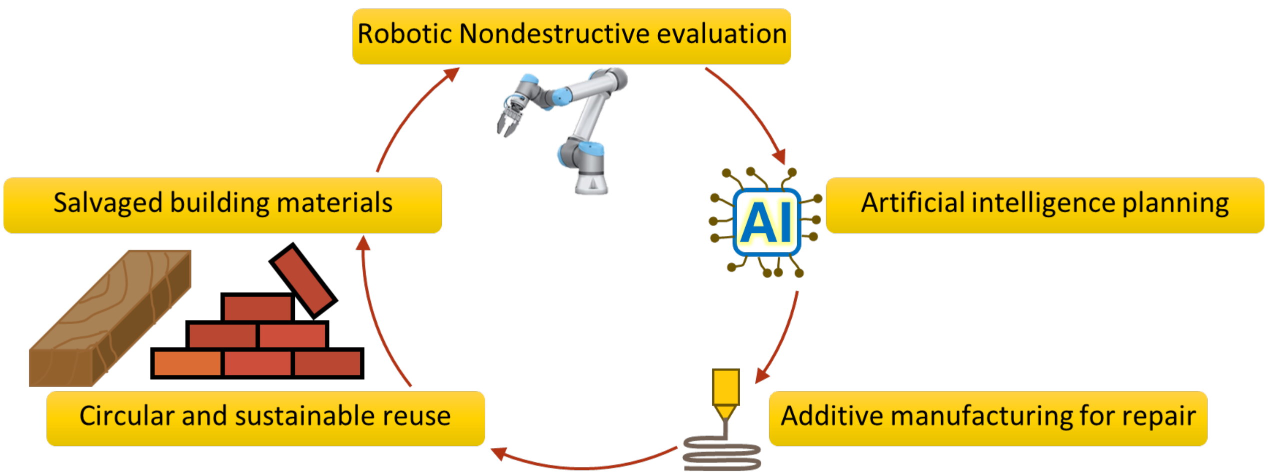
Robotic Evaluation for Circular Lifecycle Assessment of Infrastructure Materials (RECLAIM)

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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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.

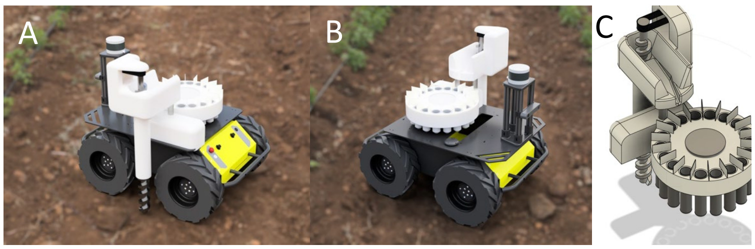

Fig 1: The ground robot and soil sampling system.

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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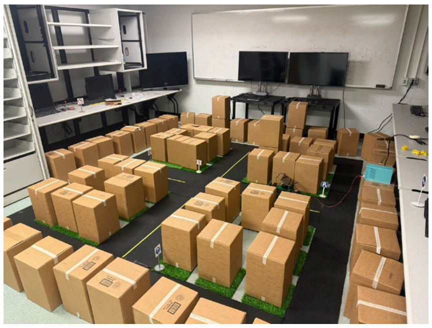
Drexel College of Engineering Longsview Faculty Award

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.

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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PARTNERS & SPONSORS

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

MENTOR CONTACT INFORMATION

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Drexel Wireless Systems Laboratory (DWSL)

PARTNERS & SPONSORS

Currently in discussions with Comcast machineQ, Impinj, and Centrak