Vertically Integrated Projects (VIP) Program

Information Packet

Winter Quarter 2023-2024

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 Winter Quarter of the 2023-2024 academic year:

- 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
- Design and Control of Robot Balloons
- Designing Smart and Healthy Transportation Systems
- Development of biomaterial-based nanofiber yarns and textiles for health applications
- High Altitude Balloon Measurements of Atmospheric Dynamics During Eclipse Events
- Measuring Air Quality with Kite-Based Sensors
- Robust and Risk-aware Planning for Autonomous Vehicles
- The Future of Power and Energy
- 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. 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!

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

The faculty mentors and research coordinator for this team are looking for team members interested in:

1. Public Engagement with Philadelphia's Adaptations to Climate Change. Drexel led a collaborative effort that developed a Climate Resilience Research Agenda for Philadelphia. There is a need for follow up efforts that engage community networks in Philadelphia and surrounding communities to understand information needs for climate change adaptation. This project will engage with community members' understanding of climate change through semi-structured interviews that identify a) current understanding, b) information sources, and c) opinion leaders. The project will pilot test different strategies for engaging with the participants, including understanding participants' sense of identity, information sources, and position in social networks, as well as their technical understanding of climate change. These efforts will be assessed through follow-up surveys and interviews with the participants.
2. Camden Floodnet sensor installation and analysis – Urban flooding is difficult to manage because of the difficulty in knowing precisely where, when, and how much flooding occurs. Team members will assist Drexel researchers collecting flood data in Camden, NJ using IoT sensors
3. Stafford, New Jersey flood mitigation project – Low-lying developments are exposed to increasing flood risk due to the convergence of accelerated sea level rise, and the increased frequency and intensity of extreme precipitation and runoff events. To address these concerns, local communities are turning increasingly to Nature based Solutions (NbS), with the goal of using the restoration of natural ecosystems to mitigate flood risk while providing other benefits in terms of biodiversity, carbon sequestration, and enjoyment of green spaces and natural areas. Team members will assist in collecting tidal data and writing up results of modeling of the effectiveness of different flood adaptation options in this NJ coastal community

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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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: COORDINATION & PLANNING FOR HETEROGENOUS MULTI-ROBOT 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

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

PROJECT 2: MULTI-ROBOT MULTI-TARGET TRACKING

This project aims to develop a multi-robot target tracking system and design coordination algorithms for the robots (drones) to actively track dynamic targets (ground robots).

RESEARCH, DESIGN, & TECHNICAL ISSUES

Developing a multi-robot target tracking system composed of multiple drones as trackers and multiple ground robots as targets; Equipping each drone with an AI camera to detect and track the target; Implementing neural networks to recognize and classify the targets; Designing coordination algorithms that enable drones to share perceptions and assign them to track targets.

METHODS & TECHNOLOGIES

Robotics system design, unmanned aerial and ground vehicles, multi-robot coordination and communication, planning and control, perception and deep learning, reinforcement learning, 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, radar, etc.), computer vision, deep learning, reinforcement learning, robot communication, system design
- Computer Science - motion planning, perception, computer vision, deep learning, reinforcement learning, algorithm design and analysis
- Mechanical Engineering - sensor design, system design, structure design, computer aid design (CAD) software experience
- Civil, Architectural & Environmental Engineering - environmental monitoring, data collection and analysis

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.

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.

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PARTNERS & SPONSORS

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

Design and Control of Robot Balloons

Drs. Lifeng Zhou and David Han (ECE) – Faculty Mentor

GOALS

This team focuses on the design and control of multiple robot balloons. These balloons can collaborate to perform a variety of tasks such as environmental monitoring, search and recuse, target tracking, surveillance, and communication. Specifically, a balloon can be equipped with cameras and other sensors to monitor large areas from above, making them useful for tasks such as wildlife observation, traffic monitoring, or surveillance in military operations. In addition, balloons can be used to gather data about the atmosphere, weather conditions, air quality, and other environmental factors. They can reach altitudes and areas that might be challenging or impossible for other types of equipment. Further, balloons can be used to carry communication equipment, providing temporary network coverage in remote areas or during emergency situations where infrastructure is damaged. 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 at top robotics and AI venues.

RESEARCH, DESIGN, & TECHNICAL ISSUES

(1), Build a team of robot balloons, each with a control board, motors, and propellers. (2), Equip each balloon with an AI camera to monitor environments and detect and track objects. (3), Equip each balloon with a trap to (collaboratively) catch the objects.

METHODS & TECHNOLOGIES

Robotics system design, unmanned aerial vehicles, planning and control, perception and deep learning, reinforcement learning, sensing techniques (camera, sonar, 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 – planning and control, perception (camera, sonar, etc.), computer vision, deep learning, reinforcement learning, robot communication, system design
- Computer Science - motion planning, perception, computer vision, deep learning, reinforcement learning
- Mechanical Engineering - system design, sensor design, structure design, computer aid design (CAD) software experience

APPLICATION PREREQUISITES

Prospective team members should have some background in use of Arduino, embedded programming, digital signal processing, and/or circuit design either through coursework or self-study.

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

None

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 build an eco-driving testbed using robot cars and eco-driving algorithms. 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 eco-driving will utilize a number of methods and technologies, including basic hardware skills (e.g., assembling sensors on a robot car), ROS programming, Autoware software platform, motion planning and control for autonomous vehicles, and computer programming (Python).

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 eco-driving testbed development goal, specific technical challenges include hardware development (assembling the robot cars, infrared distance sensor, Wi-Fi chips), wireless communication (data loss is a critical issue), software development (connecting the testbed to the Autoware framework), algorithm implementation (implementing simple vehicle trajectory controllers), and feasibility testing (testing the performance of the build testbed under various circumstances).

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
- Electrical and Computer Engineering – hardware, control, wireless communication, optimization
- Mechanical Engineering – hardware, control, optimization
- Public Health – health impacts of transportation, health policy
- Public Policy – transportation and health policies, planning
- Computer Science – big data, machine learning
- 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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Urban Health Collaborative

PARTNERS & SPONSORS

Delaware Valley Regional Planning Commission

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
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PARTNERS & SPONSORS

None

High Altitude Balloon Measurements of Atmospheric Dynamics During Eclipse Events

Drs. Richard Cairncross (CBE) & Ajmal Yousuff (MEM) – Faculty Mentors

GOALS

High Altitude Balloon (HAB) experiments provide vertical profiles of atmospheric data that is critical for weather prediction, pollution monitoring, and scientific understanding of atmospheric dynamics. This Vertically Integrated Project (VIP) focuses on designing, testing, and deploying for HAB experimental payloads during the next two domestic solar eclipses (October 14, 2023 and April 8, 2024: see https://eclipse.montana.edu/nepb-team-solicitation.html for more information). Students joining the VIP team are encouraged to participate in preparation for both eclipse launches and subsequent data analysis (that will continue through summer 2024). The VIP student team will design the HAB experimental payload to collect and continuously transmit data from the launch at ground level until the balloon bursts at 40,000-100,000 feet altitude and during the return back to the surface. Travel costs for participation in the eclipse launches and practice launches will be provided. Students participating in the HAB-VIP will engage in all the stages of real-life engineering projects and project management: equipment design, prototype testing and development, procurement, planning, logistics and deployment, field operations, data analysis, and project reporting.

PROJECTS

The VIP student team will meet weekly as a group to participate in a variety of activities supporting preparation for HAB launches:

- Literature review of prior experiments using high altitude balloons to conduct measurements of vertical profiles through the atmosphere
- Literature review of prior scientific experiments conducted during eclipses and the equipment used to make the measurements
- Training on HAB field operations, safety, data collection, and data analysis
- Brainstorming on what types of measurements can be deployed on experimental HAB payload and down-selection to a small number of specific experiments to be designed, constructed, and tested
- Design of the engineering HAB payload to conduct specific experiments during the eclipse launches. Testing of prototype payloads in the laboratory, outdoors at ground (or near ground) level, and deployed on practice balloon launches.
- Design of data collection, logging, and transmission electronics for recording results from the HAB experimental payload.
- Design and testing of a video streaming system for monitoring the experimental HAB payload during launches
- Processing data, video, photos, and other information collected from field tests, practice launches, and eclipse launches
- Modeling and predicting the path and altitude of HAB after launching
- Planning for field operations including procurement, logistics, safety and operations.
- Monitoring progress of the project and providing regular public updates through an on-line website, blog, or other appropriate mechanism

METHODS & TECHNOLOGIES

Data acquisition, wireless communication, Internet-of-Things connection protocols, GPS location tracking, mathematical modeling, systems statics and dynamics, computer programming (Arduino C++, Java, Python, MATLAB, Mathematica), web programming (Java, AWS, MQTT, Json), air quality sensors, power management, mechanical design, motor control, aerodynamics, software design, systems analysis.

MAJORS & AREAS OF INTEREST

This VIP team needs a variety of skills for successful development, planning, execution, operations, analysis, and reporting:

- Mechanical Engineering – engineering payload design
- Electrical & Computer Engineering and Computer Science – microprocessors for data collection and datalogging, wireless communication, data science, display of data
- Chemical Engineering, Environmental Engineering, Environmental Science – atmospheric chemistry and measurement of atmospheric constituents
- Video editing, photography, and public relations: eclipse events are a great opportunity for promoting STEM education and provide ample visual results for showcasing scientists and engineers in the field
- Other students with a variety of interests are welcome to apply – this is a multidisciplinary project!

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PARTNERS & SPONSORS

Collaborators: Geoff Bland (NASA/Goddard Space Flight Center); Alissa Sperling (Springside Chestnut Hill Academy); AEROKATS and ROVER Educational Network (AREN); Tethered Aerosystems Working Group (group of scientists and educators devoted to kites and balloons that meet quarterly)

Funding received from:

- Nationwide Eclipse Ballooning Project (NEPB): https://eclipse.montana.edu/
- NASA, AEROKATS, AREN projects (https://www.globe.gov/web/aren-project/overview/aerokats, http://www.iccarsproject.net/resources/remote-sensing-resources/nasa-aerokats, https://science.nasa.gov/science-activation-team/resa)
- Pennsylvania Space Grant Consortium: https://sites.psu.edu/paspacegrant/support/statewide-support/competitive-mini-grant-program/
- Drexel: Office of Undergraduate Research and College of Engineering

Measuring Air Quality with Kite-Based Sensors

Dr. Richard Cairncross (CBE) – Faculty Mentor

GOALS

Kites are a potentially lower-cost and more publicly acceptable alternative to drones for some applications of atmospheric and environmental monitoring. This project is part of a collaboration with NASA and other researchers to developed improved systems for profiling atmospheric conditions and wind within the Planetary Boundary Layer (PBL) and Surface Layer. This project is funded by NASA through the AREN project (AREN Project - AREN Project - GLOBE.gov).

NEW PROJECTS

The following is a list of projects that VIP students will be working on:

- Construction of model kites using 3D printing and other construction techniques for measurement of aerodynamic coefficients in a wind tunnel and comparison of the measured aerodynamic coefficients to published values, simulations, and models. Modification of the kite geometry to improve aerodynamic performance characteristics such as lift-to-drag ratio and stability
- Construction of dataloggers (based on Arduino or Raspberry-Pi) for recording forces and orientation of kites and atmospheric conditions (temperature, wind speed, etc.) during field testing. Analysis of field data collected simultaneously from multiple sensors to evaluate kite performance and quantify wind variations in the surface layer.
- Wireless communication between sensors in a network with upload of data to the cloud for visualization and archiving of data.
- Modeling forces and torques acting on kites and kite systems to predict performance and relate the performance to measured aerodynamic coefficients and field observations
- Developing educational modules to use kites as a vehicle for STEM education for middle school and high school students

CURRENT AND PAST PROJECTS

The following is a list of example projects that VIP students have worked on in this project. Some of these projects are ongoing:

1. Development of wireless sensor networks for field data collection using Arduino-based microprocessors and LoRa radio technology. Prior work on this project has implemented datalogging with a single Arduino and SD card; recently we have worked with Adafuit Feather units to communicate between a sensor node (mounted on a kite) and a base node (at ground level) to obtain real-time field data from the kite and datalogging relevant data for later analysis. The previous system is rudimentary and will be upgraded using the ArduinoJson library and more robust communication protocols and real-time data visualization.
2. Connection of wireless sensor network for data uploading to the cloud. We plan to use Wi-Fi hotspots or cellular data to connect to Amazon Web Services using IoT and MQTT protocols for archiving of field data and live-streaming data to web applications. Streaming data directly to the web also protects against loss of data due to failure of kite system components.
3. Construction of data analysis tools for parsing field data (from cloud or SD card or serial output) into relevant parameters and graphics. This can be done through importing data into Excel, MATLAB, or other data analysis tools. Data analysis will be used to evaluate kite aerodynamics and stability and to provide quantitative comparison of data collected between different locations and under different field conditions.
4. Raspberry-Pi-based video system with streaming directly to YouTube or another video service and subsequent (or real time) synchronization of video with a datastream. Kite Aerial Photography (KAP) is common for obtaining aerial images that are useful for evaluating environmental conditions. KAP can also be used for structure from motion analysis and monitoring of the kite system components.
5. Mathematical modeling of the physics of kite systems to enable evaluating alternative kite system designs and identify important parameters for field testing. We currently have an Excel-based model of 2D static kite pitch equilibrium (a model of forces and torques versus the angle of attack of the kite) which incorporates multiple lifting surfaces, variable center of gravity, variable bridle geometry, and variable tail geometry. This model can be expanded and used to analyze field data for more accurate estimates of the aerodynamic coefficients (lift, drag, center of pressure). We will also explore expansion of the model to improve systems

similar to those envisioned for long-term applications (with multiple kites, steerable kites, line climbing kites) and to evaluated kite system dynamics; these models could be implemented through Wolfram System Modeler, MATLAB Simscape Multibody, or customized systems models.

6. Evaluation of kite systems (either physical prototypes or mathematical models) including variable bridling systems (to control lift/drag forces and enable steerability or altitude control), line-climbing kites, ultra-light kites, Evan's loop lifting systems (where a pully is attached to the kite line enabling lifting the sensor platform after the main kite is flying at a stable altitude), measuring line tension, line inclination, and angle of attack of kites in the field.

METHODS & TECHNOLOGIES

Data acquisition, wireless communication, Internet-of-Things connection protocols, GPS location tracking, mathematical modeling, systems statics and dynamics, computer programming (Arduino C++, Java, Python, MATLAB, Mathematica), web programming (Java, AWS, MQTT, Json), air quality sensors, power management, mechanical design, motor control, tension measurement, flight dynamics, flight control, aerodynamics, software design, systems analysis.

RESEARCH, DESIGN, & TECHNICAL ISSUES

The proposed kite-based environmental monitoring and mapping system includes several sub-systems that all need to be designed to function for integration into the system. The lifting sub-system in the kite provides lift; the use of stunt kites also enables maneuvering within a three-dimensional wind window downwind of the anchor point. The flight control sub-system modifies tension on multiple lines and controls both the kite orientation and location. An "Evans Loop" ground tether involving two motors on the ground enables deploying a kite to achieve stable flight, and later lifting a sensor platform or air sampling system. The aerodynamically-stabilized sensor platform houses microprocessors to collect data from multiple lightweight sensors. The air sampling sub-system suspends an air sampling tube from the kite tether and then pumps air to equipment on the ground.

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.

- Mechanical Engineering – aerodynamics, systems analysis, motors, robotics, mathematical modeling
- Electrical & Computer Engineering and Computer Science - wireless communication, cloud computing, synchronization of data-logging with video and GPS measurements, display of data
- Other students with programming/IoT/web processing/microprocessor (Arduino Raspberry Pi)/GIS/mathematical modeling experience
- Other students with interests in applications of environmental engineering and science are welcome to apply

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PARTNERS & SPONSORS

Collaborators: Geoff Bland (NASA/Goddard Space Flight Center); Gabriel Ladd (consultant); Douglas Stout (Falcon Aero Designs); AEROKATS and ROVER Educational Network (AREN)
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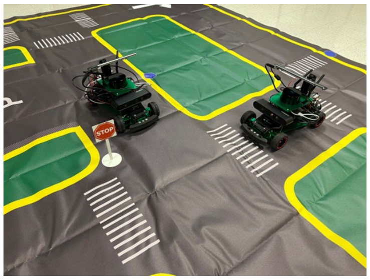
- Environmental Protection Agency, P3 (People Prosperity and the Planet) Award (https://www.epa.gov/P3)
- NASA, AEROKATS, AREN projects (https://www.globe.gov/web/aren-project/overview/aerokats, http://www.iccarsproject.net/resources/remote-sensing-resources/nasa-aerokats, https://science.nasa.gov/science-activation-team/resa)

Robust and Risk-aware Planning for Autonomous Vehicles

Dr. Lifeng Zhou (ECE) – Faculty Mentor

GOALS

Through major advances in technology, autonomous driving is already revolutionizing modern travel, navigation, and safety; however, there are major concerns with the robustness of perceptions and motion planning for autonomous vehicles. For instance, consider a motion planning scenario involving multiple



autonomous vehicles (AVs) at an intersection. The AVs use various sensors (Lidar, depth camera, sonar, etc.) along with a neural network to process sensor observations. In a normal situation, the AV is trained to perform core functionalities such as waiting at a red light and avoiding collisions with other vehicles at an intersection; however, the AV's neural networks could be easily misled by perturbations. These perturbations are primarily in two forms: natural/environmental (rain, snow, and fog) and adversarial (deceptive attackers). The perturbations can cause major issues in autonomous driving which adds uncertainty to their performance. This project is particularly relevant to "smart intersections" that are powered by AI to evaluate how pedestrians, bicyclists, and other vehicles interact and intelligently manage traffic. 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 and AI venues.

METHODS & TECHNOLOGIES

Robust deep learning, motion planning and control for AVs, perception with neural nets, sensing techniques (Lidar, camera, radar, etc.), sensor fusion, and vehicle-to-vehicle and vehicle-to-infrastructure communication.

RESEARCH, DESIGN, & TECHNICAL ISSUES

Evaluate how adversarial perturbations mislead/spoof the perceptions of AVs; Design robust neural networks to denoise observations and improve perceptions of AVs; Design risk-aware motion planning algorithms to handle uncertainties from perceptions; Address the issue of perturbations and uncertainties though vehicle-to-vehicle and vehicle-to-infrastructure communications.

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 and Mechanical Engineering – motion planning and control, robot perception (Lidar, camera, radar, etc.), deep learning, vehicle communication
- Computer Science - motion planning, computer vision, robust deep learning
- Civil, Architectural & Environmental Engineering – traffic monitoring and management, intelligent transportation

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.

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.

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PARTNERS & SPONSORS

None

The Future of Power and Energy

Dr. Fei Lu (ECE) – Faculty Mentor

GOALS

The goal of this team is to acquire the theoretical knowledge and hand-on skills in electrical power and energy needed to affect the future of the field. Undergraduate team members will be trained in both fundamental and advanced technologies in power electronics; moreover, together with the graduate team members, undergraduate team members will investigate cutting-edge research topics in electrical power and energy.

METHODS & TECHNOLOGIES

Power electronics circuit design, three-dimension electromagnetic fields simulation, finite element analysis (FEA), thermal design, intelligence design, connected and automated vehicles, electric vehicles, autonomous driving

RESEARCH, DESIGN, & TECHNICAL ISSUES

Modern power electronics system design aimed at addressing problems in the future power and energy need to be highly efficient, compact in size, low cost, reliable, and operate intelligently. To achieve these features, team research will chiefly move in two directions: 1) circuit hardware design, including the notable circuit topology of power conversion; and 2) system management design, including algorithms for controlling predesigned circuits.

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 - power electronics, power system, motor driving, circuit simulation, finite element analysis, electromagnetic field analysis, experimental experience
- Mechanical Engineering - electromechanical system design, thermal design, structure design, computer aid design (CAD) software experience
- Computer Science - software development, embedded system programming
- Materials Science & Engineering - magnetic material analysis, dielectric material analysis
- Chemical Engineering - electrochemical analysis, power battery design and analysis

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Professional Profile

PARTNERS & SPONSORS

None

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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PARTNERS & SPONSORS

Currently in discussions with Comcast machineQ, Impinj, and Centrak