Vertically Integrated Projects (VIP) Program

Information Packet

Summer 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 Summer Quarter of the 2023-2024 academic year:

- Atmospheric Remote Sensing with High Altitude Balloons and Kites
- Cognitive Neuroengineering for the Brain and Mind
- Coordination and Planning for Multi-Robot Systems
- Design and Control of Robot Balloons
- Designing Sustainable Intelligent Transportation Systems
- Development of biomaterial-based nanofiber yarns and textiles for health applications
- 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(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!

Atmospheric Remote Sensing with High Altitude Balloons and Kites

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

GOALS

Earth's atmosphere is continuously monitored by a vast array of satellites and ground-based sensors; however, weather dynamics and dispersion of pollutants depend strongly on local conditions and variable conditions in the Planetary Boundary Layer (PBL), which is not effectively monitored. The PBL extends from the surface to the tropopause at 20,000-60,000 ft. This VIP team uses High Altitude Balloons (HAB) and kites for remote sensing of a variety of atmospheric parameters within the surface boundary layer (Kites), within the PBL, and in near-space (balloons). Building robust remote sensing devices and platforms that are suitable for atmospheric sensing campaigns proceeds through a series of stages (Technology Readiness Levels, TRL) as the concepts are demonstrated first in the lab and then in successively more demanding field operations. Team members participating in the Atmospheric Remote Sensing VIP team (ARS-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.

Team members in the ARS-VIP will adopt responsibility for specific components of the remote sensing platforms and with the goal of increasing the TRL through design, testing, and development. Project components can be mechanical/structural, electrical, computational, or chemical – the ARS-VIP incorporates a variety of different fields of expertise to develop comprehensive sensing devices and deployment platforms. During each quarter, there will be a few opportunities to participate in field deployment of remote sensing devices on kites and balloons.

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, video streaming and editing, project communications.

MAJORS & AREAS OF INTEREST

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

- Mechanical Engineering –engineering payload design, aerodynamics
- 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
- Other students with a variety of interests are welcome to apply – this is a multidisciplinary project.

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

Collaborators: 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

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

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: DECENTRALIZED AND SCALABLE MULTI-ROBOT COORDINATION

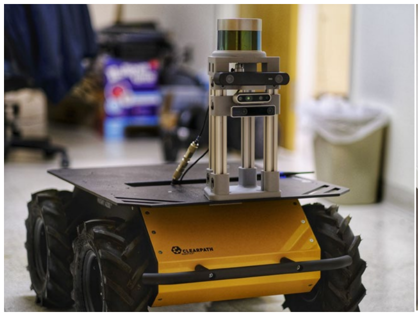
This project aims to apply graph neural networks (GNNs) and large language models (LLMs) for decentralized and scalable multi-robot coordination.

RESEARCH, DESIGN, & TECHNICAL ISSUES

1. Design GNN-based learning frameworks for decentralized multi-robot coordination
2. Apply or fine-tune LLMs for decentralized and scalable multi-robot coordination
3. Develop a high-fidelity simulator based on Unreal Engine for testing multi-robot coordination
4. Implement the algorithms into a team of drones

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.

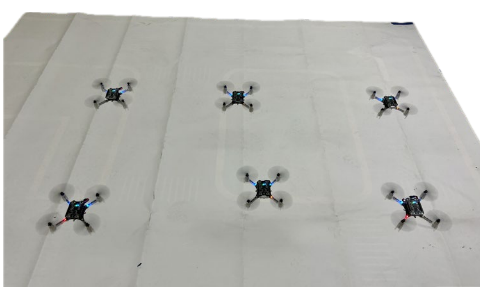
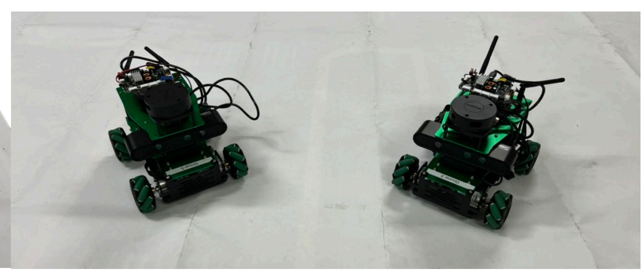



RESEARCH, DESIGN, & TECHNICAL ISSUES

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

PROJECT 3: 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

1. Develop a multi-robot target tracking system composed of multiple drones as trackers and multiple ground robots as targets
2. Equip each drone with an AI camera to detect and track the target
3. Implement neural networks to recognize and classify the targets
4. Design 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, 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, radar, etc.), computer vision, deep learning, reinforcement learning, robot communication, system design
- Computer Science - motion planning, perception, computer vision, deep learning, reinforcement learning, GNNs, LLMs, 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.

MENTOR CONTACT INFORMATION

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Drexel Zhou Robotics Lab

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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Intelligent Machine Perception and Learning Lab

PARTNERS & SPONSORS

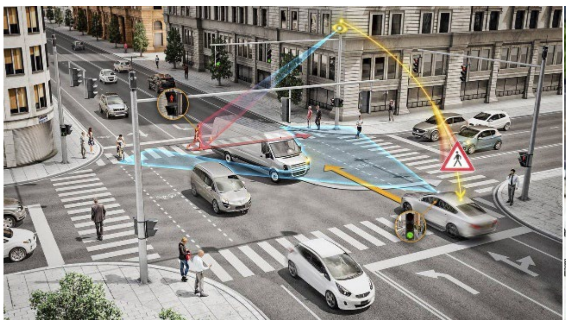
None

Designing Sustainable Intelligent Transportation Systems

Dr. Liang Zhang (ELS) – Faculty Mentor

GOALS

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



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

METHODS & TECHNOLOGIES

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

RESEARCH, DESIGN, & TECHNICAL ISSUES

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

MAJORS & AREAS OF INTEREST

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

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

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

MENTOR CONTACT INFORMATION

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PARTNERS & SPONSORS

None

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

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

GOALS

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

METHODS & TECHNOLOGIES

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

RESEARCH, DESIGN, & TECHNICAL ISSUES

This VIP will address the following challenges:

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

MAJORS & AREAS OF INTEREST

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

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

MENTOR CONTACT INFORMATION

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

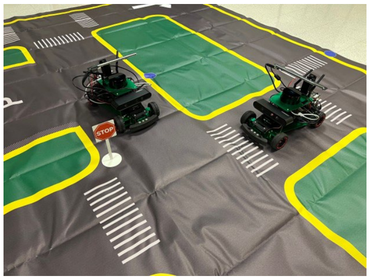
None

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

MENTOR CONTACT INFORMATION

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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

MENTOR CONTACT INFORMATION

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Drexel Wireless Systems Laboratory (DWSL)

PARTNERS & SPONSORS

Currently in discussions with Comcast machineQ, Impinj, and Centrak