Research Experience for Undergraduates in Computational Sensing and Medical Robotics

Presentations, August 6th, 2021

9:00 – 9:15

Deep Learning for Lung Ultrasound Imaging of COVID-19 Patients

Faculty Mentor: Dr. Muyinatu Bell / Photoacoustic & Ultrasonic Systems Engineering (PULSE) Lab
Dr. Lingyi Zhao (Postdoctoral Fellow)

Lung ultrasound (LUS) imaging has many potential applications, including identification of a COVID-19 infection. Deep Learning (DL) can be applied to LUS images, aiding physicians in the diagnostic process. Our research investigates multiple signal processing stages for DL application to identify B-line features in LUS images from COVID-19 patients.

Ben Frey *is a Schulze Innovation Scholar majoring in Physics, Computer Science, and Entrepreneurship at the University of St. Thomas in Saint Paul, MN.*

9:15 – 9:30

Optimization of a Photoacoustic Technique to Differentiate Methylene Blue from Hemoglobin

Faculty Mentor: Dr. Muyinatu Bell / PULSE Lab
PhD Student Mentor: Eduardo Gonzalez

Photoacoustic imaging has the potential to differentiate among surgical biomarkers, such as methylene blue (MB) and hemoglobin (Hb). A novel dual-wavelength method analyzes photoacoustic frequency spectra to make this differentiation. The goal of this project is to find the optimal parameters for this novel approach to MB and Hb differentiation.

Camryn Graham *is a rising junior Biomedical Engineering major at the University of Michigan. She is interested in biomedical imaging technologies and medical device development.*

9:30 – 9:45

Autonomous Quadcopter Flying and Swarming

Faculty Mentor: Dr. Enrique Mallada
PhD Student Mentor: Yue Shen

As technology has advanced, machine learning (ML) promises new methods for controlling robot systems. However, ML tools lack the necessary safety guarantees required. We aim to develop and test algorithms for autonomous quadcopter control with safety guarantees. We will be using a crazyflie nano quadcopter.

Ariadna Rivera *is currently a sophomore at the University of Arizona in Electrical and Computer Engineering. Her research interest is in robotics and programming.*

9:45 – 10:00

Force Sensing Surgical Drill

Faculty Mentor: Dr. Russell Taylor / Laboratory for Computational Sensing & Robotics
Additional Mentor: Anna Goodridge/research engineer

Surgeries of the skull base are extremely delicate and require a surgeon to stay within a critical range of forces. This project continues the development of a device that can precisely measure forces applied during surgery to improve patient outcomes.

Katie Sapozhnikov *is a rising sophomore at Massachusetts Institute of Technology studying mechanical engineering with computer science and is interested in the surgical robotics and medical devices areas.*

10:00 – 10:15

Evaluating SLANT Brain Segmentation using CALAMITI

Faculty Mentor: Dr. Jerry Prince / Image Analysis and Communications Lab
PhD Student Mentor: Lianrui Zuo

Image contrast of magnetic resonance (MR) imaging lacks standardization, which causes inconsistency in downstream processing. In this study, we evaluate the state-of-the-art whole brain segmentation algorithm, SLANT, by synthesizing multi-contrast T1-weighted images of the same anatomy using CALAMITI. We show that the SLANT performance varies with image contrast.

Savannah Hays *is a rising senior from West Virginia University studying biomedical engineering. Her research interests include magnetic resonance imaging, neuroimaging, and neurological diseases.*

10:15 – 10:30

Robustness of Deep Networks to Adversarial Attacks

Faculty Mentor: Dr. René Vidal / Vision, Dynamics, and Learning Lab
PhD Student Mentors: Kaleab Kinfu, Carolina Pacheco

Neural Networks have high classification and object detection performance with images and videos. However, the accuracy of most models drops with small adversarial perturbations in data, potentially leading to security risks in real world applications. This project aims to build defenses for robust deep neural networks.

Ammaar Firozi *is a rising sophomore at Saint Louis University studying computer science with an interest in computer vision.*

10:30 – 10:45: Break

10:45 – 11:00
Tumor Segmentation using a Structural MRI
Faculty Mentor: Dr. Archana Venkataraman / Neural Systems Analysis Laboratory
PhD Student Mentor: Naresh Nandakumar

There are more than 200,000 people diagnosed with a brain tumor in the United States each year. The goal of this project is to use machine learning and deep learning techniques on structural MRI data of brain tumor patients. In order to allow the surgeon a more accurate and safe pre-surgical planning.

Karina Soto Perez *is currently pursuing an Associates in Engineering at Howard Community College, with plans to transfer into a Biomedical Engineering Bachelor's program.*

11:00 – 11:15
Design of Multifunctional Legged Robot
Faculty Mentor: Dr. Chen Li / Terradynamics Lab
PhD Student Mentors: Ratan Othayoth, Yaqing Wang, Qihan Xuan

Previous research completed by the Terradynamics Lab has identified five different types of rugged terrain and different methods to overcome them. This project aims to combine the aforementioned individual navigation mechanisms into a singular multifunctional legged robot capable of navigating all five types of terrain.

Jonathan Mi *is a rising 3rd year electrical engineering student at the University of California, San Diego. He has a deep interest in robotics and plans to pursue a doctorate degree.*

11:15 – 11:30
Visualization of Telerobotic Satellite Servicing
Faculty Mentors: Dr. Peter Kazanzides & Dr. Louis Whitcomb / Laboratory for Computational Sensing & Robotics
PhD Student Mentor: Will Prior

Satellite repair is performed under conditions of high latency using a robotic arm. So, visualization is essential for ensuring that the operations are going to execute as expected. The project's goal is to create an augmented reality visualization using Microsoft's HoloLens to monitor the robot's interactions with a mock satellite.

Arko Chatterjee *is a rising 4th year mechanical engineering student at Ohio State University. He has a strong background in robotics and computer science.*

11:30 – 11:45

Can a fish learn to ride a bicycle?

Faculty Mentor: Dr. Noah Cowan / LIMBS Lab
PhD Student Mentor: Yu Yang

How does an electric fish's nervous system adapt to novel motor tasks? We designed a feedback system to destabilize a fish tracking a moving tube. Using control theory, we discovered that the fish adapted their controller to maintain system stability (like balancing a bicycle). When artificial feedback was removed, the fish rapidly reverted to pre-learning conditions.

Lauren Peterson *is a senior studying electrical engineering at the University of Washington. Her interests include control theory and biological systems.*

11:45 – 12:00

Robotic System for Mosquito Dissection

Faculty Mentor: Dr. Russel Taylor & Dr. Iulian Iordachita / CIIS Lab
Additional Mentor: Anna Goodridge/research scientist

Malaria kills nearly 3000 children every single day and infects hundreds of millions each year. This project focuses on various aspects of improving a robot that can automate the extraction of salivary glands from mosquitos. These salivary glands can then be used in the manufacturing of a novel malaria vaccine.

Josiah Lozano *is a rising Junior at the University of San Antonio Texas. His research interests involve the research and design of advanced prosthetic devices.*

12:00 – 12:15

Application of dual modality haptic feedback within surgical robotic

Faculty Mentor: Dr. Jeremy Brown / Haptics and Medical Robotics Laboratory

Current commercially available robotic minimally invasive surgery (RMIS) platforms do not provide haptic feedback to the surgeon. This limitation forces novice and expert surgeons alike to rely heavily on visual feedback, which can present significant challenges in both RMIS training and surgical practice. Previous research has demonstrated the potential utility of haptic feedback in RMIS training. We demonstrate the use of a wrist squeezing mechanism to provide surgeons with force haptic feedback. We previously designed a wrist squeezing mechanism using a servo motor and collected force data through a data acquisition device. We are now generating python scripts within a ROS framework to correlate forces applied by the surgeon to angle measurements to rotate the motor and squeeze the device around the wrist. Results are unknown. We hypothesize that novices receiving haptic feedback will reduce the forces they apply while increasing their task completion time, compared to a control group receiving no haptic feedback.

Zulekha Karachiwalla *is a rising senior studying computer engineering at University of Maryland Baltimore County. Her interests include developing brain computing interfaces for neurological disorders, and improving accessibility of medical devices/assistive technology in low resource communities.*

12:15 – 1:00: Break

1:00 – 1:15
Dynamics of Deep Learning Under Relativistic Gradient Descent
Faculty Mentor: Dr. René Vidal / Vision, Dynamics, and Learning Lab
PhD Student Mentor: Salma Tamoun

Relativistic Gradient Descent is an optimization algorithm that treats the learning process as a relativistic physical system by imposing a speed limit akin to that of light. The goal of this project is to form a theoretical understanding of RGD, focusing especially on overparameterized models such as deep neural networks.

James Campbell *is a rising junior studying physics with a concentration in artificial intelligence at Cornell University.*

1:15 – 1:30
Establishing FDR Control in Genetic Modeling
Faculty Mentors: Dr. Jeremias Sulam & Dr. Soledad Villar

A challenging task in cell identification through RNA sequencing is selecting a subset of the markers that will identify the type and state of the cell. This project seeks to apply data analysis and machine learning techniques to identify a proper subset of the RNA markers that will accurately predict the cell type and state using only the relevant markers.

Evan Dramko *is a rising junior at North Dakota State University in computer science and mathematics. His research interests are in artificial intelligence and data analysis, especially in regards to the biomedical sciences.*

1:30 – 1:45
Classroom Haptic Testbed
Faculty Mentor: Dr. Jeremy Brown / Haptics and Medical Robotics Laboratory
PhD Student Mentor: Mohit Singhala

There are many dynamics systems taught in university level classes which are very abstract in nature. While it is easy to visualise these systems on a graph, most students lack the understanding of what these systems feel like. The aim of the classroom haptic testbed is to use haptic feedback to demonstrate what dynamics systems, such as a mass spring damper system, feels like in an engaging and interactive way.

Chase Lahr *is a rising 3rd year at Johns Hopkins University studying mechanical engineering. Her research interests include using haptics to enhance classroom learning.*

1:45 – 2:00

Object Discrimination using vibrotactile feedback for upper limb prosthetic users

Faculty Mentor: Dr. Jermey Brown / Haptics and Medical Robotics Laboratory

There are thousands of people using upper limb prosthetics today. Current prosthetics help restore the mechanical function of the arm but have nothing to bring back sensation to that part of the body. We believe that vibrotactile feedback will help the prosthetic user regain the sense of touch. We will have our subjects wear a prosthesis with vibration motors and have the user discriminate between blocks based on the feedback from the vibration motors.

Anirejuoritse Egbe *is a rising senior at Johns Hopkins University majoring in electrical engineering. His research interests are neuroprosthetics and cognitive rehabilitation.*

Pre-Recorded 2:00 – 2:15:

Measuring Proprioceptive Impairment in Stroke Survivors

Faculty Mentor: Dr. Jeremy Brown / Haptics and Medical Robotics Laboratory

Every year, roughly 800,000 people suffer from stroke and about 50-65 percent of stroke survivors suffer from some form of proprioceptive impairment. Unfortunately, there are few clinical assessments of proprioceptive impairment available and the ones that do exist are often unreliable. The goal of this project is to develop a standardized system that can quantify different elements of proprioceptive impairment.

Harrison Menkes *is a rising 2nd year mechanical engineering student at the University of Michigan. His research interests include haptics and human-robot interaction.*

2:15 - 3:00

Deliberations/Break

3:00

Announcement of the Winners/Closing Remarks

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