2023 Summer Research Experiences for Undergraduates
Final Presentations

Thursday, August 3, 2023
9:00am - 12:30 pm

Agenda (times are estimated)

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Immediately to follow the voting for Outstanding Research and Outstanding Presentation will be open for each REU program. Please vote only once for each award.
REU Site: Marine Renewable Energy

This NSF REU was established to address three areas important to the responsible extraction of Marine Renewable Energy. These include (1) quantifying the availability and characteristics of marine renewable energy resources, (2) improving the design and operation of systems for extracting these renewable energy resources, and (3) assessing the environmental impacts associated with this energy extraction. This year, our undergraduate researchers conducted one project related to quantifying the availability and characteristics of marine renewable energy resources, five projects related to the design and operation of marine renewable energy extracting system, and two projects related to the environmental impacts of this energy extraction. These eight projects are summarized below.

**REU Scholar:** Grant Collins Himes  
**REU Scholar Home Institution:** Swarthmore College  
**REU Mentor:** Mingshun Jiang  
**Project:** Regional Oceanic Modeling of Ocean Current Energy Potential  

Ocean currents are a potential source of renewable energy, especially in locations like the Florida Straits, where the strong and consistent Gulf Stream contains vast quantities of energy. Therefore, this is a prime location for deployment of ocean current turbines (OCTs), a developing technology that can be used to harvest ocean current energy. For OCTs to be used most effectively, a strong understanding and accurate characterization of the target currents are needed. For example, ocean currents often produce powerful eddies, which are circular currents that can lead to changes in current velocity and direction, two critical factors for energy potential. For this project, a numerical model based on the highly advanced Regional Oceanic Modeling System (ROMS) is used to simulate ocean circulation including currents, tides, and mixing in the Florida Straits. The objectives are to understand and characterize ocean currents and estimate the current energy density in the Florida Straits, gaining knowledge which will be useful for assisting in selecting the best location for placement of OCTs.

Three numerical simulations were performed: the first did not include tidal forcing; the second did include tidal forcing; and the third was identical to the second but with increased background viscosity. As both tides and viscosity affect the model’s simulation of currents and eddies, this leads to changes in predicted energy density. Results from the different models were compared to each other as well as data from ADCP (Acoustic Doppler Current Profiler) buoys, focusing on the current speed and power density in the Florida Straits. Model power density overall is higher than derived from the in situ observations. Among the three versions, the second simulation most accurately predicted the energy at the mooring locations. In addition to revealing the usefulness of tidal forcing, this also suggests that lowering the viscosity could lead to an even more accurate power estimate. As ROMS continues to develop, it will remain extremely valuable to potential ocean current energy projects.

**REU Scholar:** Daniel David Aguilar  
**REU Scholar Home Institution:** San Diego State University  
**REU Mentor:** Yufei Tang  
**Project:** Data-Driven Control Co-Design of Ocean Current Turbine using Machine Learning  

Recent research progress has confirmed that using advanced control methods (such as, path control) can result in massive increases in energy capture for marine hydrokinetic energy systems, including ocean current turbines (OCTs) and wave energy converters; however, to realize maximum benefits, the controls, power-take-off system, and basic structure of the device must all be co-designed from early stages. This paper presents a data-driven OCT turbine control co-design framework, accounting for the plant geometry and spatial-temporal path planning to optimize the performance as measured by the average power/weight ratio.

The investigated framework evaluates the key design parameters, including the sizes of the generator, rotor, and variable buoyancy tank in the OCT system, and formulates these parameters’ effect on the OCT model and harnessed power through defining a power-to-weight ratio, subject to the design and operational
constraints. The problem is formulated as semi-supervised learning, where machine learning is used for computational advantage over traditional genetic algorithms (GA). Specifically, a decision tree is used in this study that allows the user to be able to input the geometry of the OCT and the algorithm will be able to generate the corresponding amount of power-to-weight ratio. This algorithm also allows inverse design of inputting the amount of power-to-weight ratio, which will then result in the optimal geometry and design rules that will produce that result. Compared with a GA-based design, results verify the efficacy of the proposed framework in co-designing an optimal OCT system to gain the maximum power-to-weight ratio.

**REU Scholar:** Sol E. Alverio Rivera  
**REU Scholar Home Institution:** Universidad Ana G. Mendez Gurabo Campus  
**REU Mentor:** Bill Baxley  
**Project:** Applied River Current Turbine Design  

The HBOI REU interns during 2020 through 2022 summers developed the design of a hydrokinetic turbine that would be placed in the rivers to supply power to homes near the area. Through their development of how to place the turbine in the rivers, they realized that it has a constant debris problem. As a consequence, if a typical turbine was placed in the river, the blades could break when impacted by debris, as the blades are rigidly fixed to their base. Therefore, a proposed solution to this problem is to develop a design where the blade can tilt or bend to minimize the impact of the debris, let it pass through, and then return to its initial position to continue generating power.

Proofs of concept were developed during the summer of 2023 for two designs using SOLIDWORKS that would perform the motion of bending and returning the blade to its original position during and after impact. The first design consists of a gripping system inside the blade and the second consists of a cam located inside a supporting base. In both mechanisms, they would allow the passage of a maximum amount of tensioning cable to release or hold the blade in place, depending on whether the force exerted on the blade is greater or less than the typical force of the water while generating power. They were scaled down and 3D printed to analyze their behavior and see if they satisfied the proposed solution.

For the purpose of understanding this project, MATLAB was used to visualize how the debris impact would vary with the angle of attack of the blade in generating position compared to a tilted blade during impact. As well as predicting the ideal blade behavior considering velocity, blade run profile, drag force, and angle of attack, the model was compared to actual data obtained during boat testing. Using a full-scale one-meter blade and load cell test apparatus, containing strain gauges and a GPS recorder for later analysis. This test apparatus was calibrated on land with suspended weights and then tested on the water on a small barge to obtain data on speed variations that would later be compared to each other. With this apparatus, it was possible to perform the tests and observe the different variations with the drag force and the angle of attack exerted on the blade determine the force needed to cause the blade to tilt or stay in its original, power generating position.

**REU Scholars:** Erick Rafael Colon  
**REU Scholar Home Institution:** Universidad Ana G. Mendez Gurabo Campus  
**REU Mentor:** Oscar Curet  
**Project:** Energy harvesting of an oscillation motion induces from drag forces  

There are many areas on the coast that are great resources for energy extraction in the US from Tidal flows. But for the traditional methods of large turbines there is not feasible for these areas. This limitation forces us to look upside the box, into a more abstract concept. Nature is one of the best in regard abstract concept; thus, we will be developing a bio-inspired energy harvesting system utilizing Mangroves trees as inspiration. When a flow of water passes true the mangroves, the tress starts to oscillate. Therefore, the device we are developing, its goal is to generate electric energy from the tidal flow that is passing perpendicular through our device. This device counts with a PVC pipe of 4” ID that is submerged in the water, electric motor acting as generator and coupling with a gear box 1:64 ratio. For this project we are going to induce the device to a different flow rate to determine the characteristics of the system and power output.
**REU Scholar:** Nicholas Timothy Mazurowski  
**REU Scholar Home Institution:** Ohio University  
**REU Mentor:** Jordon Beckler  
**Project:** Benthic Microbial Fuel Cells  

Nick Mazurowski worked with Dr. Jordon Beckler to create Sediment Microbial Fuel Cells (SMFCs) and explore their utility in generating energy while promoting environmental benefit. SMFCs are an emerging marine renewable energy option with a minimal environmental footprint. The primary motivation was to create a low-cost version of SMFCs, conducive to deployment at scale, that could promote sequestration of excess sediment nutrients (nitrogen and phosphorus) that contribute to harmful algal blooms (HABs).

SMFCs function by harnessing the redox reactions that occur between the microorganisms and the electrode in the sediment. Sediments are more chemically reductive when compared to the oxygenation overlying water due to the degradation of organic matter, allowing these redox reactions to take place. The SMFCs are an attractive option for directly powering remote sensors on the seafloor that would otherwise require an external power source. Through complex geochemical processes, the SMFCs were also expected to remove nutrients via mineral-surface interactions (for P) and redox transformations (for N), creating environmental co-benefits. Two separate fuel cell designs were constructed, each with their own properties with respect to power output, cost, and potential for wide scale deployment: a box-style fuel cell and “mud dart” version. The box fuel cell contained a graphite felt anode in the sediments and carbon fiber brush cathode in the overlying water column that could be inserted into sediments. The mud dart instead used two carbon fiber brushes as anode and cathode. By experimenting with different resistances between the anode and cathode over time and create polarization graphs, the optimal operational conditions of the SMFCs for generating power were determined. Effects on the sediment nutrient environment will be examined through subsequent analyses.

**REU Scholar:** Westin Cole Johnson  
**REU Scholar Home Institution:** Florida Atlantic University  
**REU Scholar:** Karl William Wolf  
**REU Scholar Home Institution:** Virginia Polytechnic Institute  
**REU Scholar:** Marcus Serrano  
**REU Scholar Home Institution:** Palomar College  
**REU Mentor:** James VanZwieten  
**Project:** Development and Testing of a Wave Energy Converter  

Ocean currents and waves are excellent sources of kinetic energy, which can be harvested using various mechanical systems. One such system, a Wave Energy Converter (WEC), harvests the ocean’s wave motion and turns it into usable power. This WEC design consists of a buoyant fin attached to a motor shaft, and when the fin’s oscillation turns the motor, AC power is generated. Three of these assemblies were constructed and placed concentrically about a buoyant central body. Atop the body is an electronics box containing our computer system and power circuitry. When fully assembled, the WEC floats and allows each fin to articulate independently across waves. This summer, we addressed several design concerns and have improved the WEC’s power generation, as well as its longevity in harsh conditions.

New couplers were machined to clamp the WEC motors to aluminum shafts that allowed for an increased fin width. The old couplers exhibited slippage, which we mitigated with the addition of a key and keyway system. On the WEC’s exterior, several 3d printed parts were redesigned and remanufactured with improved geometry and UV-resistant plastics. Additionally, several components were replaced with corrosion resistant alternatives.

The WEC’s computer system has been created, allowing for data recording and fault detection. The WEC can detect power generation, fin position and angular velocity, shaft strain, and motor torque. Additionally, the WEC has been outfitted with wireless capabilities allowing for computer control from a distance. It was intended to use WEC-Sim to run the numerical simulation of the device and compare it to the
results of in-water tests. However, issues arose in WEC-Sim involving model errors, and numerical simulation was placed on hold in favor of completion of the assembly and testing of the physical WEC.

**REU Scholar:** Javier Eduardo Cantu  
**REU Scholar Home Institution:** Centre College  
**REU Mentor:** Bing Ouyang  
**Project:** Development of a waterproof VTOL Plane to support persistent monitoring of marine animal interactions with renewable energy deployment sites  

Unmanned aerial vehicles (UAVs) are vital in performing missions that are too expensive and remote for humans. With a focus on marine renewable energy, we built a UAV to monitor protected marine animals (i.e., dolphins, whales) that interact with marine renewable energy sites. Since the locations we plan on monitoring are about 20 miles off the coast of Florida, we decided to build a vertical take-off landing (VTOL) plane, which will be able to take off like a quadcopter (without the need for a long runway) and transition into horizontal flight like a plane. This project investigated the efficiency and benefits of using a VTOL plane instead of a traditional quadcopter when flying to remote locations to perform oceanographic surveys via a multispectral camera.

**REU Scholar:** Tally R. Nesvold  
**REU Scholar Home Institution:** Eckerd College  
**REU Mentor:** Jeannette Wyneken  
**Project:** Understanding Sea Turtle Shell Strength and Resilience  

The safety of sea turtles has been a rising concern with the increase in technological innovations of marine renewable energy. While renewables are a valuable asset to provide clean energy globally, the implications that these machines may have on marine life has not been thoroughly investigated. It is crucial to examine the mechanical properties of the sea turtle shell across species and life stages to better understand how well these creatures can withstand force when interacting with renewable systems. Small samples of shell bone were compiled from 6 individuals, across four species of sea turtle, for mechanical testing. This was added to an existing dataset on shell material properties. Samples were compressed using an Instron material tester to assess the shell's resistance to deformation. Samples from 10 turtles were later scanned using micro-computed tomography to quantify and describe the micro-structure of the shell layers. Mechanical testing results were then compared with multiple bone variables to assess potential structure-function relationships. This study observed a significant correlation between trabecular thickness and cortical porosity with stiffness increasing as trabecular thickness increased and porosity decreased. Overall, shells were considered compliant across all species. By investigating the microstructure of the sea turtle shell, we can achieve an increased understanding of the implications marine renewable energy sources may have on sea turtle ecology.
REU Site: Sensing and Smart Systems

Closely related to the Internet of Things, smart systems represent an emerging class of distributed systems that provide real-time awareness of conditions, trends, and patterns to support improved decision-making, and often, automation. The students’ research projects focus on the Institute for Sensing and Embedded Network Systems Engineering (I-SENSE) three main program areas: infrastructure systems, marine and environment, and health and behavior.

REU Scholar: Emily Portalatin-Mendez
REU Scholar Home Institution: Lehman College, City University of New York (CUNY)
REU Scholar: Jennifer Uraga Lopez
REU Scholar Home Institution: Lehman College, City University of New York (CUNY)
REU Mentor: Jinwoo Jang, Ph.D.
Project: Data Fusion of 2D Perception Algorithm and 3D Spatial Data for Social Distancing Awareness Application

The Center for Smart Streetscapes (CS3) is on a mission to vitalize smart cities across the United States by creating next-generation wireless technologies, simulation awareness, and artificial intelligence (AI) applications for smart cities. Therefore, this project aims to harness a powerful 2D machine vision algorithm, combined with 3D spatial point cloud data, to estimate the social distancing behaviors of agents at a streetscape scale. Understanding those human behaviors at a streetscape level is significant to infer/identify how people interact with each other and surrounding city environments, ultimately benefiting urban planning and design. Real digital lidar data are collected and used for this study. The novelty of these data sets is that point cloud data (i.e., 3D spatial data) are correlated with 2D images/videos, which enable us to capture the 3D coordinates of objects that are detected by 2D machine vision algorithms. A convolutional neural network (CNN) was trained based on Lidar images and used to detect people. Later, the 3D coordinates of detected objects are obtained through correlated images with point cloud data, which is followed by the relative distance calculation between people based on their coordinates. The outcomes of this study have the potential to inform the development of innovative human behavior technologies for smart cities, fostering improved situational awareness and enhancing the overall urban experience.

REU Scholar: Ethan Thomas
REU Scholar Home Institution: Columbia University
REU Mentor: Jinwoo Jang, Ph.D.
Project: E-Scooter Mobility Sensing for Smart City Public Safety and Asset Management

In recent years, personal mobility devices, particularly e-scooters, have become an increasingly common sight in urban areas across the United States. Alongside this surge in micro-mobility device usage, concerns about road safety have emerged, driven by both the growing prevalence of these devices and the deterioration of road conditions. In response to these challenges, this project aims to create an innovative method to discern and differentiate between various riding surfaces based on electric scooters’ acceleration data. A mobile sensing device, which consists of a low-cost Inertial Measurement Unit (IMU), a GPS sensor, and a camera, was developed to collect real-world data. This research focuses on differentiating between Asphalt, Pavers (bricks), and Concrete Slabs with Expansion Joints. This classification process relies on harnessing the power of Machine Learning (ML), particularly a sophisticated Long-Short-Term-Memory (LSTM) Recurrent Neural Network. The implications of this low-cost technological breakthrough are vast and impactful. One of the critical applications lies in detecting hazardous riding surfaces, enabling timely warnings to riders and thereby enhancing overall safety. Additionally, the system can leverage GPS coordinates to identify and report roads requiring maintenance after being traversed by e-scooters, leading to more efficient infrastructure upkeep. Real e-scooter data was collected and used to validate the developed sensing system and ML algorithms.
REU Scholar: Ariana Galindo
REU Mentor: Jinwoo Jang, Ph.D.
REU Scholar Home Institution: Florida Atlantic University
Project: Spatiotemporal data mining and visualization for smart cities

This project investigates the development of scalable data processing tools for large-scale spatiotemporal data. The capability to understand hidden data patterns is significant since compact but insightful, analyzed information contributes to city planning and management. The objectives of this project include 1) the development of interactive front-end 2D/3D data visualizations and 2) infrastructure integrity pattern mining. These scientific efforts were tested and validated with city-scale telematics and building inventory data. The data mined patterns were visualized on 2D/3D web maps based on single/multiple data attributes, which significantly helps visualize spatiotemporal data patterns. Data clustering is performed to handle multiple data attributes efficiently, and the result data clusters are fed into front-end map visualization tools. The web map visualization tools with data-mined patterns will significantly help urban planners and city asset management.

REU Scholar: Abigail Joseph
REU Mentor: Jinwoo Jang, Ph.D.
REU Scholar Home Institution: Florida Atlantic University
Project: Digital Twin Simulation Environment Development for Smart Cities

This project aims to develop data-enabled agent models and virtual simulation environments. Current transportation simulation tools cannot effectively simulate various aspects of agents' behaviors and their integrations with their surroundings. The objectives of this project include 1) the development of city infrastructure environments based on real 3D building data, 2) defining pathfinding behaviors of agents, and 3) simulations of multiple agents' behaviors and their interactions. Unity is a cross-platform game engine that is used to "create and grow real-time 3D games, apps, and experiences for entertainment, film, automotive, architecture, and more." Integrating Unity with real data, AI technology, and C# scripting is used to create digital twin environments of West Palm Beach, where multiple agents' traveling behaviors are defined at a streetscape level. Various agent behavior parameters are implemented, including walking at a particular speed, stopping at an intersection to look for cars before crossing, and avoiding other pedestrians. This is the extent of the current research, but it is anticipated that the methods which produced these results will be used to simulate the interactions between vehicles and pedestrians with substantial accuracy.

REU Scholar: Koy Torres
REU Scholar Home Institution: Lehman College, City University of New York (CUNY)
REU Scholar: David Sanchez
REU Scholar Home Institution: Lehman College, City University of New York (CUNY)
REU Mentor: Yufei Tang, Ph.D.
Project: Federated Learning for Autonomous Driving

Federated learning, also known as collaborative learning, is a machine learning technique that trains an algorithm via multiple independent sessions, each using its own dataset. Federated learning (FL) can help devices become more secure and be an effective method to train a foundational machine learning model. In this project, we studied the application of federated learning for autonomous driving (AD). Previous research has demonstrated that training foundation models using other traditional methods results in challenges with accuracy, security, and transparency. Using a centralized cloud approach causes performance issues and data privacy-invasive issues. Reliance on a central server has been deemed unreliable. FL can influence the advancement of autonomous driving by improving model stability and handling mistrust. In this research, a network is proposed to solve the issues of a centralized learning technique with a focus on peer-to-peer. The datasets used for this research are Carla dataset, a simulated dataset with 73,235 samples distributed over 11 sequences of scenes under different lighting and weather conditions, and GAZEBO dataset, also a simulated dataset using mobile robot and the built-in scenes. We have concluded that federated learning can be a solution
to efficiently train a new foundational model as the results have shown to have better accuracy compared to other training techniques and the predicted values while reducing cycle times, up to 64%.

**InETech Intern:** Raul Mendy  
**InETech Intern Home Institution:** Florida Atlantic University  
**InETech Intern:** Aira Torres  
**InETech Intern Home Institution:** Florida Atlantic University  
**REU Scholar:** Joseph Accurso  
**REU Scholar Home Institution:** Benedictine College  
**REU Mentor/Intern Advisor:** Yufei Tang, Ph.D.  
**Project:** GPT-like Attention Mechanisms for Power Transformer Condition Monitoring and Prognostics

This research explores the application of Large-Scale Foundation (LSF) models in power transformer prognostic health management (PHM). Leveraging the capabilities of transformer-based language models, the proposed approach aims to enhance the predictive capabilities of PHM systems for power transformers. By integrating the attention mechanisms of the deep learning transformer architecture with structured power transformer PHM data, the system gains the ability to efficiently analyze diverse data sources, including textual descriptions, sensor data, and discrete sinusoidal waveforms. The advanced natural language processing techniques of the transformer architecture effectively interpret transformer-related data and extracts valuable insights for detected fault classification and remaining useful life estimations. This study also evaluates this solution against traditional machine learning techniques such as polynomial regression and support vector classification, showcasing the potential advantages that the transformer architecture provides in improving power transformer condition monitoring and contributing to proactive and efficient maintenance strategies.

**InETech Intern:** Carter Nichols  
**InETech Intern Home Institution:** Florida Atlantic University  
**InETech Intern:** Elisa Weinberg  
**InETech Intern Home Institution:** Florida Atlantic University  
**Intern Advisor:** Yufei Tang, Ph.D.  
**Project:** Hardware-in-the-Loop Simulation of Ocean Current Turbines for Grid Integration

Increased interest in renewable energy production has created demand for novel methods of electricity production. With a high potential for low-cost power generation in locations otherwise isolated from the grid, marine hydrokinetic turbines could serve to help meet this growing power demand. The large potential for electricity generation powered by ocean currents has gained attention as a viable renewable energy source that can be harnessed by ocean current turbines (OCTs). In this project, a 3-HP OCT dynamometer is customized and the hardware-in-the-loop-power (HILP) simulations are executed in the OPAL-RT environment to observe the real-time performance of the dynamometer.

First, the turbine mechanical torque output is evaluated while operating in realistic conditions simulated using Acoustic Doppler Current Profiler (ADCP) readings that were collected in the Gulf Stream. Both the collected ADCP data and the constant simulated flow speed of 1.5 m/s are modified to create a realistic environment by accounting for the impact of significant wave height, water turbulence intensity, and depth of the center of the rotor. The second case involves the OCT system that undergoes a water flow speed change at the turbine input. For the flow speed change case, we observe the step change from 1.5 (m/s) to 2.5(m/s), and the power generation profiles are recorded from the dynamometer. Results exhibit power stability of the dynamometer and this research contribute to demonstrating the effectiveness of the OPAL-RT for HILP emulation of marine energy.

**REU Scholar:** Emily Wayne  
**REU Scholar Home Institution:** San Jose State University  
**REU Scholar:** Isaac Merlin  
**REU Scholar Home Institution:** Florida Atlantic University High School
REU Mentor: Reza Azarderakhsh, Ph.D.
Project: Defending and Attacking Embedded Systems

While the cryptographic systems we have today are considered secure, there will come a time when post-quantum computers can decrypt modern public-key methods. Methods that have been used for years, like RSA, Diffie-Hellman, and Elliptic Curve Cryptography, will become totally insecure when faced with quantum attacks due to Shor’s algorithm, trivializing the discrete log problem. Due to the capability to download communications now and decipher them later, it is necessary to update to new systems as soon as possible. This suggests that stronger encryption schemes need to be implemented in order to continue to ensure the secrecy and integrity of our data as we enter the quantum age. In this presentation, we explore the shift from classical cryptography to post-quantum for embedded devices, reviewing a NIST standardized post-quantum algorithm, KYBER.

REU Scholar: Nidhi Begur
REU Scholar Home Institution: Florida Atlantic University High School
REU Scholar: Annelies Verbist
REU Scholar Home Institution: University of Edinburgh
REU Mentor: Behnaz Ghorani, Ph.D.
Project: Deep Learning for Biomedical Health Data: A Simple Framework for Contrastive Learning (SimCLR) for Human Activity Recognition (HAR) in individuals with Parkinson’s disease (PD)

Human activity recognition (HAR) in individuals with Parkinson’s disease (PD) is a growing field in which artificial intelligence, in conjunction with wearable sensors, is implemented to aid in healthcare quality. Currently, the application of traditional machine learning techniques utilizing time-series sensor data is constrained by the sparse availability and the complex nature of the data. This led to the exploration of adopting a recent advancement in self-supervised contrastive learning, Simple Framework for Contrastive Learning (SimCLR). Contrastive learning is a technique in which we maximize the similarity between 'positive pairs', data of the same type, and maximize the difference between 'negative pairs' to learn to extract valuable features from the data. SimCLR creates its positive pairs through data transformations to extract these features. The evaluation of 64 unique combinations of transformations was utilized to assess the SimCLR models' performance in recognizing daily living activities in PD individuals. Compared to the traditional, state-of-the-art fully-supervised model, initial results suggest significant evidence that using SimCLR is more efficient in identifying these activities. In particular, SimCLR models with specific combinations of transformations demonstrated, on average, an improvement in performance over the fully-supervised model when tested on individuals with different degrees of disease progression. Thus, SimCLR should be continuously (can be further) explored to monitor patients' state of well-being effectively and aid healthcare professionals in identifying medication effectiveness.

REU Scholar: Brennen Farrell
REU Scholar Home Institution: North Carolina State University at Raleigh
REU Scholar: Julia Horn
REU Scholar Home Institution: Cornell University
REU Mentor: Behnaz Ghorani, Ph.D.
Project: Detecting Alzheimer’s disease with Accessible Pose Analysis Methods
Alzheimer’s disease is a disorder that causes degradation and death of neurons, with more than 6 million cases, in the US alone. As this disorder is incurable, early detection is vital in the treatment of this disorder. This project seeks to aid in the detection of Alzheimer’s by testing if open source pose analysis methods are able to work with machine learning methods to create an accessible method of Alzheimer’s detection. After selecting AlphaPose and OpenPose as the pose estimation methods to be used, each method was on a dataset which contained both individuals with and without Alzheimer’s. Coordinate points were extracted as these pose estimation methods were run and features were calculated from these points. Significant features were then
determined and ran into a machine learning model to detect whether patients had or did not have Alzheimer’s. The combination of these pose estimation methods and the machine learning consistently performed at around a 90% accuracy, which was on par with or sometimes better than other methods such as the Microsoft Kinect Camera. Thus, it was concluded that these pose estimation methods were a valid method of detecting the presence of Alzheimer’s disease in patients.

**REU Scholar:** Richard Gao  
**REU Scholar Home Institution:** Rice University  
**REU Mentor:** Xingquan Zhu, Ph.D.  
**Project:** Graph Learning For Network Data

Many datasets naturally lend themselves to be structured as graphs. Leveraging their topological information allows Graph Neural Networks (GNN) to outperform their non-graph based counterparts. However, most real world graph datasets are heterogeneous and cannot be processed by traditional GNNs due to inconsistent node and edge typing. In this presentation, we introduce a homogenizing pipeline that will allow us to modify these data sets to be compatible with current GNN technology. By choosing a specific metapath and nodetype, we can transform heterogeneous, single-labeled graph data into homogeneous, multi-labeled data that we can pass through traditional GNN structures. The multi-labeled nature of the transformed data requires us to adapt traditional, single-label classification models to scale to the multiple-labels, or create new, multi-label specific models. Then, by evaluating these different GNN architectures on the transformed heterogeneous graphs and comparing their performances, we can find the optimal architecture for the multi-label node classification task in the context of heterogeneous graphs.

**REU Scholar:** Oriana Matney  
**REU Scholar Home Institution:** Florida State University  
**REU Scholar:** Batsheva Gil  
**REU Scholar Home Institution:** Florida Atlantic University  
**REU Scholar:** Connor Rieth  
**REU Scholar Home Institution:** University of Central Florida  
**REU Mentor:** Georgios Sklivanitis, Ph.D.  
**Project:** Development of a Wireless Remotely Operated Underwater Vehicle

Wireless remote control of a single or a fleet of underwater vehicles by a single human operator will offer the opportunity to collect more data than a single ship/vehicle and effectively carry out operations such as subsea mapping, search-and-rescue and infrastructure monitoring, to name a few. Commercial underwater modems are large to fit small-size submersibles, prohibitively expensive for large-scale deployments and typically closed source which limits their interoperability with other sensors and therefore their application in research. In this project, we focus on establishing wireless communication between a remotely operated vehicle (ROV) and a surface station using an in-house built underwater acoustic modem and an affordable underwater ROV. The endeavor involves a systematic approach, encompassing research, simulation, experimentation, and hardware design. Our research explored radio, optical and acoustic communication methods for wireless underwater vehicles and hybrid underwater vehicles, with acoustic-based communication being chosen for its reliability and long range. Additionally, we considered a hybrid vehicle as a short-term goal, facilitating a gradual transition from tethered to fully wireless systems. To assess wireless communication performance we built a high-fidelity simulation framework using MATLAB, Python and HoloOcean -an underwater robotics simulator based on Unreal Engine. We first tested Binary Frequency Shift Keying (BFSK) in MATLAB-which is one of the communication modes tested experimentally with the first generation of the FAU underwater modem-for communication between the surface station and the ROV. We tested both an ideal communication channel and an underwater channel model that attenuates the BFSK signals based on environmental parameters that are provided by HoloOcean. To assess the viability of command and controlling the ROV we simulate the MAVLink protocol that generates the messages to be exchanged between the ROV and the surface station. These messages are then exchanged over the simulated BFSK transceiver and underwater channel. Finally, to
evaluate the feasibility of deploying a fleet of ROVs we designed and constructed a small, lightweight, low-cost ROV. This ROV will serve as the platform to test swarm acoustic networking technology in future work.