ECE DAY PROGRAM

Senior Design Projects 2025

BU Department of Electrical & Computer Engineering

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

The Boston University Department of Electrical & Computer Engineering (ECE) prepares students to be Societal Engineers for the 21st Century.

The ECE academic experience incorporates guidance from respected faculty members, cutting-edge facilities, a diverse student body and an emphasis on university-wide interdisciplinary research. After establishing a strong engineering theory foundation, students enhance their understanding by developing technical skills.

ECE seniors graduate with experience in mobile cloud computing with security, intelligent computation and data science, image and optical science, nanotechnology and bioengineering.

This combination of practical and theoretical education ensures a breadth of experience in innovative problem solving and exploration that will prepare students for careers in industry, academia, and government.

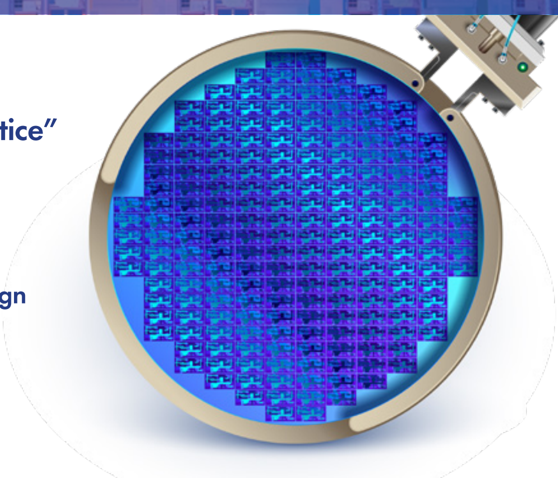
SENIOR DESIGN

The ECE Senior Design capstone course serves as an opportunity for students to execute the education they have gained in the classroom throughout their undergraduate careers, in order to produce prototypes for real-world clients. Student teams serve volunteer customers drawn from industry, government, small businesses, non-profits, schools, artists, faculty, and staff. The course offers:

- The technical, communication, individual and teamwork skill-building needed for successful design work in electrical and computer engineering.
- Knowledge of and experience working with specifications and standards, information collection, design strategies, modeling, computer-aided design, optimization, system design, failure, reliability and human factors.
- Proficiency in oral and written communication, particularly when presenting technical information.
- An understanding of team dynamics and ethical issues in design.
- Experience completing a design project for a small-scale electrical or computer system.

ECE DAY AWARDS

- **Alan D. Pisano "Systems-in-Practice" Senior Design Award**
- **Design Excellence Award**
- **Michael F. Ruane Award** for Excellence in Senior Capstone Design
- **Entrepreneurial Award**
- **Teaching Assistant Award**



ECE DAY 2025

AGENDA

Friday, May 2 • Photonics Center • 9th Floor

9:00 AM	Breakfast
9:45 AM	Chair's Welcome
10:00 AM	First Demo Session
12:00 PM	Lunch Break
1:00 PM	Second Demo Session
3:00 PM	Judges Deliberate
3:30 PM	Award Ceremony

ALUMNI JUDGES

Ben Cootner
Ben Duong
Peter Galvin
Stanley Nguyen
Carmen Hurtado Garcia
Eugene Kolodenker
Andreas Papadakis
Ryan Rosenberger
Bradley Rufleth

View the agenda on your phone:

TEAM 1 - Resource Rally

Henry Nguyen, Eirini Theodorakopoulou, Tejas Singh, Colin McDowell
Client: Sabina Laurino

Abstract

The Resource Rally project tackles a critical problem faced by the autistic community and their caregivers: the difficulty of finding sensory-friendly and inclusive resources. Even though awareness of autism spectrum disorder is growing, a significant gap remains in centralized platforms that provide easy access to sensory-friendly businesses, services, and products.

This project aims to deliver a user-friendly app that links the autistic community to accessible resources. The app uses technology such as React Native for its cross-platform design and Firebase for ensuring secure data storage. It has unique accessibility options like customizable layouts, dyslexia-friendly fonts, and specific user sensory profiles. Resource Rally seeks to empower the autistic community and their caregivers to navigate their everyday lives more confidently and efficiently by combining these elements with community-driven reviews and ratings.

TEAM 2 - ExerSights

Jilin Zheng, James Knee, Anish Sinha, Howell Xia

Student-Defined Project

Abstract

Fitness coaches and physical therapists (PTs) often teach their clients a set of exercises as part of a fitness/recovery routine. However, when clients perform these exercises on their own time, their coaches or PTs are not present to verify whether they are maintaining correct form. Furthermore, many people lack easy access to coaches or PTs, so their form may never be assessed at all. Improper form for exercises can lead to long-term injuries and/or slow down personal fitness progress. Our solution to this common problem is ExerSights. ExerSights is an AI Fitness Coach/PT application that leverages computer vision models to judge and correct a user’s form on particular exercises and movements to ensure that they are being performed safely and effectively. As part of the final deliverable, users can either upload existing videos or activate their device webcam to receive real-time text and audio feedback on a catalog of exercises. This feedback allows the user to immediately correct improper form, reducing the likelihood of injury and improving the efficacy of their workout.

TEAM 3 - AI Coffee Machine

Sebastian Seun, Naomi Gonzalez, Krish Shah, Bryan Zhang
Client: Kenn Sebesta

Abstract

The AI Coffee Machine project addresses the long-standing challenge of brewing consistent, high-quality coffee, a process made difficult by the complex chemistry of coffee, which contains over 1,000 compounds. Our solution is a centrifugal coffee machine that automates critical brewing parameters such as pressure, temperature, and grind size, providing an innovative, user-friendly approach to delivering consistent flavor profiles. The machine incorporates a state-of-the-art machine learning model that analyzes user feedback and dynamically adjusts brewing settings to achieve optimal results.

The final deliverable is a fully functional prototype that combines cutting-edge mechanical design with advanced software capabilities to bridge the gap between user preferences and precise brewing. Key innovative features include the use of FDA-compliant materials, an inverse problem-solving algorithm for flavor optimization, and integration of user feedback to enhance performance over time. This project represents a significant step toward revolutionizing coffee brewing, providing both convenience and quality for coffee enthusiasts and professionals alike.

TEAM 4 - EdenScope

Heshan Chen, Yidi Wu, Hailan Gan, Yiwen Wu

Student-Defined Project

Abstract

EdenScope is an AI-driven plant health monitoring system that integrates robotic automation, cloud-based AI analysis, and multimodal sensing technologies to assess urban vegetation health with precision and efficiency. Our system leverages ground-based robotic platforms, equipped with high-resolution cameras, to detect and diagnose plant diseases in real time.

At the core of EdenScope is an advanced AI analysis engine, featuring YOLO-based detection models, EdenScopeVL for agent-based plant health scanning, and EdenScopeVL_CoT for reasoning-based Chain-of-Thought diagnosis. These models process images captured by the robotic systems, providing comprehensive analysis, including bounding box annotations, disease classification, and deep diagnosis. The entire pipeline is integrated with our software across a variety of platforms and Amazon Web Services (AWS) for scalable cloud storage and computing, ensuring seamless data processing and accessibility.

A key innovation of EdenScope is its robotic arm system, designed to autonomously capture images from multiple angles before uploading them to the cloud for analysis. The robotic arm, upgraded with 85 kg high-torque servos, enhances stability and precision, ensuring optimal imaging conditions in diverse urban environments. This modular approach allows the system to be deployed across self-driving vehicles, drones, and stationary monitoring stations, adapting to various urban and agricultural landscapes.

EdenScope's impact extends beyond research—its low-cost, scalable design makes it accessible to urban forestry managers, environmental agencies, and policymakers seeking data-driven solutions for plant health monitoring. By combining robotics, AI, and cloud computing, EdenScope represents a cutting-edge approach to automated plant health diagnostics, paving the way for sustainable urban ecosystem management.

TEAM 5 - Roomform AI

Jack Edelist, Brennan Mahoney, Amruth Niranjan, Zane Mroue

Student-Defined Project

Abstract

Roomform AI is an advanced, web-based Virtual Interior Design Platform that leverages Artificial Intelligence (AI), 3D modelling, and augmented reality (AR) to revolutionize interior design. Catering to both professional and non-professional users—including furniture designers—the platform allows users to input natural language prompts, search for, and virtually place furniture within custom 3D-rendered room environments. The platform offers dynamic room configuration, including adjustable dimensions, flexible layouts, and an intuitive drag-and-drop interface for seamless furniture arrangement.

A unique feature of Roomform AI is its "scan-in" capability, which employs background separation and cutting-edge 2D-to-3D model generation to convert real-world objects into 3D models. This feature provides significant value to furniture creators and design enthusiasts by enabling the integration of custom pieces into the virtual design space. Additionally, Roomform AI offers a powerful custom room shape editor, allowing users to accurately represent any room shape or configuration with ease, enhancing the platform's versatility in real-world design scenarios.

The platform also supports AR visualization, allowing users to experience their designed rooms in real-world settings via smartphone, bridging digital design with physical reality. Users can save and share their designs, fostering collaboration and creative expression within the design community.

The platform's infrastructure is built on robust cloud technologies, including an AWS EC2 instance (g4dn.4xlarge, T4 GPU) running Ubuntu 22.04. Custom furniture models are securely stored in AWS S3, with an NLP-driven search engine powered by a lightweight BERT model and Pinecone vector database. The frontend utilizes Next.js/React.js and Three.js for a rich, interactive 3D design experience, while Django manages backend operations, supporting large files and frequent API interactions.

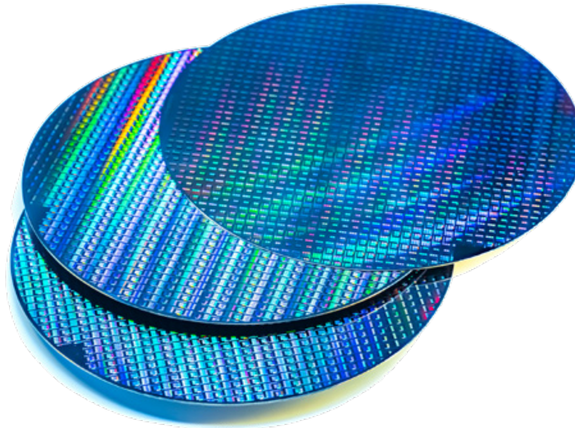
Roomform AI fills a critical gap in the design tools market by providing an accessible alternative to complex 3D software like Blender and generalized 2D design tools such as Figma and Adobe Illustrator. By combining AI, AR, and 3D modeling with a user-friendly platform, Roomform AI democratizes access to professional-grade design tools, setting a new benchmark for innovation and creativity in the interior design industry.

TEAM 6 - AI Trading Platform

Odilon Quevillon, Gabriel Brown, Yagiz Idilman, Adrian Pawlowski
Student-Defined Project

Abstract

This project develops a trading platform that delivers actionable buy or sell outputs for selected stocks. By integrating multiple machine learning techniques, the platform provides a sentiment analysis score, an LSTM-based price prediction, an XGBoost classification, and a reinforcement learning-generated trading signal. Based on the analysis of previous day outputs, the system adopts a simple trading strategy of holding stocks from market open to close the following day. This approach not only simplifies decision-making for users but also serves as a proof-of-concept for combining diverse analytical models to generate coherent trading insights.



TEAM 7 - Semi-Autonomous Bike for the Visually Impaired

Front: Tara Gill, Cole Resurreccion, Yiran Yin
Back: Jason Calalang, Linden Adamson, Zhilang Gui
Client: Dan Parker, Professor Eshed Ohn-Bar

Abstract

Our project is a semi-autonomous recumbent tricycle designed to provide independent mobility and exercise opportunities for visually impaired individuals. Despite advancements in assistive technology, no autonomous cycling solutions exist for those without sight, limiting their ability to navigate independently in increasingly bike-friendly urban environments. Our tricycle addresses this gap by incorporating self-driving functionality, real-time obstacle detection, and a user-friendly interface for designation input. While pedaling is done manually by users, the tricycle will autonomously control steering and braking. The system integrates computer vision for obstacle detection and navigation, a GPS-linked voice interface for designation selection, and multi-modal feedback mechanisms, including haptic feedback, to enhance user awareness.

To autonomously navigate, our tricycle uses a Jetson Orin Nano to make low-latency decisions based on camera and sensor input. Our main RGBD camera is an OAK-D equipped with depth imaging to aid in object detection. The images and other precise data sources, like our VectorNav IMU, will serve as inputs into a model computed by our Orin, which will then communicate with actuators for steering and braking through ROS. Our steering system uses a 24V DC motor connected to the central steering joint on the tricycle by a timing belt. Attached to the motor is a position encoder that sends position data back to the Orin for precise control. Our brakes are controlled by servo motors attached to push rods connected to both brake pads. WS2801 LED strips are attached to the bike as braking and turning indicators for the safety of the user and their environment. A haptic motor is also attached to the upper lumbar of the seat to alert the user when not to pedal. For user-friendliness, A 90dB buzzer is activated via a 433MHz RF signal key fob that alerts the user audibly to the tricycle's location. Our user interface also includes a voice-activated module that uses a USB microphone with CMU Sphinx speech-to-text API to process user commands. Selected by these commands, designations are linked with IMU data and Google Maps API for navigation planning.

Our final deliverable is a low-power, semi-autonomous recumbent tricycle tailored for visually impaired users, integrating safety mechanisms such as emergency braking and redundant control systems. Our client, Dan Parker, a blind racecar driver and Guinness World Record holder, exemplifies the demand for this technology. His experience using advanced guidance systems to continue racing highlights the potential for autonomy in personal mobility, as well as a survey that indicated 87% of visually impaired people seeking more accessible transportation options. By bridging the gap in accessible mobility, our project aims to expand transportation and fitness opportunities for the visually impaired community and others who are excluded.

TEAM 8 - BikeGuard

Front: Marissa Ruiz, Margherita Piana
Back: Bennett Taylor, Albert Zhao, Beren Yagmur Donmez

Student-Defined Project

Abstract

Our product BikeGuard aims to offer a comprehensive theft detection system designed to protect the 80% of bike owners affected by theft. Utilizing machine learning, the system classifies an event as a theft attempt from theft activity, such as lock picking and wire cutting, with an accuracy of 90%. Following a detected theft attempt, BikeGuard delivers real-time alerts via Wi-Fi or cellular data to a user interface. Our user interface can be accessed via a mobile application or a web interface. The interface offers a seamless solution to control the device, featuring a live camera feed of the environment, a map with GPS tracking of the bike, and options to set off a buzzer to deter thefts. With its innovative approach, BikeGuard goes beyond traditional locks to offer cyclists a scalable, intelligent solution for theft prevention, reimagining bike security with real-time technology and advanced analytics.

TEAM 9 - NeuroToys

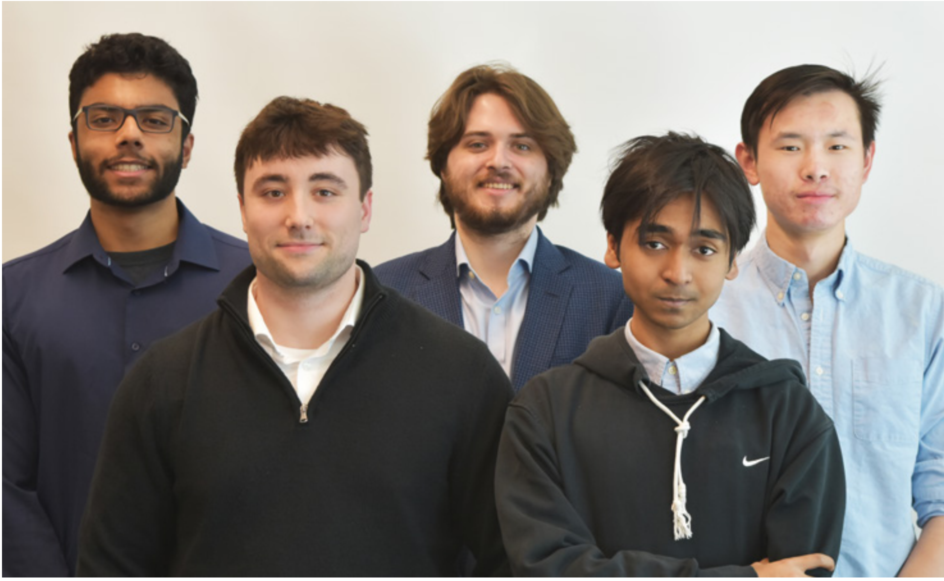
Front: Andres Marquez Santacruz, Gabriela Porto Machado
Back: Adam Shaikh, Robert Bona, Mete Gumusayak
Student-Defined Project

Abstract

This project aims to revolutionize human-machine interaction by enabling control of a robotic device using brain signals. It addresses the challenge of enabling individuals, particularly those with mobility impairments, to control devices effortlessly and intuitively using their brain activity. Traditional device control methods such as joysticks and remotes are restrictive and often inaccessible. Using Electroencephalography (EEG) signals, NeuroToys aims to create a non-invasive brain-computer interface (BCI) that translates brainwave patterns into real-time motor commands for a car toy.

The final deliverables will include a fully functional robotic device controlled by EEGsignals, a software interface for real-time feedback, and a user-friendly graphical interface for calibration and monitoring. The system will incorporate robust signal processing, achieving 95% noise reduction and a command recognition accuracy exceeding 85% after calibration. The portability and wireless nature of the system ensure ease of use with a communication range of at least 10 meters.

The proposed technical approach integrates machine learning for signal interpretation classification, dynamic threshold calculation for real-time command interpretation, and innovative hardware design. NeuroToys features a low-cost, portable, and user-friendly EEG system optimized for comfort and usability. This solution not only fosters greater independence for individuals with disabilities but also opens pathways for applications in healthcare, rehabilitation, and entertainment, contributing to the advancement of accessible human-machine interaction technologies.



TEAM 10 - Semi-Autonomous Ground Convoy

Front: Michael Moran, Md Sadman Kabir
Back: Nikhil Krishna, Hugo Silmberg, Benjamin Hsu

Client: Charles Stark Draper Laboratories

Abstract

The Convoy addresses critical safety and autonomy bottlenecks in dynamic environments through an integrated vision-aided perception and control system for TurtleBot 4 robots. Our semi-autonomous solution enables robust target recognition, tracking, obstacle avoidance, and adaptive following behaviors. The system incorporates transfer learning-based recognition, multi-modal sensor fusion, and advanced control algorithms within a comprehensive ROS2 framework. The Convoy delivers real time follow the leader behavior for designated targets, elegant and simple swarming, as well as predictive control systems for seamless navigation.

TEAM 11 - Herd It Here

Front: Chen Zhang, Lucia Gil, Trieu Tran
Back: Cole Knutsen
Client: Labby Inc.

Abstract

Our project is an automated cow identification and tracking system designed to integrate with milk analysis technologies in modern dairy farms. The system enables real-time, automated tracking of individual cows using computer vision and deep learning to streamline farm management and improve livestock monitoring efficiency, as opposed to current manual methods of identification.

Our system operates using a Raspberry Pi equipped with a Hailo 8 hardware accelerator, ensuring low-power, high-speed edge AI processing for real-time detection and tracking. Our product features two high-resolution HQ cameras to capture images of cows as they move through the milking stations, enclosed within a weatherproof enclosure. These images are then processed through our data pipeline that ensures accurate cow identification while preventing duplicate detections.

First, YOLO is used to detect ear tags in the images, identifying their location on each cow. Once detected, a multi-object tracking system assigns a unique tracking ID to each ear tag, ensuring that individual cows are consistently tracked across multiple frames. This prevents duplicate values from being recorded when the same cow appears in consecutive images. Once the ear tags are reliably tracked, the system extracts their values using an OCR model, converting the ear tag numbers from the images into text. After processing, the extracted ear tag numbers, along with their timestamp and position data, are automatically sent to the customer's database, where they can be linked to the milk analysis system. This enables precise correlation between each cow's identification and its corresponding milk yield, quality parameters, and health indicators, providing farmers with deeper insights into herd health, nutrition, and productivity.

By automating cow identification and eliminating the need for manual record-keeping, this system significantly improves record accuracy, intensive manual labor, and optimizes herd management. Designed for deployment in dairy farms and research facilities, this fully automated, scalable solution ensures seamless integration with existing livestock monitoring tools. By supporting data-driven decision-making, it enhances efficiency with livestock farming, reduces labor costs, and lays the groundwork for future expansions into monitoring and behavior analysis.

TEAM 12 - BUtLAR

Suhani Mitra, Jacqueline Salamy, Noa Margolin, Andrew Sasamori
Client: Yobe Inc.

Abstract

Existing chatbots present several limitations to human-machine interactions. They often require manual input, lack personalization, and struggle to provide accurate responses to complex queries. To address these challenges, we introduce the Boston University LLM Auditory Responder (BUtLAR), a voice-powered digital human assistant designed to offer an interactive and personalized conversational experience. BUtLAR incorporates advanced features such as speaker identification, noise immunity, and real-time answer generation. BUtLAR processes audio accurately in real-time. Starting with the Yobe Software Development Kit (SDK), this tool preserves voice data, such as denoising speech in a loud environment and identifying who the speaker is. Speech-to-text transcription is then performed through API calls and passed to a large-language model (LLM), which makes SQL queries to BUtLAR's database. For our demonstration, the database contains structured information about Boston University, with an emphasis on ECE-related topics. The software is deployed on a Raspberry Pi 5 with an LCD screen and microphone, offering an intuitive interface and feedback loop. By combining AI-driven speech processing, language modeling, and database interaction, BUtLAR enhances the efficiency of voice-based human-computer interactions.

TEAM 13 - E-FUNDRAISE

Carther Theogene, Kevin Chen, Damia Duendar
Client: Professor Siddharth Ramachandran

Abstract

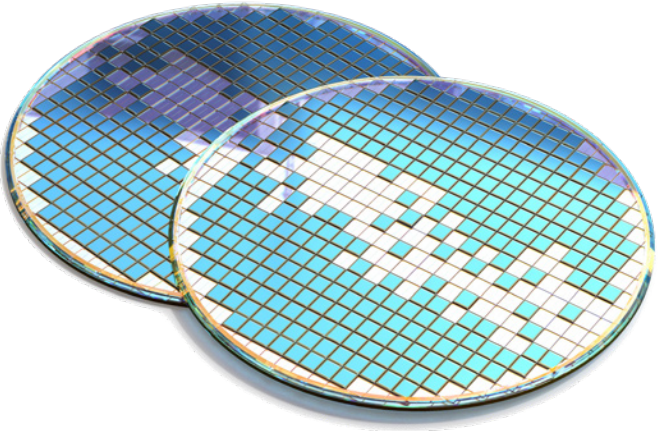
E-FUNDRAISE is an AI tool that automates identifying funding opportunities by matching funding opportunities with researcher profiles. This project aims to provide researchers with personalized recommendations that align with their funding needs, saving them time and improving their chances of securing funding. The final deliverable will be a web application with a user-friendly interface that allows users to input or select the researcher profiles (e.g., PDFs of past publications) and retrieve the grants that are most relevant to their interests. These recommendations will also include descriptions detailing the pros and cons of each funding opportunity.

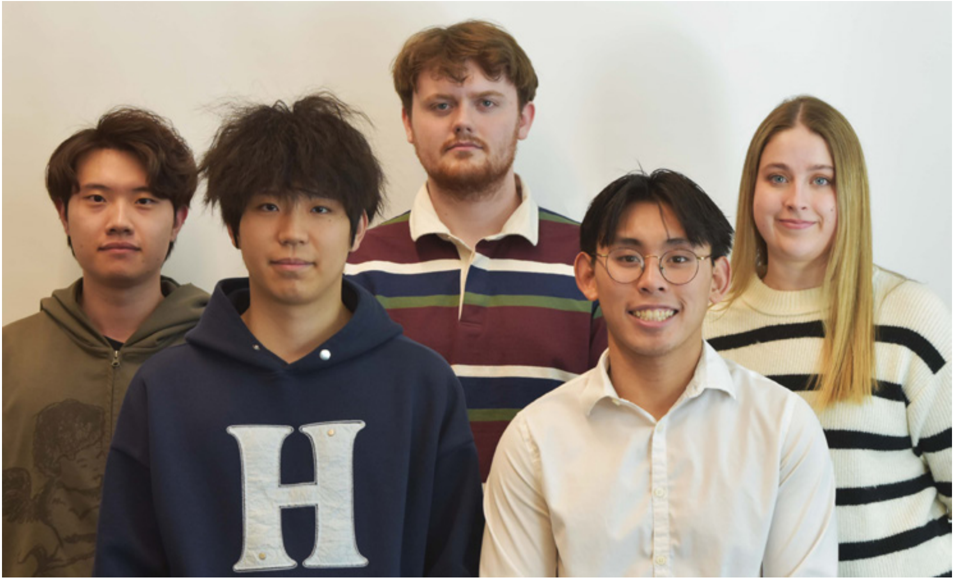
TEAM 14 - Financial News Service

Ivan Garcia, Rohan Kumar, Harlan Jones, Karl Naba
Student-Defined Project

Abstract

The Financial News Search Engine project aims to democratize access to financial information by creating an open-source alternative to expensive financial terminals. Our solution provides real-time financial news aggregation with advanced search capabilities, machine learning-powered analysis, and customizable filtering - all at no cost to end users. First semester progress has established core infrastructure including the search engine, web scraping system, and basic frontend interface.





TEAM 15 - FitnessWatch

Front: Zhuowei Chen, John Tran
Back: Youchen Li, Peter West, Carly Butler
Client: Emily Lam

Abstract

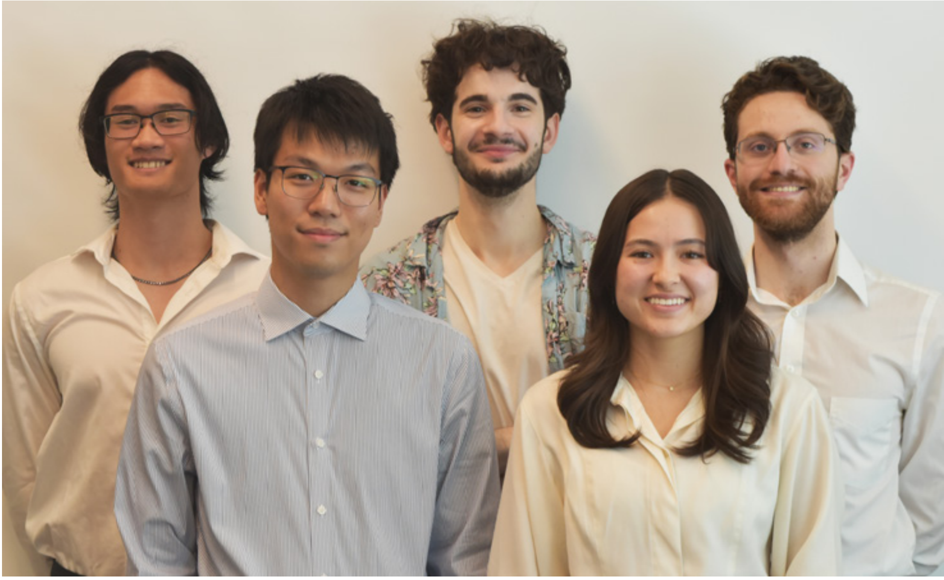
The modular fitness watch adapts the same sensing functionality of a traditional, bulky smartwatch but disperses the hardware around the entirety of the watchband. This allows for a sleek and comfortable watch that integrates GPS, heart rate, altimeter, and IMU sensors in a compact configuration to collect health data. The watch will also offer standard clock features such as a timer and stopwatch. Additionally, the modularity of the battery allows for easy replacement and includes a low-power mode option to minimize the need for the wearer to remove the watch for charging. The data collected by the smartwatch can be personalized to the user's preferences to align with their individual health goals. The data will be featured directly on the digital display of the watch, and the complete health profile will be available to the user on a smartphone app through bluetooth and Wi-Fi connection.

TEAM 16 - MiniBots

Front: Benjamin Gilbert, Ella Hedman
Back: Noah Robitshek, Eliott Dinfotan, Samuel Kraft
Client: Professor Thomas Little

Abstract

MiniBots aims to build floating, movable bots to replace traditional buoys with anchors. Traditional buoys can be a pain to move and require a boat and an anchor. Our bots serve as dynamic markers for remote-controlled sailboats, maintaining their position in the water until commanded to move. We are engineering a system of three interconnected bots equipped with two motors, a GPS module, and an IMU, enabling precise movement and stability. Controlled via a mobile app, the bots can navigate forward, backward, left, right, or to a designated location. Communication is handled through an ESP32 microcontroller integrated with a custom PCB that connects LoRa modules, ESCs, power management systems, and voltage sensors.



TEAM 17 - Molecular Dynamics

Front: Sora Kakigi, Emika Hamond
Back: Austin Jamias, Vance Raiti, Fadi Kidess
Client: Professor Martin Herbordt

Abstract

Molecular dynamics is a popular method in computational biology where simulations are dominated by range-limited non-bonded forces. We plan to develop three mplementations of accelerators: FPGA, GPU, and CPU for this application. For each of these, we plan on optimizing the memory-network interconnects as well as the locality of reference, while making the underlying architecture more generalized and portable to different environments. We plan to do all this while introducing a strong scaling framework that will leverage higher computational power on smaller data sets.

TEAM 18 - BU Renew

Front: Ryan Flynn, Abdulaziz Alrasheed
Back: Gabriel Ferreira, Jeremy Sajda, Lucas McLean
Student-Defined Project

U.S. Dept. of Energy Solar District Cup Collegiate Design Competition Entry

Abstract

As part of the Solar District Cup collegiate student teams are tasked to design and model distributed energy systems for a campus or district, then present those designs to a panel of industry professionals. The competition works by first assigning 9 teams to each district use case where each team develops a solution using the data, plans, and goals of the district, enabling the teams to work on a real-world project with actual energy load, utility rate, and site data while developing distributed energy solutions. The systems proposed by students then consider and integrate solar photovoltaic (PV) generation, battery electric energy storage, and other distributed technologies and capabilities within the district's existing energy sources, uses, infrastructure, and community considerations. Our assignment as the team BU Renew was to plan, design, and model a campus wide PV power system proposal with battery-storage options for The College of New Jersey (TCNJ) in Ewing Township, NJ with the goals of the proposal being to maximize energy offset at the lowest cost while integrating into the aesthetics and community of TCNJ.

TEAM 19 - Personal Alert Device

Logan Lechuga, Richard Yang, Renad Alanazi, Tanveer Dhilon
Client: Professor Michael Ruane

Abstract

The population of seniors above 65 is growing rapidly as the Baby Boomers age. Many live alone and struggle with physical or mental disabilities. Home accidents, typically falls, happen even with healthy elders. Current solutions in the industry are expensive and suffer from high false alarm rates, typically triggered by unintended activation of the alert device. A more intelligent, more reliable design is needed. We propose to deliver a home-based wearable alert actuator that interfaces with the user's mobile device through a native application. By incorporating high-accuracy sensors and utilizing the user's phone as a computational hub, we can better diagnose medical emergencies while providing the user with dynamic health information and records. Through the innovative usage of machine learning models in our system, we can better differentiate and diagnose real emergencies automatically. Through the integration of the device with our native application, a new layer of personalization, usability, interoperability, and adaptive functionality can be achieved, enhancing the overall user experience and effectiveness of our alert device as compared to traditional alternatives.

TEAM 20 - Piano Pedals

Rohan Alexander Krishnan, Joseph D'Innocenzo, Mallory Cook, Sebastian Gilligan
Client: Professor Alan Pisano

Abstract

Our project is a device that allows a piano player to use the pedals of the piano without using their feet or legs. Our goal is to give the full capabilities of a piano to musicians who cannot use their legs or feet. The device depresses the pedals using linear actuators which extend downward on top of the pedals. The device is portable, and the linear actuators are adjustable so it can work on any standard piano with three pedals. The device makes use of three different sensors for each pedal, two finger-pressure sensors for sustain and sostenuto and one shoulder-motion sensor for the soft pedal. These sensors plug into our control unit, which has controls for each pedal to adjust maximum and minimum depression of the piano pedal, as well as sensitivity of the input sensors. The control unit then outputs a signal to our linear actuators which depresses the pedals with the force the user instructs it to. Our device allows the user to seamlessly and dynamically actuate the pedals of the piano while they play the keys.

TEAM 21 - LungDetect

Front: Astrid Mihalopoulos, Shadin Almaiman
Back: Matthew Pipko, Phuc Thinh Nguyen, Hilario Gonzalez
Client: Dr. Andrey Vyshedskiy

Abstract

LungDetect is an acoustic imaging system that is capable of detecting and identifying pneumonia-indicative "crackles" from lung sounds. The device consists of six microphones embedded into a foam pad housing protected with a regularly disinfected acrylic enclosure. The microphones are then connected to a USB-C splitter allowing simultaneous recording on a computer with a dedicated software system. This system uses cross-correlation to find crackle families and estimate their locations and includes a React front-end for visualization, a Node.js back-end for processing data, a calibration script that synchronizes the channels, and Python analysis scripts to examine captured .wav files and provide details on the lung noises detected. This non-invasive and cheap approach offers a promising alternative to the use of radiation-based X-rays and stethoscopes and introduces innovation into pneumonia diagnostics through acoustic technology.

TEAM 22 - Pollux

Front: Wenhao Cao, Caelan Wong
Back: Louis Cicala, Karl Carisme, Noah Hathout
Client: Jennifer Remigius

Abstract

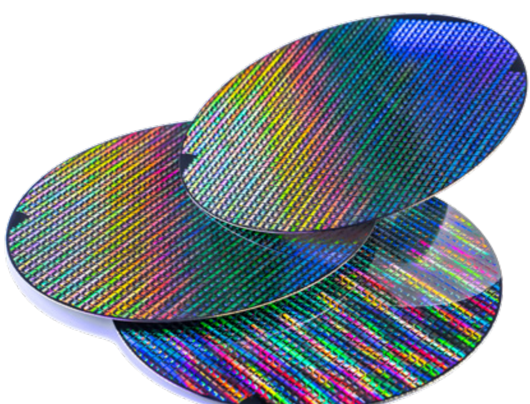
The Pollux is an autonomous countertop cleaning robot built around a Raspberry Pi using the Robotic Operating System (ROS) framework. Utilizing an array of distance sensors, the Pollux collects data about its environment to navigate around cliffs and obstacles. As opposed to traditional cleaning methods, the Pollux is equipped with germicidal UVC diodes for hands-free sanitization. Finally, to supplement the Pollux is a reinforcement learning model, which uses Proximal Policy Optimization (PPO) – it is built for efficient navigation and intended for future implementation.

TEAM 23 - Portable Language Translator

Cristian Palencia, Ryan Liao, Andrew Nguyen, Yohan Kim
Student-Defined Project

Abstract

Communication is one of humanity's most fundamental needs, yet language barriers and lack of widespread knowledge of ASL hinder our ability to connect. Our project aims to provide an all-in-one translation device that enables real-time translation between spoken languages and seamless conversation between ASL and speech. Our device will use speech recognition and translation, a camera, and a screen, all in a portable form factor to bridge communication gaps. It will enable users to engage in natural conversations, translating spoken words bidirectionally and interpreting ASL gestures into speech, fostering inclusivity and accessibility for diverse communities.



TEAM 24 - Rescue 365

Kenneth Byun, Jayden Raphino, Santos Zuniga, Nicholas Ramondo
Client: Yasie Saadat

Abstract

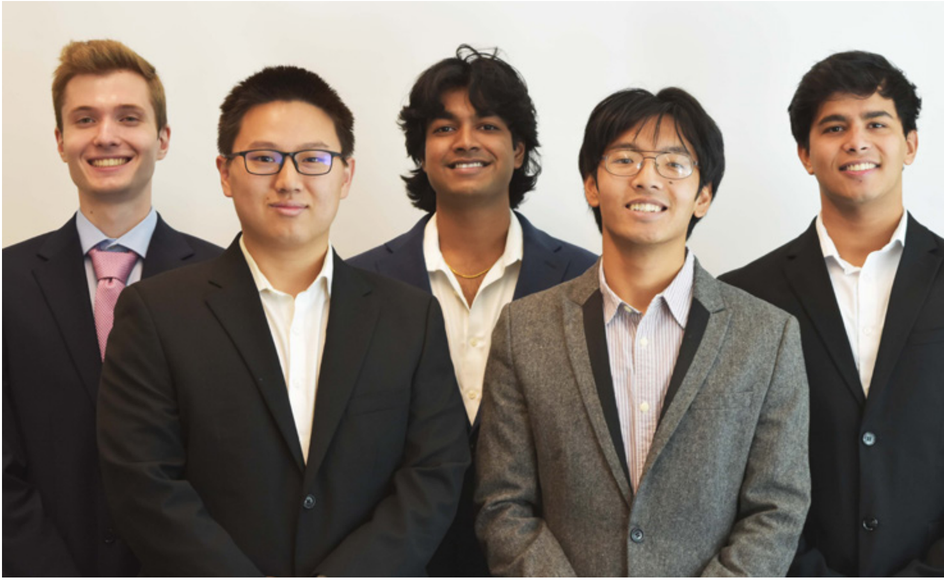
Rescue 365 is a mobile application that moderates all pieces of the rescue process. This app will allow users to report new animal rescue cases which will be tied to the geographic location of the user's phone. These new cases get uploaded to our database, where rescue users in the area with the knowledge and capability to make a rescue are immediately alerted. A rescue user will be able to claim the rescue, alerting the community that help is on the way to eliminate overlap and confusion. This rescue user will then receive access to the location of the rescue report, go to the location and complete the rescue. Finally, veterinary clinics that partner with Rescue 365 will be able to accept active rescue cases, alerting the community that the animal in need is safe and sound, as well as giving the clinic an approved space to disperse accurate information to the public about current status, surgeries needed etc. This solution relies on users taking advantage of their personal mobile devices, so hardware is not necessary. This application is a first of its kind approach to moderating the animal rescue space on a national scale, uniting these fractured groups to achieve a more efficient system in every community.

TEAM 25 - Sailboat Nav

Front: Leyandra Burke, Kyla Wilson
Back: Matthew Guacho, Diegonisio D’Angelo-Cosme, Kevin Connell
Client: Professor Ryan Lagoy

Abstract

The Triton is a portable, multi-sensor system that provides useful information to the sailor via a mobile iOS application, including object sensing and visualization, GPS data, wind speed and direction, and speed over ground. The Triton is easily installed and removed on any sailboat, with its primary function being to assist sailors when docking or maneuvering through crowded areas, such as a busy port. The Triton consists of three separate sensing modules attached to the bow, starboard, and port areas of the boat. Each of these modules communicates via Bluetooth Low Energy. The data from each of these modules is continuously offloaded to the connected iOS device in real time, giving the operator the most up-to-date information about the current conditions.



TEAM 26 - Simple Sprouts

Front: Arthur Hua, Jared Solis
Back: Alex Muntean, Dilhara DeSilva, Sourav Shib

Student-Defined Project

Abstract

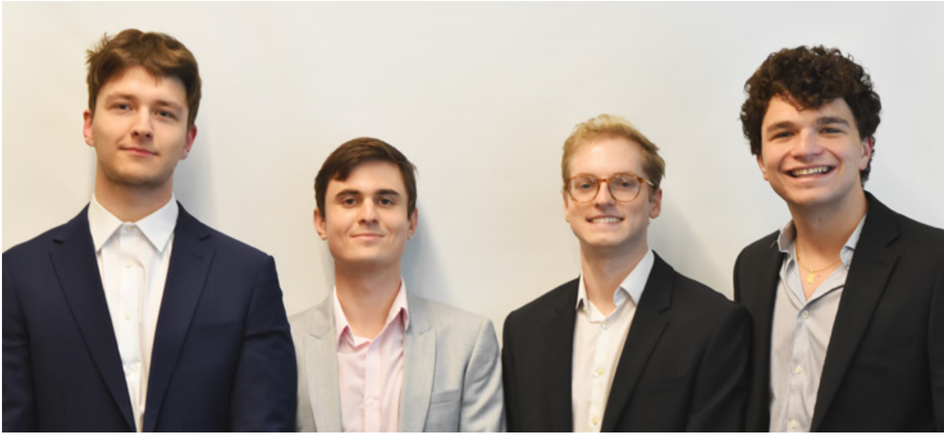
Simple Sprouts is an automated vertical farming system designed to optimize plant growth in a controlled indoor environment. The system integrates a Raspberry Pi 5 for real-time monitoring and control of essential growing conditions, including soil moisture, temperature, humidity, and lighting. It features a multi-level enclosed structure with a custom PCB that consolidates sensor inputs, automated irrigation, and climate control components. The goal is to provide a self-sustaining and efficient plant-growing system that requires minimal user intervention, making it suitable for urban gardening, research, and education.

TEAM 27 - Domus

Venkata Sai Andra, Vansh Bhatia, Akhil Bongu, Anirudh Singh
Student-Defined Project

Abstract

Domus is a smart home and security system built on the Raspberry Pi platform. It integrates home automation with robust security features by combining industrial IoT components and a hardware-software co-design framework. With an edge-deployed Large Language Model processing user commands locally, Domus delivers rapid response times, enhanced privacy, and reliable control over smart devices and security systems without cloud dependency.



TEAM 28 - Machine Learning Powered Electrical Control

Mateusz Gorczak, Konstantin Agrachev, Benjamine Axline, Avishai Lean

Student-Defined Project

Abstract

Climate change represents an existential threat towards global health and populations. As a result, there has been an increased focus on electrification, as well as shifting more traditional electrical generation sources towards renewables like solar and wind. However, these new renewable or low-emission generation sources present an additional problem for grid systems as they are volatile and require optimal outside weather conditions to generate power. As these renewables constitute a larger percent of the total electrical generation, there are increasingly times in which renewables overproduce electrical demand and must be curtailed, while there are times in which demand peaks and renewables have little generation causing increased reliance on non-renewable sources.

Our final deliverable will be machine learning algorithms that can accurately predict day-ahead renewable generation. These algorithms will be used to power a web application that allows a user to manage electrical consumption and schedule non-essential loads at times when there is maximum availability of renewable energy generation. Essentially, the application's aim is to shift consumption from times of low renewable generation towards times with higher renewable generation. Finally, we will attach these algorithms to an outlet that can be controlled entirely by our web application as a proof of concept for these controls.

Our technical approach involves the creation, testing, and implementation of machine learning models and web applications. The energy generation sources models will be developed with various types of Neural Networks each written and tested independently. These models will be retrained on a regular basis with the latest data that is automatically pulled from Independent Systems Operators and Weather sources. Once created, these models will then be used to predict the following days based upon weather data and predicted total load from the ISO. The web application will be created using JavaScript/React for the frontend and Python/FastAPI for the backend. It will feature power consumption analytics, renewable predictions, and load control as its basic features.

Predicting renewable generation is an increasingly important field of research and one in which our team has drawn inspiration towards our algorithms. The innovative aspect of our project is to change electrical loads towards times of renewable generation. Currently, the status quo for data centers, chemical makers, or large power consumers is to only consume power when the cost is below a certain amount. We are changing this optimization towards that of carbon emissions instead of money.

TEAM 29 - Smart System for Visually Impaired

Front: Lukas Chin, Shamir Legaspi
Back: Jake Lee, Jason Li, David Li

Student-Defined Project

Abstract

In the United States, there are over 20 million people who are visually impaired, with about 1 million of those with blindness. Every day these visually impaired individuals have trouble navigating their surroundings with many needing to use white canes or guide dogs for assistance. While white canes and guide dogs provide great aid for everyday navigation, our Smart System for Visually Impaired offers even greater enhanced mobility through wearable technology that combines obstacle detection, realtime object recognition, live haptic and auditory feedback, and speech control. Smart System for Visually Impaired uses cutting edge computer vision techniques to detect everyday hazards, and it listens to the user for quick and automatic speech input. Our Smart System for Visually Impaired combines a Smart Cap and an Intelligent Wrist-Wearable wirelessly to provide the user with exceptional environmental awareness and navigation confidence.

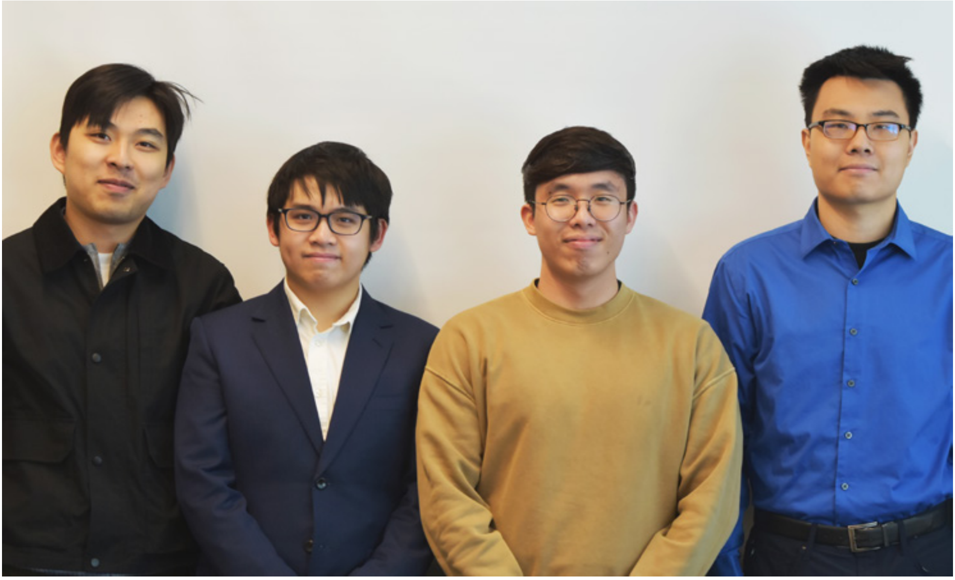
TEAM 30 - SmoothOperator

Front: Eric Chen, Celine Chen
Back: Nicholas Nguyen, Christian So, Jacob Chin
Student-Defined Project

Abstract

Post-COVID staffing shortages in the hospitality industry have increased mobility challenges for travelers with physical impairments, particularly regarding luggage transportation. With over 61 million Americans (26% of adults) living with disabilities, there is a significant need for assistive solutions. The hospitality sector has experienced a 38% reduction in workforce since 2019, with airport ground staff decreasing by 25%, further limiting available assistance.

SmoothOperator addresses this need through an interactive robotic assistant designed to autonomously and safely transport luggage in consumer environments. We developed a complete full-scale, end-to-end robotic solution that seamlessly integrates multiple subsystems. This involved manufacturing custom components and assembling a sophisticated network of sensors, actuators, algorithms, and communication protocols. These systems allow SmoothOperator to navigate using either terminal destinations or direct user input via an onboard touchscreen interface. To ensure safe and reliable operation, we implemented multiple redundancy strategies and layered safety mechanisms, including dynamic obstacle avoidance that prioritizes human interaction. SmoothOperator is designed to enhance accessibility and convenience in the hospitality sector, improving the quality of life and providing greater confidence for individuals with mobility impairments when traveling.



TEAM 31 - OptiView

Jialin Sui, Luong Quoc Thai Nguyen, Thinh Phuc Nguyen, Benny Li
Client: Professor Osama Alshaykh

Abstract

The Text Glasses is an assistive device that aims to combat hearing disability by offering a visual reproduction of real-time speech for its users by displaying spoken words on glasses' lenses. The product processes and displays spoken speech as texts in real-time with a low latency of less than 100ms, ensuring conversational flow. The design prioritizes practicality and comfort through its lightweight construction and streamlined components, making it suitable for daily wear. Text appears on the lower portion of the lenses, creating a balanced view where users can simultaneously read conversations and maintain full awareness of their surroundings. This unobstructed design ensures wearers can confidently engage in activities requiring clear vision while using the device. The product is designed to be paired with a mobile phone app that allows users to manage the glasses software features just as language switching, chat history recall, conversation summary and calendar integration. For enhanced versatility, the system includes a standalone processing unit, allowing the glasses to function with minimal latency without a phone or internet connection.

TEAM 32 - Visually Impaired AI Wearable

Houjie Xiong, Louis Jimenez-Hernandez, Heather Li, Dylan Ramadhan
Student-Defined Project

Abstract

Cooking poses numerous challenges for the visually impaired such as operating touchscreen appliances, identifying ingredients, and doing measurements among others. To address these obstacles, we wish to propose Mimir, an AI bodycam with an accompanying application to provide real-time guidance in the kitchen. Leveraging computer vision and AI, Mimir will provide object recognition, text extraction, precise measurement, and recipe guidance to the user. Through the connected application, we will be able to utilize cloud-based computations for more complex tasks including web-scraping, image processing, and natural language processing. To assist with accessibility, we will incorporate voice command, and text-to-speech feedback delivering an intuitive and user-friendly experience. By combining cutting-edge AI technologies with an accessibility-focused design, Mimir aims to empower visually impaired individuals with independence, safety, and confidence in the kitchen.

TEAM 33 - Wind Powered Research

Front: George Cicero, Nyomi Inda
Back: Philip Nied, Mateo Marsella Balzola, Joshua Bardwick
Client: Professor Ryan Lagoy and the Woods Hole Oceanographic Institute

Abstract

Our project this year was to build an autonomous boat for researchers at Woods Hole Oceanographic Institute (WHOI). They need an autonomous vehicle to navigate around the coast of Southern Massachusetts and Rhode Island to take time and location-stamped readings from their environmental sensors. Our vessel must be able to make a two-hour journey, up to a kilometer from shore, without human intervention. Our boat is able to switch between emergency manual control, autonomous navigation under motor power, and autonomous navigation with sail power. The base structure of the boat, including the keel and wing, is 3D printed polylactic acid, with waterproof sealing on the surface and acrylic paste in contact points for waterproofing. Our project also has a custom web user interface that is accessible offline for use in remote areas near the coast.

THESIS STUDENT
Woud Alsadoun

ADVISOR: PROFESSORS MIGUEL JIMENEZ & RABIA YAZICIGIL

"A Microfluidic Chip for Single Cell State Analysis Using Electrochemical Impedance Spectroscopy (EIS)"

Abstract

Fermentation is a process in which microorganisms convert complex molecules into simpler organic compounds, such as acids, in the absence of oxygen. Monitoring the health of these microbial cells in real-time is essential in industrial processes such as pharmaceutical production, as it is a key factor in the final product yield. Traditional methods of quality checking involve extracting samples from the fermentor for bench-top testing. This method does not allow for real-time monitoring of microbial health. The proposed microfluidic chip addresses this issue by enabling single-cell level signal detection via electrochemical impedance spectroscopy (EIS) during the continuous flow of the culture populations directly within the fermentor. Additionally, this microfluidic device adds the benefit of reading signals off of individual cells rather than bulk cells, allowing for a detailed quality check of cell state. In this study, the goal was to design and fabricate a microfluidic chip to be tested with continuous flow of an Escherichia coli cell culture. These cells are housed between thin-film electrodes on a glass substrate and a polydimethylsiloxane (PDMS) microfluidic chip. The fabrication of this chip required photolithography, soft lithography, deposition, and lift-off techniques. Preliminary results show that the proposed microfluidic design has the ability to precisely position cells for individual analysis under continuous flow without requiring centrifugation. Instead, the design uses the geometry of the microfluidic channels to align and position cell streams for viability testing through both microscopic imaging and EIS. Insights from such chips indicate a promising method for industrial application in the future.

THESIS STUDENT
Recep Alyamac

ADVISOR: PROFESSOR DOUGLAS DENSMORE

"Protein Expression Optimization with AI"

Abstract

Protein engineering is a rapidly growing field with significant applications in medicine, biotechnology, and agriculture. Despite substantial advancements in the prediction of protein structure and function, optimizing protein expression is still an underexplored area. This project aims to bridge this gap by developing an AI-driven platform for protein expression optimization with a novel approach to generating function-preserving mutations with enhanced expression.

Our proposed solution consists of four key components: (1) an organism-specific machine learning model that predicts protein expression with high accuracy, (2) a mutation engine that efficiently narrows the mutation space while ensuring functional preservation, (3) a ranking system that selects optimal mutants based on expression levels, diversity, and risk assessment, and (4) a user-friendly API and web interface for accessibility and scalability. Unlike existing solutions, which are expensive and require extensive manual intervention, our system leverages computational biology and AI to offer a scalable and cost-effective alternative.

The first semester focused on developing and validating the core components. We achieved a Spearman correlation coefficient of 0.82 for E. coli expression prediction, reduced the mutation space to fewer than 10 million candidates while maintaining high diversity and implemented an initial ranking system using clustering and risk assessment algorithms. During the second semester, an API and Web interface prototype was developed and deployed for ease of use. We also refined our prediction accuracy and expanded our system to five organisms with models for more host organisms still in development. The ranking algorithm was also improved by targeting soluble expression rather than pure expression and we were able to get experimental validation from wet lab results. This research has the potential to significantly impact the synthetic biology space by reducing costs and improving efficiency in protein production.

THESIS STUDENT
Jivesh Jain

ADVISOR: PROFESSOR BOBAK NAZER

"Modifying Transformer Decoding Using Viterbi Algorithm"

Abstract

Large Language Models (LLMs) rely on an encoding-decoding process to generate text. During encoding, an input sentence is transformed into a sequence of numerical representations, which the model processes to understand context. In decoding, the model generates output tokens sequentially, predicting the next word based on previously generated words. However, standard autoregressive decoding algorithms limit LLMs by using only past context, often leading to locally optimal but globally suboptimal predictions.

This project aims to propose another transformer decoding algorithm by integrating the Viterbi algorithm, a dynamic programming approach used in sequence optimization. Instead of selecting each token greedily, our method incorporates both past and future tokens to determine more probable sequences, treating text generation as an optimization problem. By refining token selection based on structured constraints, our approach aims to find more probable text, on average, than standard decoding algorithms such as greedy search. The final deliverable is a modular decoding framework that can be integrated into existing transformer architectures and be used for generating high probability text.

THESIS STUDENT
Wiktor Lidwin

ADVISOR: PROFESSOR LUCA DAL NEGRO

"Physics-Informed Neural Networks for Phonon Boltzmann Transport and Magnetic Resonance Electrical Property Tomography"

Abstract

Physics-informed neural networks (PINNs) represent an emerging framework in natural science and engineering to accurately solve complex differential equation models both in a forward and inverse modality. Building on the universal approximation theorem for multilayer neural networks, in PINNs we use the entire network as a surrogate solution for partial differential equation (PDE) models. The network is trained to minimize the error residuals on a set of randomly distributed collocation points in the solution domain and boundary. Unlike traditional numerical solvers, PINNs use automatic differentiation and powerful stochastic optimization for accurate solutions that are automatically constrained by the physics of the problem. Monte Carlo methods for phonon BTE transport and FEM for inverse tomography are computationally expensive, motivating our efficient PINN approach.

Our work solves the mesoscopic heat transport in semiconductor electronic devices based on the phonon Boltzmann transport equation (BTE) at large temperature gradients. Using relaxation time data provided by our collaborators at the Universities of Utah and Notre Dame, we demonstrate the effectiveness of PINNs in modeling the thermal properties of various compositions of AlGaN. Accurate simulation of AlGaN-based silicon devices lays the foundation for the inverse design of next-generation high-efficiency electronics.

In addition, we use PINN to solve the magnetic resonance electrical property tomography (MR-EPT) problem for non-invasive imaging via reconstruction of the electrical properties (EP). This work utilizes PINN to solve the Helmholtz PDE, which describes how the magnetic field interacts with EP. Working with our collaborators from New York University Department of Radiology, we enhance the accuracy of state-of-the-art MR-EPT PINN architecture, leading the way for high-resolution 3D brain imaging.

THESIS STUDENT
Nicolas Malamug

ADVISOR: PROFESSOR ROBERTO PAIELLA

“Wavelength Independent Metasurface Photodetectors for Compact Phase Contrast Imaging”

Abstract

Angle-sensitive photodetectors, unlike traditional image sensors, can detect the direction of propagation of the incident light. They have been explored as compact, cost-effective solutions for biomedical imaging techniques such as phase contrast microscopy. However, current designs suffer from spectral dependence, limiting their use to controlled environments with single-wavelength laser illumination. This work aims to design and evaluate metasurface-based photodetectors with wavelength-independent angle sensitivity over the ranges of 1510–1640 nm and 1360–1640 nm. The proposed approach leverages data-driven optimization and angle-resolved photocurrent measurements. This research aims to support the development of phase contrast microscopy systems operating under broadband LED illumination, reducing both system cost and speckle-related aberrations.

THESIS STUDENT
Naeel Quasem

ADVISOR: PROFESSOR ENRICO BELLOTTI

"Mercury Cadmium Telluride Photodetector Array Optimization for Long-Wave Infrared Detection"

Abstract

The rising demand for longer-range and highly sensitive infrared radiation (IR) detection in applications such as space exploration and greenhouse gas monitoring calls for increasingly efficient and less noisy devices. Mercury cadmium telluride (MCT) has emerged as a premier semiconductor material for this exact purpose. The alloy's properties such as its tunable bandgap and large optical absorption provide exceptional performance across the entire infrared spectrum. However, a major challenge remains: the fabrication and cooling of MCT devices are remarkably expensive, greatly slowing performance improvements. This thesis focuses on optimizing the quantum efficiency and minimizing the dark current of a 20×20 MCT detector array designed for long-wave infrared detection through a simulation-based approach. Leveraging 3D simulations in Sentaurus, a TCAD software from Synopsys, this research investigates key design parameters, including carrier lifetimes, alloy compositions, and pixel geometries. This research employs advanced 3D simulation techniques developed within our research group, offering a cost-effective and scalable alternative to the costly and complex experimental testing methods. By refining the MCT detector design through simulation-driven insights, this work contributes to the development of more efficient and reliable infrared sensing technologies for critical space-based and environmental applications.

SENIOR DESIGN FACULTY

ALAN PISANO Associate Professor of the Practice

Dr. Alan Pisano received a Ph.D. in electrical engineering from Northeastern University in 1974. He retired from General Electric in January 2010 after a 39-year career there in both Power Systems and most recently Aircraft Engines. There, he was responsible for numerous advanced controls technology programs and held a variety of managerial positions including Manager of Turboshaft/Turboprop Controls and Manager of Advanced Controls Technology and Planning. After retiring from GE as a Department Staff Engineer, he was appointed to the full-time faculty in the ECE Department at Boston University as Associate Professor of the Practice. AY 2024-25 is his final year as lead professor and course coordinator of the capstone Senior Design course prior to a well-deserved second retirement. He will be missed!

Dr. Pisano at various ECE Day celebrations over the last couple of decades.

OSAMA ALSHAYKH **Lecturer & Asst. Research Professor**

Dr. Alshaykh is CEO of NxTec. He was CTO of Packetvideo corporation, Scientist at Rockwell and Visiting Researcher at UC, Berkeley. Osama received a Ph.D. in Electrical and Computer Engineering from Georgia Institute of Technology in 1996. Osama received a Fulbright Scholarship and served as associate editor for IEEE Transactions on Circuits and Systems, Video Technology. He served as consultant, board member and advisor for several companies and groups. Dr. Alshaykh serves as co-instructor of the capstone Senior Design course.

MICHAEL HIRSCH **Research Scientist**

Michael's research focus includes remote sensing and scientific computing. Michael's work connects first-principles space physics and aeronomy models in real-world applications of AI / ML algorithms from edge sensors to HPC. His research helps enable the GNSS receivers in smartphones to serve as a space weather detection network, including the 2024 solar eclipse. Dr. Hirsch serves as faculty mentor for the capstone Senior Design course, guiding student teams tackling data-driven sensing and signal-processing projects.

RYAN LAGOY **Adjunct Professor**

Ryan Lagoy is an Adjunct Professor at Boston University and Director of Hardware, Systems, and Manufacturing Engineering at Starry, Inc. He previously held research and engineering roles at BAE Systems and has contributed to neuroscience and RF systems research at Boston University. Ryan earned his M.S. in Electrical Engineering from the University of Massachusetts Amherst and his B.S. from Boston University. He is an inventor on multiple RF technology patents and has lectured on affordable internet technologies. Ryan has served in leadership roles within IEEE and has been recognized with numerous industry and academic honors for his contributions to engineering innovation and education, including the Michael F. Ruane Award for Excellence in Senior Capstone. Ryan advises Senior Design teams on hardware architecture, RF systems, and product realization, shepherding prototypes from concept to field testing.

TEACHING ASSISTANTS

RACHEL CHAN GST

Rachel is a PhD student in Professor Lei Tian's Computational Imaging Systems Lab. Her research interest is developing computational tools for optical design in biomedical imaging applications. She currently works on PSF engineering for neural imaging.

LUCA ERRICO GST

Luca is a second year PhD student from Politecnico di Torino working in the Computational Electronics Lab. His focus is on numerical methods for ultra wide bandgap semiconductor simulations.

NOLAN VILD GST

Nolan is a PhD Candidate working in Tianyu Wang's lab. He is currently developing novel optical neural networks that push the capabilities of what's possible using photonics and AI.

THANK YOU, CLIENTS
Thanks to all who challenged the seniors with their real-world engineering needs, and encouraged their student team as they worked to solve them.

THANK YOU, ALUMNI JUDGES
Special thanks to our ECE Alumni judges, who took time from their schedule to be here with us today.

THANK YOU, ECE & ENG STAFF
ECE Staff have worked countless hours to support the year-round needs of the Senior Design class, as well as to coordinate ECE Day itself. Thank you all.

and finally, THANK YOU, STUDENTS
Thanks to all the seniors for the months of hard work and dedication put into these projects, from the day you walked into the first session of EC463 at the start of the Fall semester.

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