RUTGERS–NEW BRUNSWICK

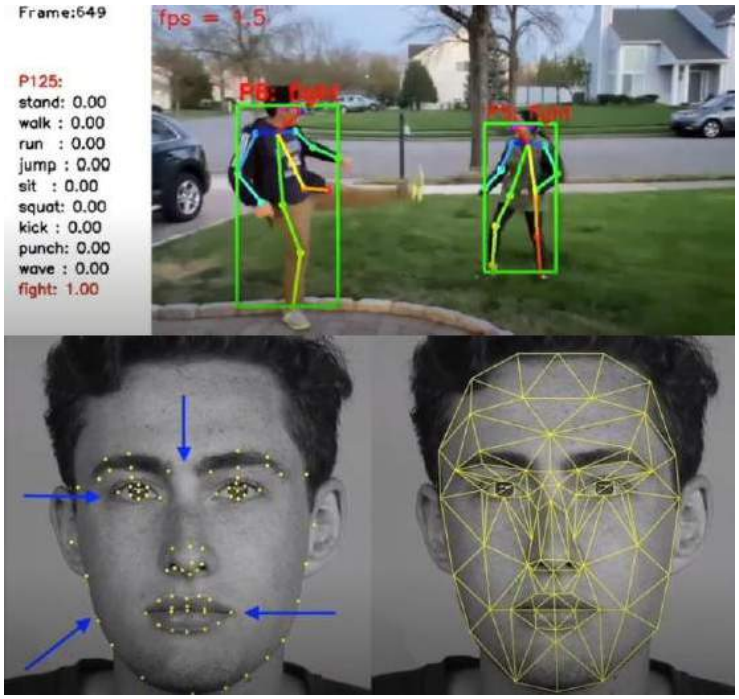
School of Engineering

Department of Electrical and Computer Engineering

Capstone Program Spring 2024

Senior year Design Projects

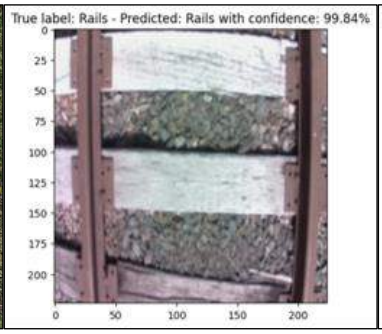
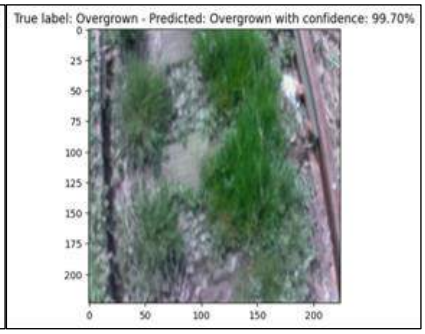
At a Glance



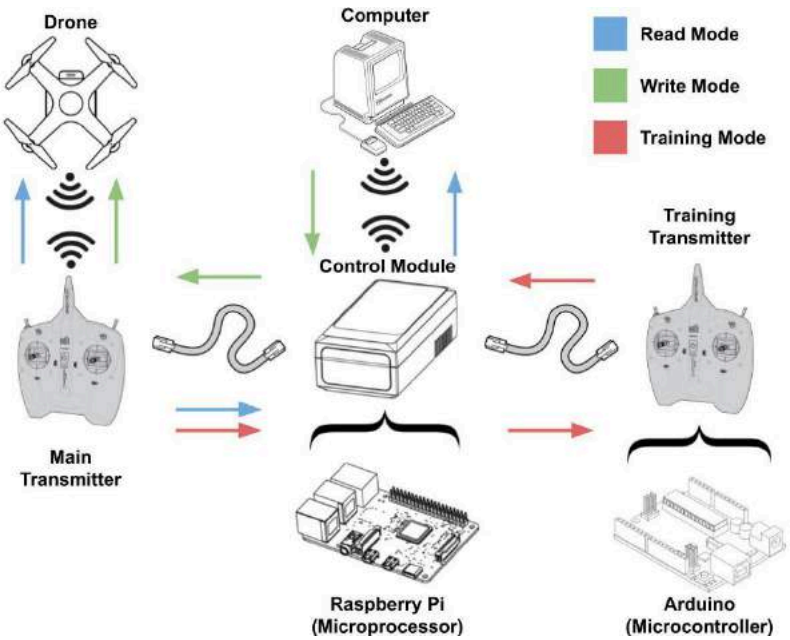
S24-01	**Title**: *RTC with Audio Signal Processing* **Team Members**: *Alden Lipiarski, Deqi Wang, Joseph Kabashima, and Keny Exantus* **Adviser**: Dr. Maria Striki
Keywords	Digital Signal Processing, Real Time Communication, Online Meeting, Audio Quality Enhancement, Noise Reduction
Abstract	This experiment aims to enhance the audio quality across modern real-time communication systems (RTC) systems. This is achieved using a combination of RTC and digital signal processing (DSP). Our implementation consists of a hybrid architecture (client-server and peer-to-peer). Our servers and sockets are deployed using Heroku, which guarantees connection between the peers of the RTC system. Furthermore, for our DSP system, a bi-quad filter is used for equalization and leverages the Web Audio API for efficient audio processing. In the audio engineering field, high-performance end audio interface units enhance audio quality; however, the equipment used is not accessible for most users due to the cost. Moreover, the hardware used for these types of systems requires maintenance and upkeep. Therefore, the motivation for this project stems from wanting to implement this using a software product that enhances the audio quality of an RTC system. The digital signal analyzer along with user presets is provided to seamlessly manipulate the audio quality if necessary. To reduce the latency of our media stream, PeerJs was adopted, enabling our peer-to-peer connection between users to be without lag. Our system further uses the MongoDB database to take the load off our user sockets to manage user information. This hybrid architecture is required for our implementation as it is what model leads to the best performance results. After measuring the performance the median response time of our server was 1.0 milliseconds, and the memory usage fell to 13.3 MB, which was only 2.6% of the server.

Figure 1. Equalizer User Interface.

Figure 2. Equalizer with RTC System.

S24-02	***Title**: RailVision: Overgrowth Detection Drone* ***Team Members**: Steeve Cantave, Osmin Nolasco, Dhruv Patel, James Sullivan* ***Advisers**: Professor Daniel Burbano & Professor Sasan Haghani*
Keywords	Drone, Machine Learning, Overgrowth, Infrastructure Maintenance, Railroad Safety
Abstract	Each year, billions of dollars are spent by North American Class 1 Carriers for rail maintenance. One of the issues that pose various risks is the overgrowth of vegetation along railroad tracks. This overgrowth creates safety hazards, fire hazards, infrastructure damage, and leads to negative economic and environmental impacts. Current overgrowth maintenance techniques require inspectors traveling along a rail line for hours, manually keeping an eye out for any signs of overgrowth. These manual inspections are time consuming and expensive and it has been shown that it is difficult for inspectors to maintain consistency with the regulatory standards. Each inspector tends to have their own definition of 'overgrowth,' and likely due to the mundaneness of the task, their definitions tend to change as the inspection goes on. To address this, we built an autonomous vertical take-off and landing drone using the energy efficient 4+1 quadplane configuration. The quadplane autonomously flies alongside railroads and detects cases of vegetation overgrowth. The quadplane is equipped with a camera, GPS module, and companion computer. The companion computer, utilizing our image classifying convolutional neural network (RailNet), differentiates between images of maintained or overgrown rails in real time. If RailNet determines a segment of the rail has any overgrowth, the companion computer obtains the GPS coordinates from our GPS module, and subsequently packages this alongside the image to be sent to railroad maintenance. Through RailVision, we aim to contribute to the safety of maintenance workers, address the inefficiencies and failures of manual overgrowth checks, improve the lifespan of our railroad infrastructure, and make leaps toward preventing wildfires, to better conserve our infrastructure and environment.  Fig. 1: VTOL Quadplane  Fig. 2: Example of Clean Rail Inference  Fig. 3: Example of Overgrown Rail Inference

S24-03	***Title***: *Drone-Assisted Replication Training* ***Team Members***: *Aaron Yagudayev, Ryan Meegan, Keyur Rana, Sean Maniar, Jinam Modasiya* ***Advisor(s)***: *Dr. Laleh Najafizadeh (ECE), Dr. Laurent Burlion (MAE)*
Keywords	Drone, flight training, wireless communication, replication learning, haptic feedback
Abstract	Introducing DART: Drone-Assisted Replication Training. An instructor will pilot the drone using their transmitter, and we will record this to create a benchmark flight path (think of it as a training drill). The flight path can then be replayed and the student can attempt to replicate this path using their own transmitter for the following modes: trace mode, live trace mode, and comparison mode. Trace mode allows students to feel the instructor's control inputs directly on their transmitter from a pre-recorded flight path, helping them become familiar with the joystick movements for a given flight path. Conversely, comparison mode challenges students to recreate a flight pattern independently while receiving real-time feedback through vibration motors and sound cues, enhancing their control skills. Additionally, we have also implemented a live trace mode where the student transmitter has servo-controlled joysticks which can trace the instructor's inputs live, adding another interactive method for the instructor to guide the student. Key features of DART are its real-time feedback mechanisms such as servo-controlled joysticks, haptic feedback, and sound feedback, which facilitate immediate corrective actions and tailored instruction, flattening the learning curve. This training methodology can be utilized by professional athletes, surgeons, musicians, robotics, and any domain where fine motor control is a key component.



System Block Diagram

S24-04	***Title***: *FACTS Improvement Initiative* ***Team Members***: *Sharad Prasad, Qadis Chaudhry, Daniel Bhavsar, Simon Grishin* ***Adviser***: *Alex Reedy, Matteo Turilli, Shantenu Jha*
Keywords	Restructuring, Kubernetes, Distributed Programming, Docker, Containerization
Abstract	FACTS is the Framework for Assessing Changes To Sea-Level. Used to predict uncertainty in future global, relative, and extreme sea-level change, it provides imperative information used in shaping our future. The current FACTS team, consisting of climate researchers and domain scientists, requested our team to build an optimized framework that can improve current computing process. By incorporating parallel and distributed computing processes using clusters and resource allocation techniques we designed, we were able to create a more efficiently functioning framework than that which was present. Additionally, maintaining consistency and integrity of the domain research while improving usability and overall efficiency was an important consideration. The architecture will be designed and implemented such that the framework present is able to communicate effectively within itself, as well as function in a host of different environments. The proposed and accepted solution uses a plethora of technologies including Docker and Kubernetes to handle the local resources efficiently and allocate runtime clusters depending on deployment criteria. Furthermore, we restructured the current computational structure to simplify and containerize each individual module for easier debugging and reduced runtime requirements. The new framework is more adaptable to the required resource and module computation by separating the modules to run in their own environments and in parallel using Kubernetes management resources. Lastly, to measure the efficiency of our implementation we added a memory profiler to track the runtime and the memory usage for different runs.

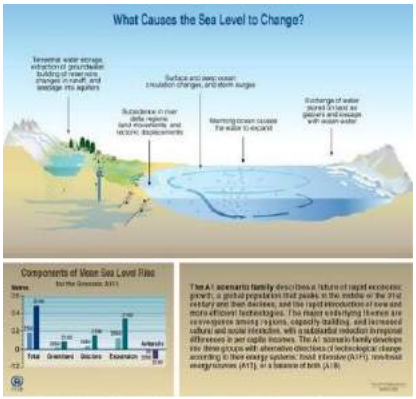


Fig. 1 Memory usage comparison for the current framework and the improved framework using Kubernetes.

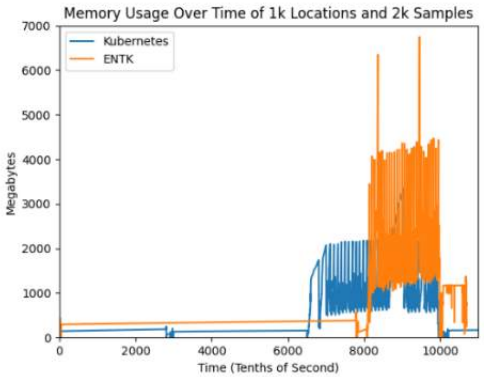
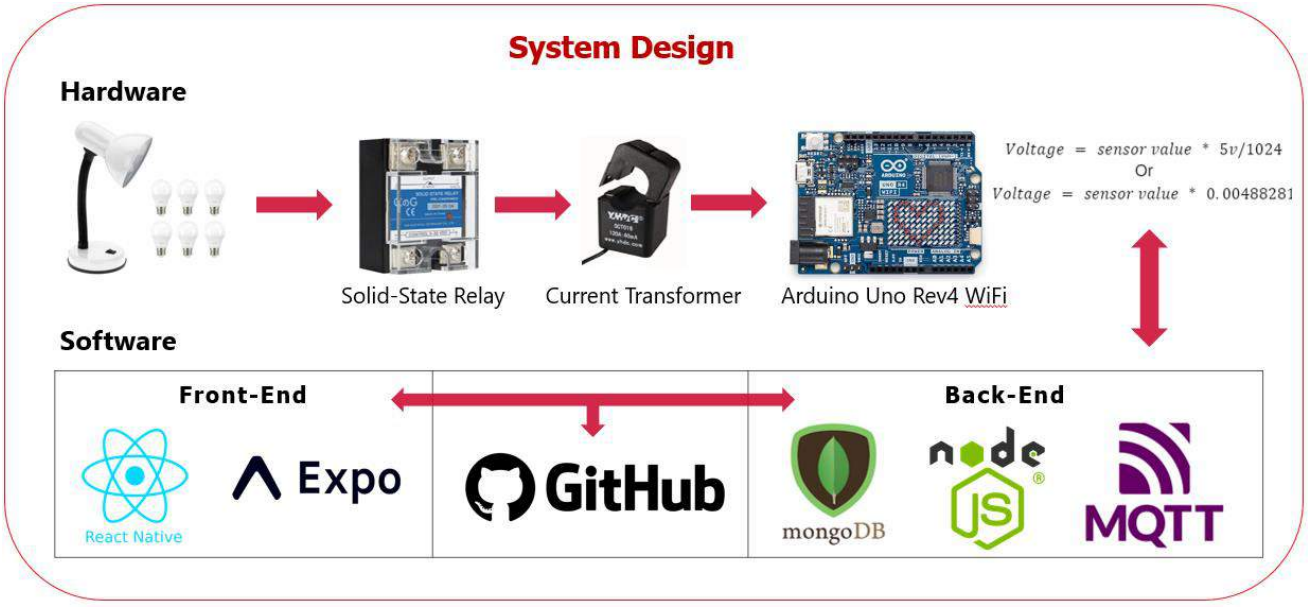
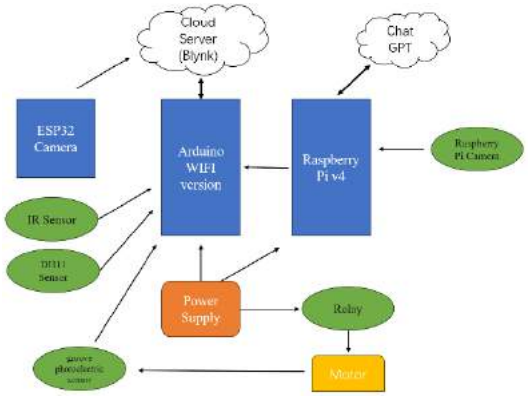


Fig. 2 Visual representation of the causes of sea-level rise causes

S24-05	***Title**: Home Energy Monitoring & Management System* ***Team Members**: Pranav Angiya Janarthanan, Monali Mohapatra, Katherine Moreira, Sean Rogers, and Aditya Sharma* ***Advisor**: Dr. Michael Caggiano*
Keywords	Energy Monitoring, Smart Device, User-friendly Interface, Smart Home Technology, Machine Learning
Abstract	Team SP24-05 has developed an energy monitoring and management system, integrating hardware and software components to provide users with a comprehensive solution. Central to this system is the hardware components which is a power strip capable on controlling the state of appliances and transmit power consumption data to the software for accurate consumption analysis. The utilization of a solid-state relay allows for the control of individual devices, a current transformer allows for the power consumption to be measured, and a microcontroller allows for the communication of the hardware design with the software component. The software has three main segments: the data collection of the hardware components, a backend server which will receive and process the raw power data, and the front end for user interaction and the presentation of relevant information. The software enables users to receive custom notifications and recommendations for efficient energy usage. This approach aims to empower users with precise insights into energy usage, fostering responsible consumption and simplifying household contributions to simplify a household's contribution towards energy conservation efforts while decreasing utility costs for consumers.



Above: Building blocks of design for the hardware and software components

S24-06	***Title***: *AI-Based Campus Patrol Robot* ***Team Members***: *Yuxiang Fan, Weijie Yu, Pengchong Xu, Zihan Wang* ***Adviser***: *Prof. Sheng Wei*
Keywords	Arduino, Raspberry Pi, Blynk, GPT4, Crowd Density
Abstract	Our project is an AI-based Campus Patrol Robot designed to provide real-time information about campus situations and maintain campus security. The robot mainly consists of Arduino and Raspberry Pi, which are the most crucial central control components. Among them, Arduino serves as the robot car's sensor data collection, autonomous navigation, and data upload platform. Raspberry Pi is used in computer vision to capture images, upload, receive GPT4 data, and detect crowd density based on OpenCV. This artificial intelligence-based robot car also utilizes infrared distance sensors and groove photoelectric sensors to follow routes, detect obstacles and people. As the robot car patrols the road, it can collect data through a camera and then send the images to GPT4 to identify potential threats on campus. This novel design of the robot car will improve patrol efficiency and help reduce the burden on the police. It also reduces police response and call times, which can help police act faster and resolve emergencies better, thereby reducing crime, keeping students and university staff safe.   

S24-07

***Title**: RINSIGHT - Real-time Interactive Neural Sensory Integration Glasses for Hearing Technology*

***Team Members**: William Ching, Jonathan Romero, Aliza Ezrapour, Aman Saxena, Matthew Gravatt*

***Adviser**: Dr. Sheng Wei*

Keywords Smart Glasses, Assistive Technology, Wearable Technology, AI for Accessibility, Speech-To-Text

Abstract

In a world where nearly 430 million people experience debilitating hearing loss, the need for innovative communication solutions is more urgent than ever. The RINSIGHT project introduces a groundbreaking approach to assistive technology through the development of smart glasses designed specifically for individuals with hearing impairments. Utilizing a combination of AI technologies and advanced wearable design, these glasses offer real-time transcription of spoken words into text displayed on a micro OLED screen, directly within the user's field of vision.

The core technology integrates a neural sensory system that processes audio signals with high accuracy, even in noisy environments. This is facilitated by sophisticated firmware housed within a specially designed PCB, supported by the ESP32-PICO-D4 microprocessor for optimal power and connectivity. The device not only transcribes speech but also supports interactive features such as a translation module and text-to-speech capabilities, enhancing communication between hearing-impaired users and those unfamiliar with sign language.

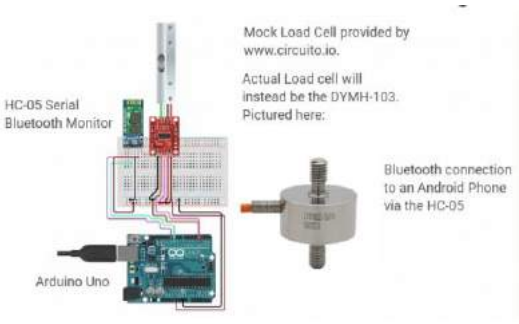
Our team has navigated numerous challenges, including the integration of complex hardware components and the development of a user-friendly R-INSIGHT companion app. The project aims not just to create a tool for better communication but also to foster inclusivity and independence, offering a cost-effective alternative to traditional hearing aids.

The potential impact of RINSIGHT is significant, promising to transform everyday interactions for millions, making communication more accessible, and ultimately, enhancing quality of life.

RINSIGHT Smart Glasses and Mobile Companion App

S24-08	***Title***: *Ten(Sen)sor* ***Team Members***: *Gurveer Grewal, Danial Fahim* ***Adviser***: *Demetrios Lambropoulus*
Keywords	Arduino, Mobile App Design, Fitness, Health, Force Detection
Abstract	Regular physical exercise, particularly weightlifting, is fundamental for a healthy lifestyle. However, improper form during exercises like the deadlift can lead to severe back problems, hindering fitness progress and diminishing quality of life. Our capstone project addresses this issue by focusing on raising awareness about the importance of proper deadlift form and implementing a technological solution to assist users in maintaining correct posture during lifting. By utilizing load sensor technology, our project aims to detect improper form during the deadlift by measuring force on the back. A load cell anchored on the upper and lower back detects deviations from the ideal straight posture, indicating potential injury risks. We developed a mounting rig using a high-strength rope to connect the load cell securely to the user's back, ensuring accurate readings. Through extensive research, we identified a suitable load cell capable of detecting up to 20kg of force, providing versatility for various body types and lifting techniques. Additionally, we created a mobile application to complement the hardware solution. The app, built using the MIT App Inventor, serves as a controller for the load sensor and provides users with real-time feedback on their lifting form. Furthermore, the app offers tutorials, exercise logging capabilities, and resources on correct form to enhance users' health and fitness journey. Our end goal is to create a comprehensive system that fits diverse users comfortably and educates them on proper deadlift technique, ultimately preventing severe injuries. By combining technological innovation with fitness education, we aim to empower individuals to lift safely and effectively, promoting long-term well-being and fitness progress.

Ten(Sen)sor Mobile App



Load Cell Configuration

S24-09	***Title***: *Gesto Glove* ***Team Members***: *Peter Wilmot, Anthony Triano, Ryan Han, Anthony Kam* ***Adviser***: *Ivan Seskar*
Keywords	3D-printing, Arduino, Motors, Wearable Technology, Virtual Reality
Abstract	Strokes, caused by blockages in arteries, deprive the brain of oxygen, leading to neurodegeneration and impairments in movement. Despite affecting nearly 800,000 Americans annually, only 10% recover completely. Our project aims to reduce the time from stroke onset to recovery by creating a glove that stimulates hand movements, potentially improving recovery rates. Existing innovations such as the "SaeboGlove" lack finger control, while others with electronic signals or air pressure lack precision. Our glove will provide precise finger movement with variable torque, aiding muscle mass and coordination. Additionally, the glove can be used as an everyday tool if needed to help those who can't fully recover. In virtual reality, our glove will act as a haptic feedback device, offering realistic sensations for object manipulation. Unlike current gloves, it will offer precise pulling and pushing motions. We'll employ servo motors controlled by an Arduino Nano for finger movement, utilizing their precise positioning and torque. 3D printing will be used to form the housing, while fishing lines connected to the servos will mimic tendons for natural movement. Advanced programming will track finger position, ensuring accuracy. Our product development process involves CAD design, prototyping, and iterative improvements. We'll customize gloves for individual users as needed. Ultimately, we aim to produce a functional prototype capable of accurately tracking and modifying hand movements, potentially revolutionizing stroke rehabilitation.

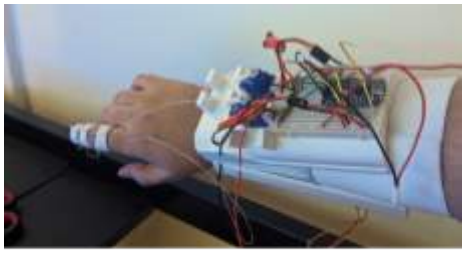


Figure 1. Prototype on a real hand

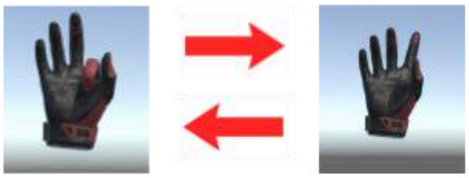
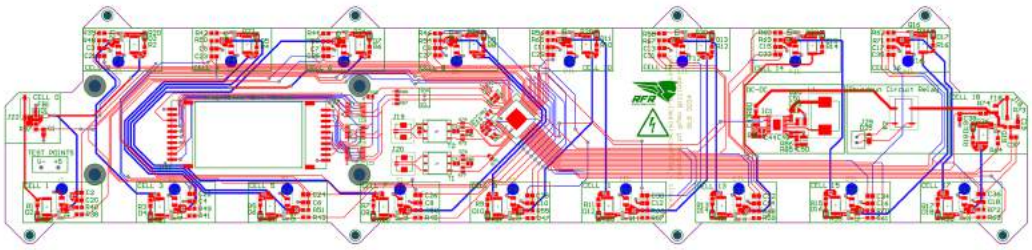
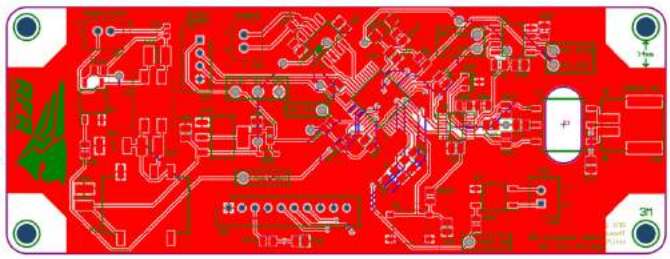
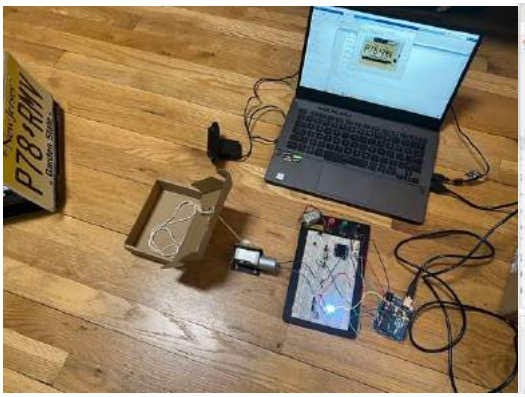


Figure 2. Demonstration of Finger Curl/Extension based on motor position

S24-10	**Title**: *Design and Application of a Battery Management System for a Formula-Style Car* **Team Members**: *Ryan Billings, Dana Fabiano, Tommy Forzani, Daniel MacCormack, Mukund Ramakrishnan* **Adviser**: *Dr. Michael Caggiano*
Keywords	battery management system, Li-ion battery pack, passive balancing, electronics, power
Abstract	This project is inspired by the work that some of our teammates have done for the Rutgers Formula Racing (RFR) student organization. FSAE is a competition in which student teams build formula-style racecars. All-electric vehicles (EVs) used for this competition require a battery management system (BMS) to prevent over/undervoltage of lithium-ion cells, thermal runaway, to compute the state of charge (SoC) of the battery pack, prevent overcurrent due to a short circuit, detect faults, and communicate information with other devices in an EV, such as an inverter or dashboard. The design of a BMS within formula-style racecars poses hardware integration, safety, and regulatory compliance with the competition's ruleset. RFR currently relies on an off-the-shelf BMS. Off-the-shelf components have limitations concerning packaging efficiency and hardware integration. These limitations cause constraints on other designs within an EV. Building a custom-designed Battery Management System (BMS) circumvents these limitations, while also being substantially less expensive than the prevailing off-the-shelf options. The objective of this capstone project is to build a BMS to circumvent the design limitations imposed by off- the-shelf solutions.  Figure 1. The PCB layout of the balancing board.  Figure 2. The PCB layout of the control board.

S24-12	***Title***: *License Plate Identification At The Garage Gate: Enhancing Security and Efficiency with Intelligent Systems* ***Team Members***: *Dehui Zhang, Liurui Xu, Yubo Su, Zipeng Ni* ***Adviser***: *Guosong Yang*
Keywords	MATLAB, Camera, automation, Smart home
Abstract	This project aims to improve the safety and convenience of people, especially the elderly and disabled, by simplifying the process of getting from their cars to their homes. The project utilizes an intelligent system driven by MATLAB to help people arrive home, especially when they enter their home from their car. The system's approach involves recognizing license plates as the car approaches the garage. Once the license plate is recognized, the system automatically performs actions such as opening the garage door, turning on lights and unlocking the door. These automated processes are critical because they not only simplify the process of arriving home, but also reduce the risks in poorly lit conditions. Additionally, automated processes can significantly reduce the probability of burglary due to people forgetting to close their garage doors. This innovation extends beyond simple entry tasks. It has the potential to be integrated with a variety of home automation functions, such as adjusting the thermostat, deactivating the security system, and activating the indoor monitoring system. Overall, the goal is to simplify life and provide peace of mind, increasing autonomy and security in the living environment. The project not only enhances the user's daily life, but also offers the potential to further increase home automation, creating a safer and more comfortable home environment. The project marks the beginning of a wider range of applications that will further simplify and protect home activities.  MATLAB Program with garage demo  MATLAB Plate identify program

S24-13

***Title**: Interview Preparation AI Chatbot*

***Team Members**: Aryan Doshi, Kylenino Espinas, Parth Gujrathi, Matthew Kokolus, Rohan Kumar*

***Advisor**: Professor Anand Sarwate*

Keywords Interview Preparation, Artificial Intelligence, Professional Skill Development, Interactive Learning, Natural Language Processing

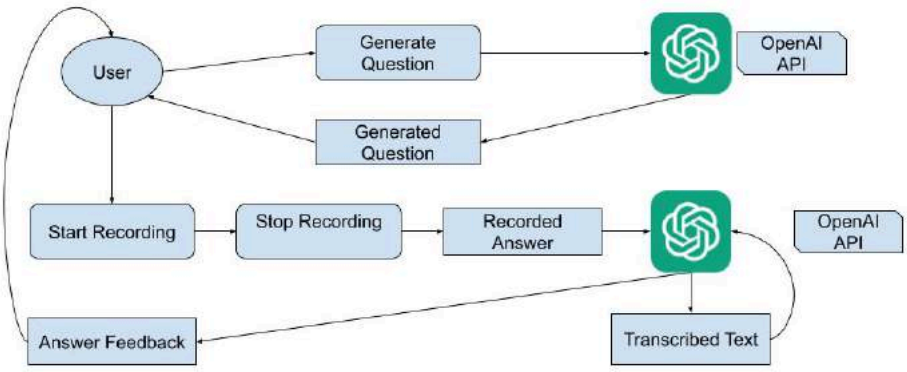
Abstract:

The objective is to create an all-encompassing full-stack web application tailored to aiding users in optimizing their interview preparation endeavors. Users of the platform receive AI-based interview questions with instant feedback and tailor-made recommendations for improvement in order to have their toolset to learn and improve their communication skills, which are the keys to success in a wide spectrum of interview situations.

It also provides users with instant feedback after every question. They get guided feedback on their performance from advanced AI, along with actionable ways in which they should improve their interviewing ability. This feedback mechanism provides for and empowers the users to fill the communication gaps wherever and whenever they see them so that there is continuous improvement and growth.

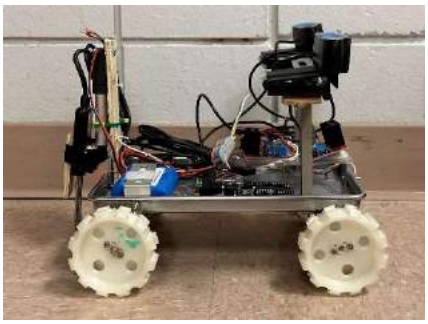
It also has a feature for providing personal improvement advice in light of the data on performance and communication style patterns. With that, when analyzing user interaction and feedback, the platform churns out customized advice and resources aimed at an effective way of strengthening your interview skills. The suggestions offered include educational resources and strategies to defeat specific communication challenges so that users can be accorded targeted support as per their needs.

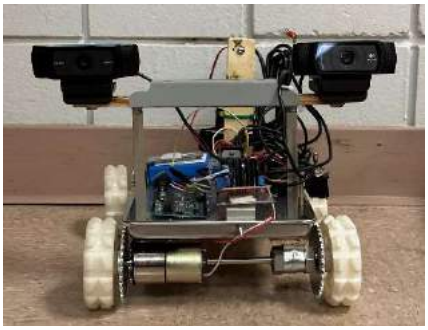
Interview preparation has never taken the form of a dynamic and interactive process before this thorough full-stack web application. It leverages generative AI-driven simulations with real-time feedback and personalized recommendations for improvements. This, in turn, means that users have at their disposal everything they might need to ace interviews and eventually end up fulfilling their professional dreams.

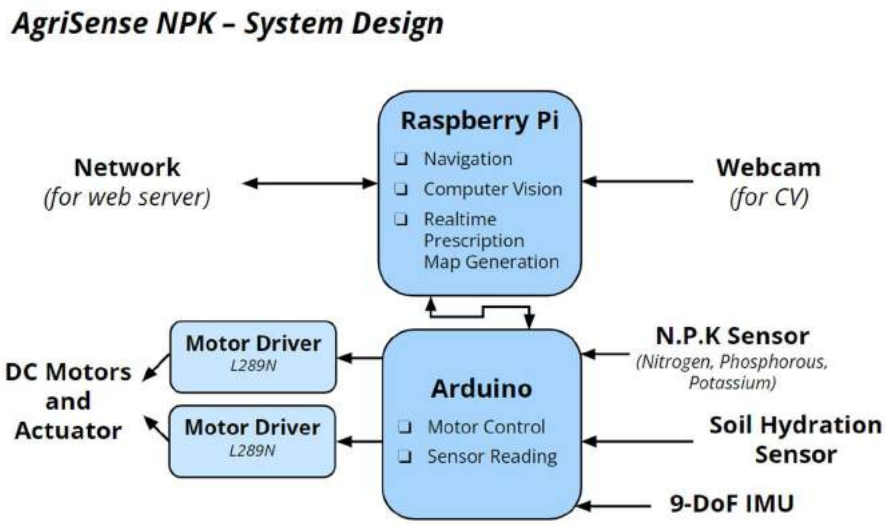


System Architecture Flowchart for AI Interview Chatbot

S24-14	***Title***: *AgriSense NPK – Autonomous Mapping of Water and Fertilizer Levels in Soil* ***Team Members***: *Joseph Arrigo, Anthony D'Agostino, Ali Eke, Briella Payami* ***Adviser***: *Kristin Dana, Sasan Haghani*
Keywords	Agriculture, Robotics, Sensors, Computer Vision, Mapping
Abstract	AgriSense NPK is an autonomous robotic land vehicle that utilizes both sensors and computer vision to navigate agricultural fields and perform on-site soil sampling to generate a prescription map with real-time feedback. The agriculture industry lacks an abundance of modern technologies to optimize soil treatment for crops, and as a result, there is often widespread misuse of water and fertilizer on farms, which can devastate local ecosystems and harm crop yields. This project provides a low-budget robotic solution to large-scale soil monitoring which helps reduce the misallocation of resources, support maximum crop yield, and improve sustainability. The robot uses two cameras to generate stereo disparity maps in order to triangulate relative distances of objects and navigate around them autonomously. As opposed to collecting soil samples for remote testing, AgriSense NPK performs on-site soil sampling through a series of probes attached to an actuator mechanism to measure nitrogen, phosphorus, potassium, and moisture concentrations. The real-time data is converted into a prescription map, which details fertilizer levels for each subdivided region, and displays it in a user-friendly interface. This solution has the potential to give farmers a better understanding of resource distribution, prevent unnecessary losses, and prevent harm by normalizing the amount of water and nitrogen entering local ecosystems.







S24-15	***Title**: IoT Mobile Application for Alzheimer's Disease Caregivers* ***Team Members**: Logan Pasternak, Monica Rubens, Ameek Chadha, and Christian Yanez* ***Adviser**: Sasan Haghani*
Keywords	Visual Short Term Memory (VSTM), QoL (Quality of Life), IoT, Mobile application
Abstract	The work being proposed in this project is the testing of a prototype mobile application which integrates Internet of Things (IoT) technology to enhance the QoL of Alzheimer's disease caregivers. The app has six main functionalities: medication management, facial recognition, biometric data logging, tumble detection, VSTM evaluation, and patient location tracking. The medication management feature allows a caregiver to set reminders about when medications need to be administered to a patient. The facial recognition feature allows a patient to identify friends and family members with the use of a live-streaming miniature camera attached to a pair of glasses. The camera sends data to a remote server that is preloaded with images of friends and family. The server executes facial recognition analysis and updates the patient whenever there is a match. Biometric data monitoring and tumble detection allows a caregiver to receive real time updates on patient health. Heart rate, temperature, and acceleration data is transmitted from a wrist bound sensory device. A caregiver receives an SMS notification when abnormal readings occur. VSTM evaluations are directly administered on the app and allows a caregiver to monitor the status of a patient's condition. Finally, the patient location tracking aspect of the application allows a caregiver to identify the location of a patient among a set of rooms within a home using PIR sensors. If a patient leaves their home, then an SMS notification will be sent to the caregiver instructing them to monitor the patient's location using an apple airtag.

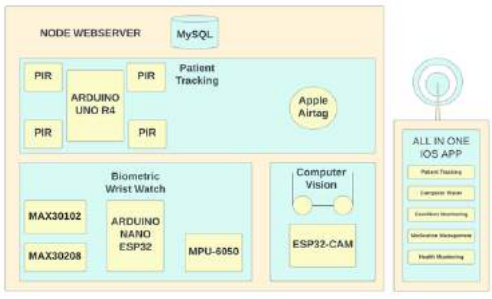


Figure 1. Project feature overview

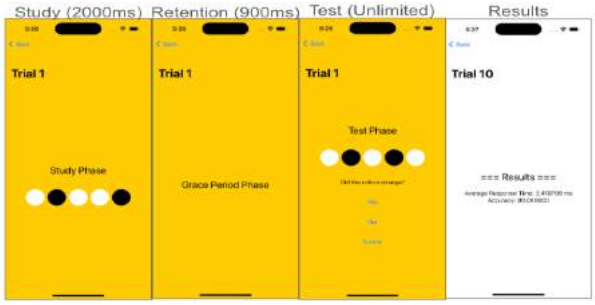
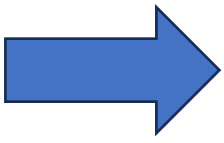
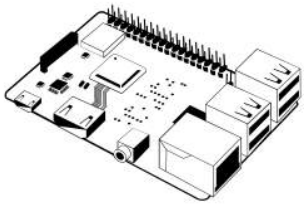


Figure 2. VSTM Trial Phases and Result in App

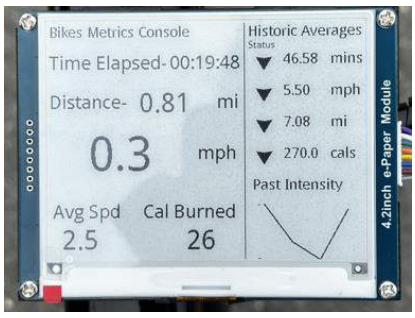
S24-16	***Title***: *Bike Metrics Console* ***Team Members***: *Amir Michael, Pietro Mandato, Ashwin Penumetch, Anthony Zappone, Alex Cherfane* ***Adviser***: *Sasan Haghani*
Keywords	Fitness, Raspberry Pi, Data Analytics, Motion Sensors
Abstract	This project seeks to bring the advantage of having statistics about the current exercise session to outdoor bicycle riding. Additionally, building upon that with historical data analytics to improve goal attainment. Performing cardio on stationary machines in a gym has the benefit of showing current workout session data such as distance traveled, calories burned, and average rate of travel. When riding a bike outside there are no indicators of the exercise being performed. This introduces limitations when trying to train for specific goals. The current state of technology in this sector revolves around communicating data collected by clip-on bike trackers to other devices such as smartphones. Then, the data is read by phone based software like Health Data and Exercise applications. The objectives of this project are firstly to create a bike tracker that can show information about the current workout including speed, distance traveled, and calories burned. And secondly, to show trends of that data from past workouts all on the same device. Current bike trackers don't have the ability to store data from past workouts and show trends. By building our bike tracker using the Raspberry Pi platform, our device has the capability to not only show information about the current ride, but trends from past rides. We use a Raspberry Pi with an attachment to a display and a battery to power it, along with a GPS sensor and accelerometer. The data collected is sent to the Raspberry Pi for computation and storage before showing the desired fields such as speed, distance, calories, and workout time.

GPS data collected from satellites





Compute metrics, read/write to storage



Display current and historical metrics

Outdoor bike workout

S24-17	***Title**: motorVision: System for Intelligent Hazard Detection for Motor Vehicles* ***Team Members**: Lance Tago, Sam-Fone Cheung, Michelle Lee, and Brian He* ***Adviser**: Dr. Bo Yuan*
Keywords	Embedded Computer Vision, Machine Learning, Image Processing, Road Surface Detection, Driver and Road Safety
Abstract	Each year, nearly one-third of all road accident fatalities result from poor road conditions, with potholes being the most common among these conditions. Despite their widespread presence on streets, roads, and highways, potholes lack the necessary warning signs and markings, rendering them a significant hazard to drivers and motorists. To resolve these issues, motorVision employs a system that performs computer vision and machine learning (ML) algorithms to offer real-time video feed for the detection of hazardous road conditions while driving. motorVision uses an LCD camera to capture images, which are then processed by our modified computer vision and ML algorithm. Subsequently, the processed data identifying road hazards is displayed on the LCD monitor, providing real-time alerts to the driver regarding potential dangers. Our processing unit, the NVIDIA Jetson Nano, is responsible for executing the entire project, serving as the central unit for its operation. Our ML model is trained using open-source repositories, enabling it to accurately recognize potholes on the roads captured by the camera module. The model then applies precise bounding boxes around these potholes to facilitate accurate detection. We expect motorVision to deliver a responsive system that provides motorists and drivers the ability to detect and navigate hazards in high-speed conditions with minimal latency, thereby augmenting road safety.

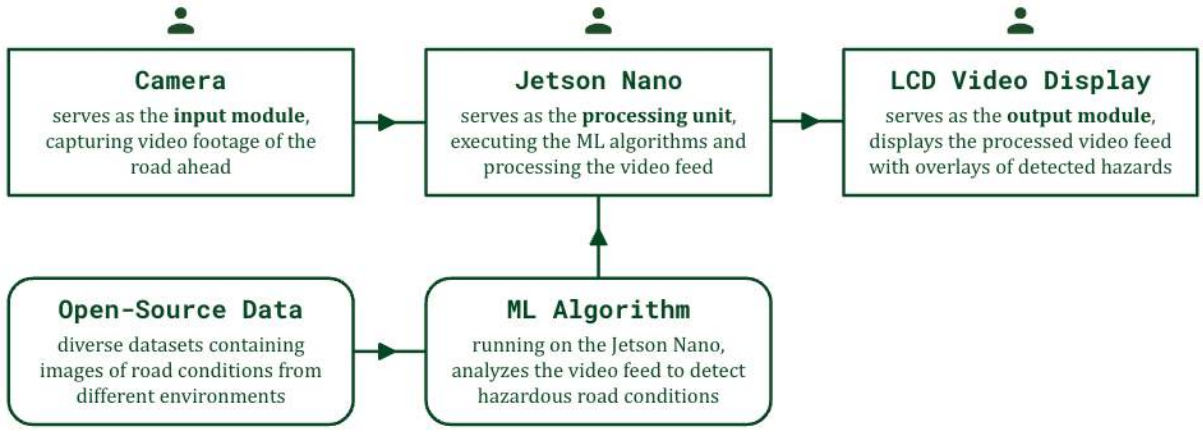


Figure 1: The figure illustrates our project's theory of operation. The user icon indicates which of the system's features the end-user has access to. Our machine learning algorithm leverages open-source data for training and testing, and it is integrated with the Jetson Nano processor.

S24-18	***Title***: *Electronic Patient Monitoring System* ***Team Members***: *Joseph Saffioti (POC), Eric Wu, Drew Mastronardi, Jurgen Haxhiu, Eghosa Omwan-Ehioba, Hector Roman* ***Adviser***: *Dr. Sasan Haghani*
Keywords	healthcare, patient monitoring, biomedical
Abstract	The modern healthcare system relies heavily on devices that track patients' condition using multiple metrics and various methods of transmitting and visualizing data. These devices are mainly used to tend to patients who have been admitted into their rooms and are under care by a physician. However, patients outside the rooms who are waiting to be admitted receive almost no tracking, and healthcare staff may end up missing vital data about these patients in the time before they are properly monitored. Our project seeks to address this issue by designing a small, wearable device and accompanying software application that can autonomously track patient data, transmit it to healthcare staff, and alert staff if abnormalities are detected. This is accomplished using a WiFi-enabled Arduino microcontroller and several sensors, that, when connected to an MQTT-based broker, can securely send messages to healthcare staff. In our design, the device would monitor things like heartrate, blood oxygen concentration, and temperature. These values would be tracked over time in a user-friendly desktop application that a hospital's staff would always have access to. Our device's primary mode of data transmission is WiFi, meaning that it could have applications for long-distance monitoring of at-risk patients in addition to in-house monitoring.  *Figure 1: Example of Data Graphed by our Desktop Application*  *Figure 2: High-level Diagram of our Communication System*

S24-19	***Title***: *RFID Wallet* ***Team Members***: *Louie Saez, Vahid Afsari, Clyde De La Cruz, Nabhan Zaman, and Eseosa Omwan-Ehioba* ***Adviser***: *Prof. Anand Sarwate*
Keywords	RFID, simplicity, compact, microcontroller, efficiency
Abstract	This project introduces a novel RFID wallet card designed to revolutionize access control systems. The RFID wallet card presents a versatile solution, capable of accommodating multiple access keys within a single, lightweight, and convenient form factor. This innovative card, featuring multiple programmable RFID tags, is designed to enhance convenience and security for an everyday user. It promotes the shift from individual, nonconforming keys to a unified collective system, which can integrate several areas of access. The project integrates multiple RFID inlay tags within the card, each functioning as a unique key with its own ID. To prevent tag collision and ensure fast authentication, a UHF reader with built-in anti-collision software is employed. The card's assembly utilizes 3D printing for precision durability, while verification features like LED lights and buzzer enhance user experience. The design also allows for the addition of external signals increasing adaptability. The project responds to a clear demand for streamlined access management in both personal and professional settings.


```
22:48:50.637 -> Scanning
22:48:50.872 ->  EPC_STRING_DATA: R U T G E R
22:48:50.919 ->  EPC_STRING_DATA: R U T G E R
22:48:50.966 ->  EPC_STRING_DATA: R U T G E R
22:48:51.013 ->  EPC_STRING_DATA: R U T G E R
22:48:51.013 ->  EPC_STRING_DATA: R U T G E R
22:48:51.667 -> Scanning
22:48:52.659 -> Scanning
22:48:52.893 ->  EPC_STRING_DATA: B Y E B Y E
22:48:52.941 ->  EPC_STRING_DATA: B Y E B Y E
22:48:53.646 -> Scanning
22:48:54.632 -> Scanning
22:48:55.664 -> Scanning
22:48:56.638 -> Scanning
22:48:56.826 ->  EPC_STRING_DATA: S P R I N G
22:48:56.873 ->  EPC_STRING_DATA: S P R I N G
22:48:56.873 ->  EPC STRING DATA: S P R I N G
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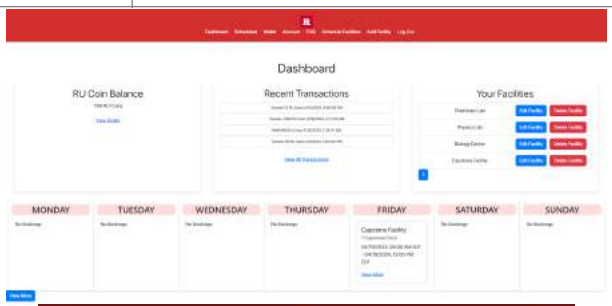
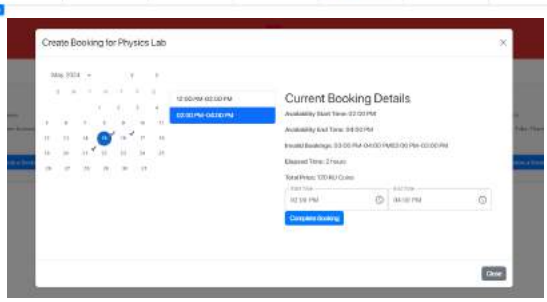
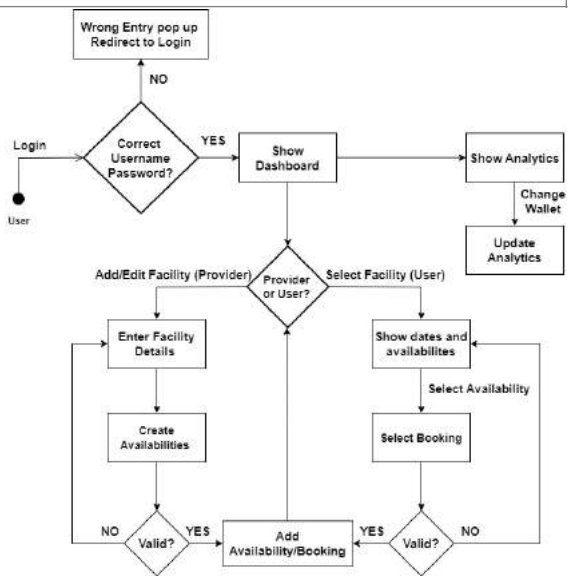
Readability of various EPC in short succession

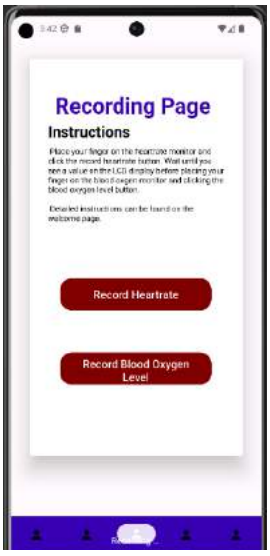
S24-20	***Title***: *RU Cores Wallet* ***Team Members***: *Mehraaj Tawa, Sahmi Abubakar, Varsini Dhinakaran, Kavin Sakthivel, Konrad Radecki* ***Adviser***: *Dr. Wade Trappe*
Keywords	*React, Express, JavaScript, MySQL, Financial Management, Research Facilities, Quality Improvement*
Abstract	In order to eliminate the need for third party systems like iLab, the RU Cores Wallet project introduces a centralized, in house financial management system for renting core facilities. While iLab is a robust service, it has some limitations in flexibility, user-friendliness, and incorporation with Rutgers infrastructure. Moreover, the project is not merely about developing a new system; it's about redefining financial management in core facilities. RU Cores Wallet uses a virtual currency unique to Rutgers, RU Coins, to streamline transactions, which can be earned through Rutgers activities or topped up by paying real money. All accounts are linked to Rutgers financial accounts for easy transfer of research grants/funds into RU Cores Wallet. Of the two types of accounts, users in the app can manage their finances and schedule appointments, while providers can view their service appointments and manage incoming revenue. Both account types can view transaction logs for previously made transactions for auditing purposes and data analytics to view spending/revenue trends and other beneficial statistics. Using Express, React, Javascript, TypeScript, and MySQL alongside common security practices, the web based application will be available for Rutgers personnel to manage scheduling CORE services. This solution enhances budget tracking through analytics, simplifies fund allocation through linking Rutgers finance accounts, and offers a more intuitive and user friendly experience. Our solution has also been containerized using Docker in order for easy scalability for future updates and optimizations.



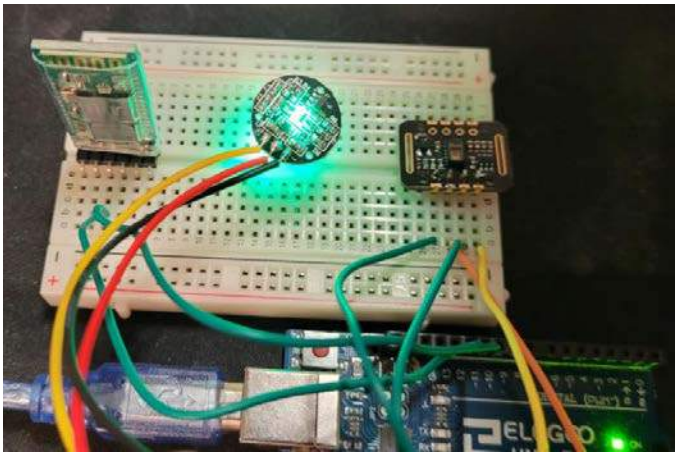




S24-21	***Title***: *Stress Monitoring Device* ***Team Members***: *Nathaniel Lin, Nelusha Dias, Ryan Lin, Afreen Fatima, Sebastian Gonzalez* ***Adviser***: *Umer Hassan*
Keywords	Arduino, App, Health, Biomarkers
Abstract	The project aims to develop a noninvasive stress monitoring device that measures biomarkers such as heart rate and blood oxygen levels. The primary goal is to provide a user-friendly approach to stress monitoring, allowing individuals to easily track their stress levels and take appropriate actions to manage them. On the hardware side, the project integrates a heart rate monitor, a pulse oximeter, an Arduino UNO microcontroller, and a Bluetooth module. These components work together to collect and transmit data, which is crucial for accurately assessing stress levels. The software aspect of the project includes the development of a mobile application, and this app will serve as the interface through which users can receive feedback about their stress levels and access resources to help them manage stress. The app will be designed to be intuitive, ensuring that users can quickly understand their stress data and take action accordingly. Additionally, there is a stretch goal of integrating the hardware into a wearable device for continuous monitoring. This would enable users to track their stress levels throughout the day and identify patterns that may be contributing to their stress. Overall, the project aims to differentiate itself from other stress monitoring technologies released in 2023-2024 by focusing on noninvasive biomarkers and a user-friendly approach. By providing individuals with a simple and effective way to monitor their stress levels, the project has the potential to greatly improve the well-being of those looking to manage their stress.

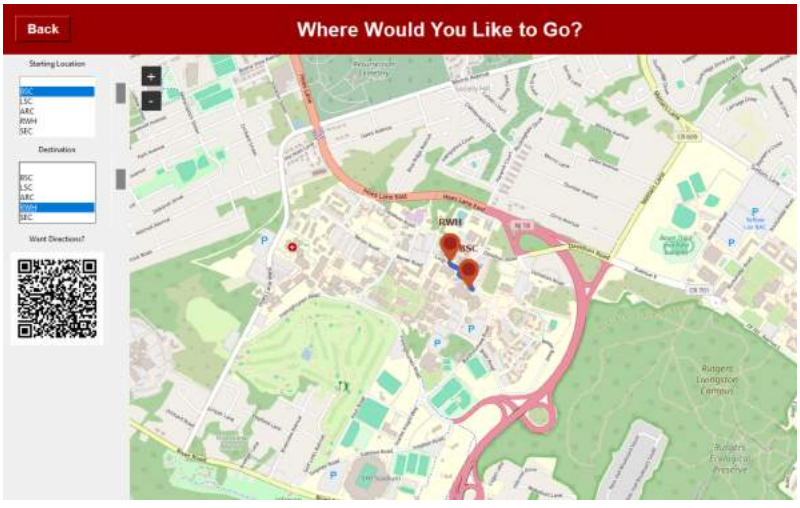


Software Component: Arudino App



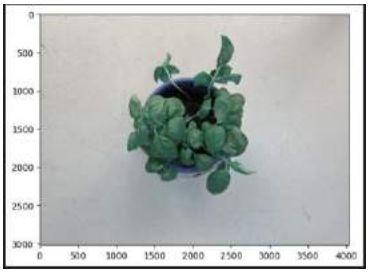
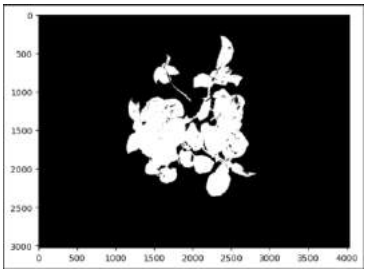
Hardware Component:
Biosensors and Bluetooth Connection

S24-22	***Title***: *Remote Utility Bot for Education and Navigation (R.U.B.E.N)* ***Team Members***: *Carina Manek, Abid Azad, Jeff Acevedo, Samuel Fabian, Sampat Pachade* ***Adviser***: *Maria Striki*
Keywords	Software, Hardware, Database, Navigation, Accessibility
Abstract	RUBEN the robot aims to help mitigate the complexity students may deal with when first entering the university and using the provided services with a hard to grasp organizational framework. To alleviate the stress of websites that are constantly recalculating or maps that are just not detailed enough, RUBEN will be there for you. Our robot is a beacon of knowledge and one-stop shop, providing students with comprehensive information about respective Rutgers campuses and locations. The user interface is interactive with QR codes that load map directions or event links. On the "RDB" or Rutgers database page, users can enter a query in the search engine to be referred to relevant questions and answers. Questions range from how to find internships and student clubs to local coffee shops and the gym. On the "Where to?" screen one can choose a starting location and destination, each distinguished with a red pushpin marker. A blue path from point A to point B will highlight the directions. Additionally, we implemented a frequently asked questions page. The "Events" page contains specific details about upcoming events on campus and another page lists lost and found items with corresponding images. Hardware components such as Arduinos, Raspberry Pi, mecanum wheels, DC encoder motors, motor drivers, and HC-05 bluetooth bring our robot to life. Our omnidirectional robot is a cost effective solution that is capable, safe, and meets size needs. In short, RUBEN is a machine with an emphasis on simplicity, utility, and navigation for students.



Directions User Interface

Robot Design

S24-23	***Title***: *SustainASmart: A Smart Green System* ***Team Members***: *Anuj Chaturvedi, Maanvita Doddapaneni, Mansi Masrani, Udayan Rai* ***Adviser***: *Dr. Shirin Jalali*
Keywords	Predictive Analysis, Machine Learning, Multimodal Sensing Systems, Sustainable Agriculture, Smart Ecosystem
Abstract	The project scope of SustainASmart is to create a Smart Ecosystem using a combination of data analysis, predictive modeling, and live sensor data input for Sustainable Agriculture. Using various sensors, including soil moisture and humidity, we can capture data from our live plants to figure out the ideal plant conditions that will optimize plant growth in specific plants. We use plant growth, measured using live images, to differentiate between ideal versus non-ideal conditions for plant health. Our goal is to use the labeled data to learn optimized farming practices, which are specialized for different plants. In order to meet these goals, we began the development of our smart system by focusing on sustainability limitations faced by traditional farming practices. With our data-driven approach, we began by first gathering data on two plants. With these plants, we used sensors to capture data on conditions such as soil moisture and monitored the growth of these plants through the processing of top-view images. We decided that measuring growth via leaf area would be the most accurate and efficient. As we tracked plant growth through imaging, we began to establish a correlation between certain plant conditions and positive plant growth to figure out which conditions are most ideal. After analyzing the leaf areas, we labeled our training data as optimal or not optimal and used a classification model to classify the conditions of sensor readings. In the long term, we would ideally create a correlation between these positive conditions and larger plant growth in order to determine which agricultural practices are the most efficient for the practice of sustainable agriculture.  **Fig. 1: Raw image of plant**  **Fig. 2: Processed image using cv2**

S24-24	***Title***: *Accessible Video Game Controller for One-Handed Individuals* ***Team Members***: *Mayank Barad, Andrew Chacko, Marco Ghbrial, Georgiy Aleksanyan, and Teerth Patel* ***Adviser***: *Jorge Ortiz*
Keywords	*App Development, Automated Feedback Tool , User Input/Control, Video Games, Accessible Gaming*
Abstract	Individuals who have one hand face distinct challenges in their daily lives, particularly when it comes to engaging with video games. The standard video game controllers are designed to be operated using both hands, which poses a significant hurdle for those who have one hand. Existing one-handed controller designs aim to address this issue but often fall short in terms of optimization, portability, and competitive play. Some of these designs may be bulkier or more complex, affecting their practicality and ease of use. Moreover, players who use these adapted controllers may experience reduced reaction times and less precise movements. As the gaming industry continues to grow and diversify, there is a pressing need for more inclusive design that allows gamers with one hand to fully enjoy and excel at their favorite games. Our project aims to tackle all of these issues as well as work towards creating a far more fair gaming space for those with disabilities. The main way our project does this is with the use of a gyroscope. Gyroscopic aiming and camera control within a video game gives the user accuracy that we have found is on par with that of a traditional controller. Allowing the user to both be able to carefully aim and look around with just the movement of their own arm. The rest of the controller includes all of the other features and buttons seen within a traditional controller(extra joystick, traditional 4 buttons, triggers, d-pad) with optimizations made towards comfortability with a single hand, to further adapt this sense of comfortability we have also added wireless connectivity via bluetooth. With this we are able to take a significant step towards giving one handed individuals a chance at having the same competitive edge as others in the gaming space.

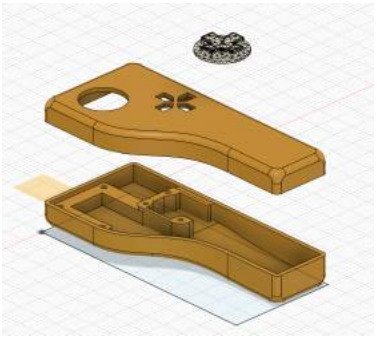
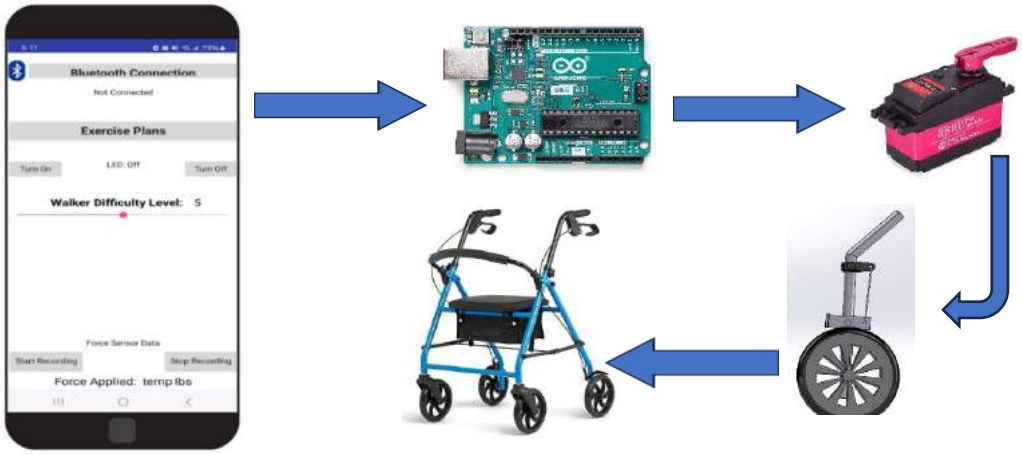


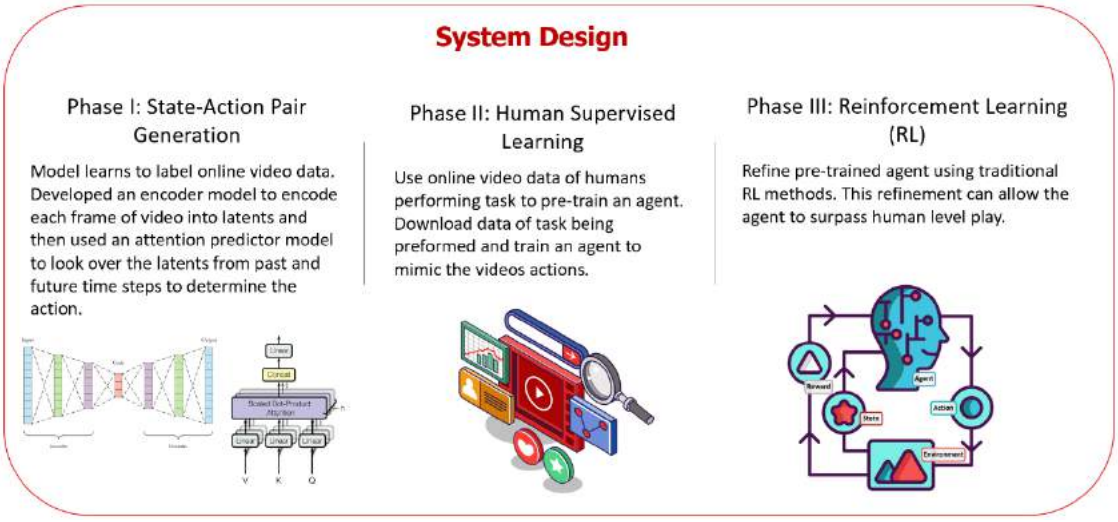
Figure 1: Cad model

Figure 2: Top View

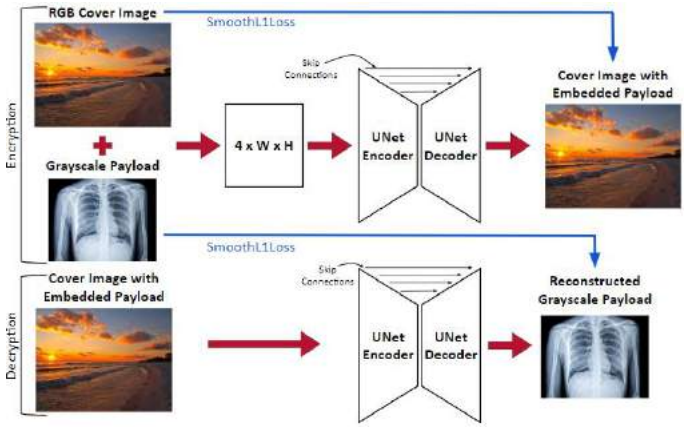
Figure 3: Back View

S24-25	***Title***: *SWIFT: Smart Walker with Integrated Fitness Training* ***Team Members***: *Adam Hecht, Joel Paley, Jonathan Pickett, Hannah Schwartz* ***Adviser***: *Prof. Daniel Burbano*
Keywords	Mobility Assistance, Exercise, Stroke Patients, Walker
Abstract	Ninety percent of stroke survivors experience some functional disability, particularly in mobility, and recent studies have shown incorporating arm strengthening exercises can help improve mobility. SWIFT, the Smart Walker with Integrated Fitness Training, serves as an add-on mechanism to walkers to assist stroke patients in their recovery journey, providing an integrated approach to strengthen both arm and leg muscles. SWIFT employs a motorized braking system that can be adjusted to provide varying levels of difficulty, to assist patients in various stages of the recovery process. When the motors engage the braking system, it resists forward movement which forces patients to use their arm muscles to push the walker. By incorporating this braking system onto a walker, it encourages the patient to strengthen their arms at the same time as walking, helping them to regain their ability to walk independently. To accomplish this, we incorporated a stepper motor into the walker's braking system. As the motor turns, it will strengthen or loosen the grip of the brake on the wheels, which adjusts how difficult it will be to push the walker. The difficulty settings can be remotely set by an app connected through a Bluetooth module. Additionally, the app offers tailored exercise plans to further support the patient's recovery process. SWIFT presents a promising solution to enhance the rehabilitation experience for stroke patients, offering convenience, customization, and a novel approach to integrated fitness training.  SWIFT: Signal Transmission Pathway

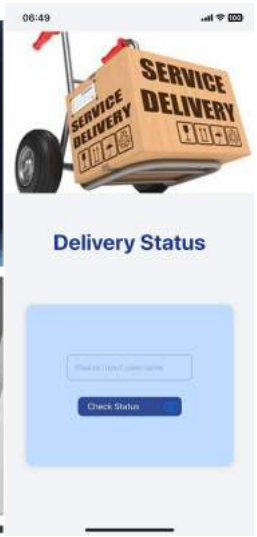
S24-26	***Title***: *Video Pre-Training for Autonomous Self-Driving* ***Team Members***: *Ronik Kapadia* ***Adviser***: *Professor Kristin Dana*
Keywords	Reinforcement Learning, Machine Learning, Neural Network, Efficient, Computer Vision, Data
Abstract	Traditional Reinforcement Learning (RL) and human-supervised learning methods face significant challenges in training artificial intelligence (AI) agents for complex tasks. RL can be inefficient due to large action spaces and sparse rewards, while human-supervised learning can be costly, time-consuming, and not scalable. Furthermore, there exists a vast amount of unlabeled online video data that remains untapped for AI training. This project stands as an independent reimplementation of the method known as Video Pre-Training and applies it to the field Autonomous Self-Driving. The core of this approach is a neural network model capable of generating state-action pairs from online video data, effectively labeling the otherwise unlabeled online video data. This process unlocks a vast resource for training AI agents, improving efficiency and scalability while reducing costs. This method has several benefits. It improves efficiency by learning from both state and action information, enhancing the quality and efficiency of the learning process. The approach leverages the large and diverse online video data, increasing the scalability and robustness of the training data. It significantly reduces the amount of human involvement required, thereby reducing the cost and time of data collection, making it cost-effective. The model can potentially learn from any task that has online video data available, increasing the generality and applicability of the approach. For this project this method was tested on the Mario Kart video game to demonstrate its potential for autonomous self-driving applications. The project provides a comprehensive solution to the challenges faced by traditional AI training methods and contributes to the field of AI by providing a novel approach to AI training that leverages the untapped potential of online video data.



S24-27	***Title***: *Cascaded-UNet: Medical Image Security Enhancement Through AI-Powered Digital Watermarking and Visual Cryptography* ***Team Members***: *Zachary Asis, Yesmina Hammouda, Irina Mukhametzhanova, Thomas Trieu, Fiona Wang* ***Advisers***: *Prof. Dario Pompili and Tingcong (Jason) Jiang, CPS Lab*
Keywords	Secure Data Sharing, Medical Data Protection, Digital Watermarking, Visual/Image Cryptography, UNet
Abstract	Rising concerns about medical data privacy and security, coupled with the potential ramifications of data breaches and tampering, demand robust protective measures. As digital data spreads across various domains, safeguarding sensitive medical information becomes paramount. Conventional Visual Cryptography has been commonly used in secure data sharing while suffering from pixel expansion, low image quality, and low robustness to noise introduced by the communication transmission process (over wired or wireless channels). All these factors limit the applications and development of visual cryptography. To this end, we propose an innovative approach utilizing the principles of visual cryptography, digital watermarking, and machine learning to enhance the secure sharing of not only medical images but also serializable data in general. Together, these techniques ensure that unauthorized access to image shares only reveals encrypted, non-sensitive content, thereby preserving patient confidentiality and mitigating the risk of privacy breaches. The proposed architecture involves two cascaded UNets (C-UNet), forming an autoencoder structure, for the encryption and decryption processes to enable efficient extraction of joint features from cover images and payloads, and integrating digital watermarking techniques to enhance tamper resistance and robustness. Evaluation using the LIDC-IDRI dataset (consisting of lung images) demonstrates consistently higher Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index Measure (SSIM) compared to existing methods across various multiplicative noise scenarios typical of communication channels (wired or wireless). The project improves on previous works by creating a more accurate and high-quality decrypted image. This research contributes to the advancement in secure medical image transmission, paving the way for enhanced privacy protection in healthcare and beyond.



Cascaded UNet (C-UNet) utilizing two UNets to form an autoencoder-like architecture to encrypt and decrypt images based on given secret information (Payload)

S24-28	***Title**: Delivery Checking System* ***Team Members**:* Li Zuo, Shuxin Liang, Ziqiong Wei ***Adviser**: Kristin Dana*
Keywords	Computer vision, Machine Learning, mobile app, image detection
Abstract	The Delivery Robot Checking System is a game-changer for the food delivery industry, tackling the issues of stolen or undelivered takeaways head-on. Using advanced computer vision and machine learning techniques, along with webcam integration, this system lets customers submit their order numbers after placing an order. These order numbers used to identify and track takeaways once delivered. Cameras deployed in delivery areas kick into action, distinguishing takeaway packages from their surroundings and linking them to order numbers. This enables real-time tracking and monitoring from delivery to pick-up, ensuring the package's safety. If anything sketchy happens or someone tries to snatch the takeaway, the system alerts the customer immediately through an app. It even keeps an eye on pick-up times, reminding customers if they forget to collect their orders, making sure no takeaway is left behind or taken by mistake. Customers can check the real-time status and location of their orders anytime on the app, complete with images and location details of their food. This not only makes takeaways safer but also adds a layer of convenience for customers, improving their overall experience and trust in food delivery services. The Delivery Robot Checking System is all about using technology to secure and streamline the process, making food delivery more reliable and satisfying for everyone involved.  Image Analysis: Receipt Identification on a Shelf  App home page

S24-29	***Title**: Autonomous Parking Lot Navigation for Self-Driving Model Car* ***Team Members**: Isaiah Pajaro, Oliver Rzepecki, Vraj Panchal, Ryan Elizondo-Fallas* ***Adviser**: Dr. Hang Liu*
Keywords	Autonomous Driving, Model Car, Computer Vision, OpenCV, Python, Nvidia Jetson, Around View Monitor, Semantic Segmentation, TensorFlow
Abstract	The rise of IoT and embedded systems has spurred the development and prevalence of self-driving vehicles. Autonomous vehicles have the potential to remediate the significant issue of motor vehicle accidents. While fully autonomous cars are still far from being available to the public, the technology to develop them is known. With more than 50,000 car crashes in parking lots each year in the United States, this project focuses on the design and implementation of a self-driving 1/10th-scale model car capable of traversing any parking lot/parking garage and parking itself without the input of a human. Our prototype is equipped with four fisheye lens cameras and an onboard Nvidia Jetson TX2 single board computer. The four cameras are used to create a surround view of the model car, also known as an around view monitor, which is the car's sole method of processing the environment. Semantic segmentation is a deep learning algorithm that categorizes every pixel in an image. A TensorFlow semantic segmentation model is implemented in our model car to label each pixel surrounding the car as either a driving area, obstacle, or parking line. This processed environment is then used for autonomous decision making to determine the start and endpoint of the car. Finally, these start and endpoints are used in coordination with the processed obstacles and free driving area to plan a path for the car. The onboard computer interfaces with the motor and steering servos on the car via general purpose input output pins (GPIO).

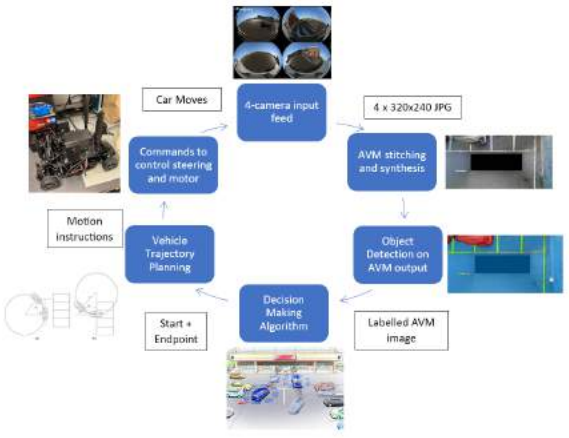


Figure 1: *Project Workflow.* Demonstrates the hardware and software lifecycle of the self-parking car

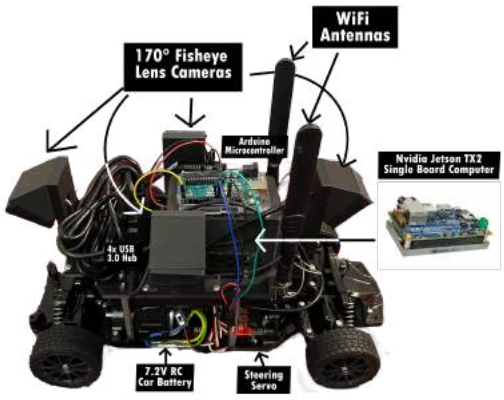


Figure 2: *Hardware Diagram.* Demonstrates all physical hardware on the model car.

S24-30	***Title***: *ScriptCity* ***Team Members***: *David Hu, Bianca Patel, Rohan Patel, Roshan Patel, and Viral Patel* ***Adviser***: *Professor Yuqian Zhang*
Keywords	Web Development, OCR, LLM, AI Chatbot, Generative AI
Abstract	A century of innovations has brought the world to a powerful and advanced digital landscape. However, the world has centuries of recorded tangible data and continues to record data in various forms of media today. Bridging the gap between the information of the real world and the digital world is a challenge and need that persists today. ScriptCity emerges as a solution, leveraging web development, Optical Character Recognition (OCR), and cutting-edge AI, namely in Large Language Models (LLM). ScriptCity is a versatile platform enabling users to upload diverse static media, mainly images and PDFs, for rapid language digitization, encompassing both handwritten and typed content. Augmented by an AI chatbot powered by ChatGPT-3.5-turbo, users can engage in discussions about the uploaded text, enhancing the interactive experience. The chatbot not only provides a platform for text-based conversation but also offers context-based interpretations, summaries, and suggestions, facilitating deeper understanding and exploration of the uploaded content. Additionally, leveraging developments in generative AI through DALL-E-2, users can edit media through simple prompts. DALL-E-2's advanced image generation capabilities allow for creative and precise modifications to images and graphics uploaded to ScriptCity. Users can transform, enhance, and manipulate images seamlessly, opening doors to innovative visual storytelling and content creation. With ScriptCity, the convergence of OCR, LLM, and advanced AI technologies creates a dynamic and interactive environment, bridging the divide between the real world's rich data and the digital realm's potential. This platform not only digitizes but also enriches and transforms the way users interact with and interpret their media, fostering a new era of digital exploration and creativity.

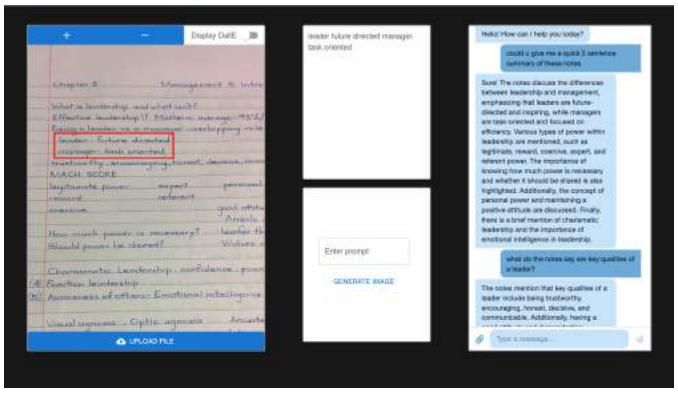
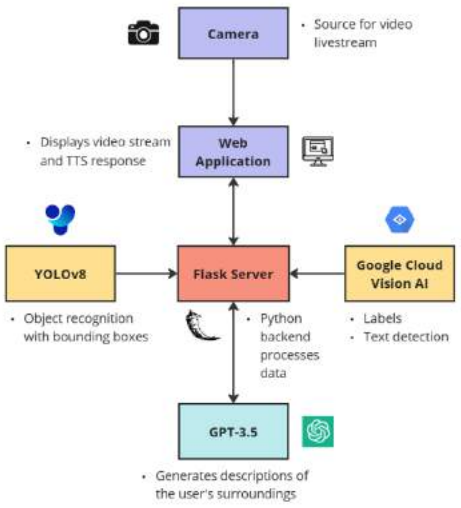


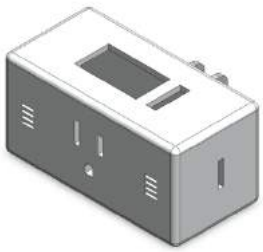
Figure 1. ScriptCity Text Detection and AI Chatbot example

S24-31	***Title***: *SensoryNav* ***Team Members***: *Ramya Ramabhadran, Nandana Pai, Hima Nukala, Raveena Gupta* ***Advisor***: *Dr. Jorge Ortiz*
Keywords	Environmental awareness, Audible guidance, Generative artificial intelligence
Abstract	Individuals with visual impairments encounter numerous challenges as they navigate their daily routines. Existing solutions rely on mobility aids or assistance from others. Hence, we aim to develop a system that facilitates independence and hands-free navigation to enhance awareness and mobility with respect to everyday tasks. SensoryNav seeks to address this challenge by creating an innovative application that provides a user with real-time feedback based on their surroundings, which will be sourced from the camera on their personal device. The system will alert the user of objects that are in their line of sight, to avoid injury or contact, through audible responses. In addition, this device has the functionality to detect and recognize road signs, provide detailed information on the immediate surroundings, and alert users of hazardous conditions. The system will alert an individual to any potential dangers that may exist and give environment-based guidelines to ensure individual safety. These advancements are made possible by breakthroughs in technology, particularly in open source APIs and artificial intelligence, such as large language models. The tools selected for developing this system include YOLOv8, Google Cloud Vision AI, GPT-3.5, and Flask. The integration of these components will allow for the development of an advanced web application that mimics the human line of sight to offer audible feedback to the user. The information provided by the system would help a visually impaired individual to navigate their surroundings safely and independently.

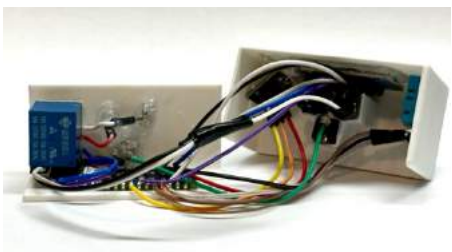


This is a diagram of the system architecture.

S24-32	***Title***: *BlazeGuard : An Automated Fire Prevention Plug for Electronics and Appliances* ***Team Members***: *Devesh Kaloty, Jason Peake, Taylor Scheuering* ***Adviser***: *Dr. Sasan Haghani*
Keywords	Fire Safety, IoT, PCB design, Sensor Automation
Abstract	Annually home electrical fires account for 51,000 incidents resulting in 500 deaths and millions of dollars in property damage. The primary cause often stems from appliance and battery malfunctions. These electronic devices/appliances can reach high temperatures before emitting smoke and catching fire. Therefore, the prompt interruption of power upon detecting excessive heat or smoke can effectively thwart potential fire hazards, by stopping the progression of a fire. Current solutions in the market often fall short in both effectiveness and user-friendliness. They are prohibitively expensive, require professional hardwiring, and do not intervene. BlazeGuard fills this critical gap in the market and is designed as a smart plug to fit seamlessly into any outlet, empowering users to connect their devices with peace of mind. Equipped with advanced onboard sensors, our plug offers automatic monitoring of current, smoke, and heat; should any of these parameters approach critical levels, BlazeGuard swiftly cuts power to the affected appliance, simultaneously notifying the user. Additionally, it features a built-in timer to prevent overcharging and provides real-time alerts through our app. For certain devices that are further away from the power source our solution also includes an external sensing module. Offering the versatility of magnetic placement for the module and connectivity options including Wi-Fi or Bluetooth, it seamlessly integrates into various environments. From personal residences to data centers, BlazeGuard stands as a reliable safeguard against fire hazards, safeguarding electronic devices, properties, and lives alike. We anticipate our innovation to revolutionize fire prevention and offer invaluable protection across diverse settings with affordability and reliability in mind.



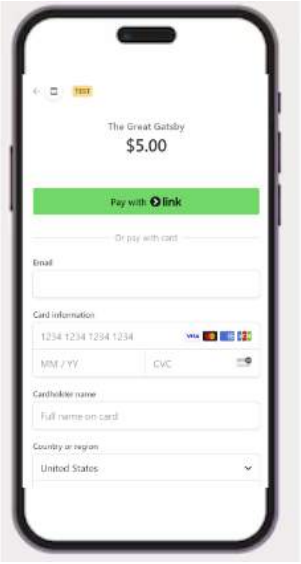
BlazeGuard CAD model



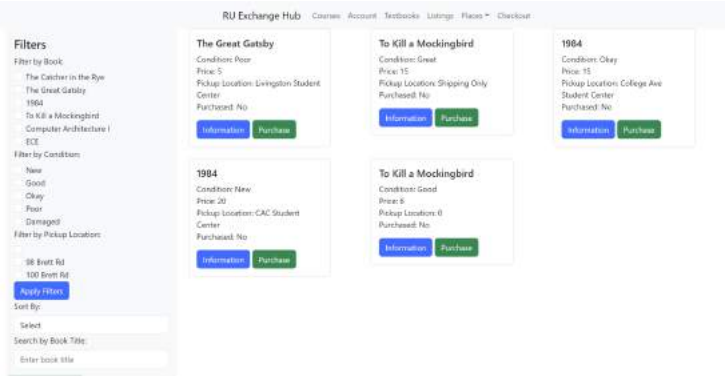
Internal view

External sensor module

S24-33	***Title***: *RU Textbook Exchange* ***Team Members***: *Kayla Olivo, Yiran Zhang, Matthew Kubiak, Antonio Mena, Hariraj Krishnan* ***Adviser***: *Sharin Jalali*
Keywords	App Development, E-commerce Platform, MERN Framework, API, Textbook
Abstract	The rising costs of education have created a significant financial burden on students, particularly in acquiring textbooks. To address this challenge, we have designed RU Textbook Exchange: a comprehensive software engineering initiative tailored for Rutgers University students. The core objective is to alleviate the financial strain on students by developing a user-friendly application that facilitates the buying and selling of used textbooks securely. RU Textbook Exchange introduces a robust marketplace where students can seamlessly list and purchase second-hand textbooks, fostering a cost-effective approach to academic resources. To ensure the security of transactions the application uses encryption and authentication protocols. This guarantees that users can engage in buying and selling activities without concern for fraud. Our application has been developed using MERN(MongoDB, Express.js, React.js and Node.js) framework to ensure seamless integration of external APIs such as Stripe for secure payment processing and Google for login authentication. These tools ensure that students can be confident in the authenticity of our platform.



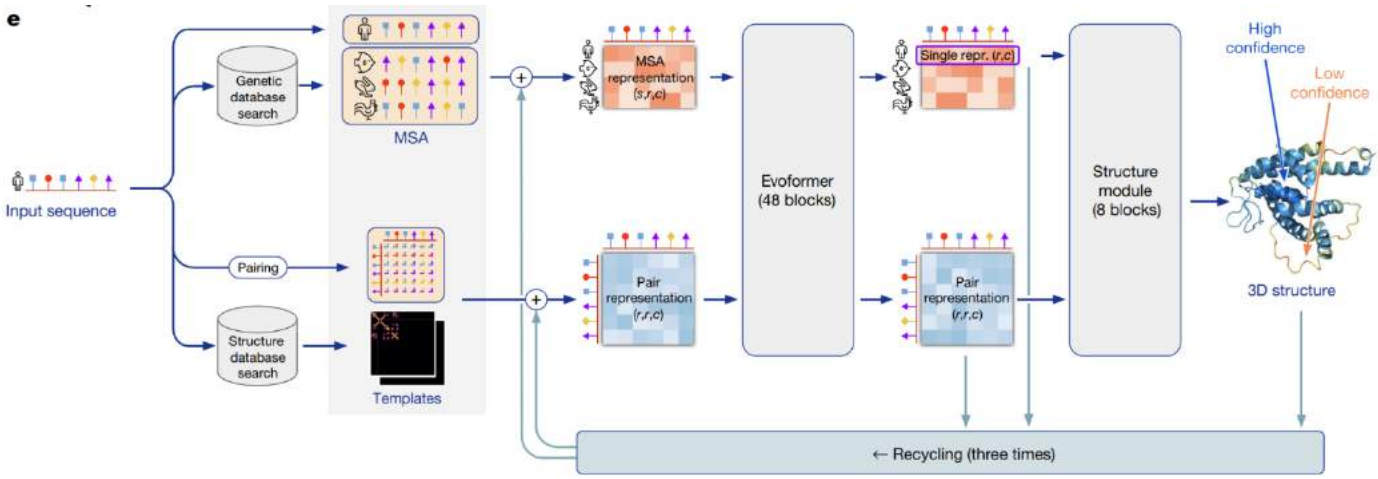
Checkout Page on Mobile



Listings page on Web

S24-34	***Title**: Electric Vehicle Battery* ***Team Members**: James Yim, Metin Sari, Konrad Lalik, Josh Baumgardt* ***Adviser**: Dr. Mehdi Javanmard*
Keywords	Electrification, Renewables, Batteries
Abstract	As a part of Rutgers Formula Racing FSAE EV an electric battery (accumulator) is required to store energy for the vehicle a swell as implement safety features through a shutdown circuit which controls power delivery outside the battery container through relays. This battery consists of 720 muRata VTC5a cells in the configuration 8p90s along with the Orion BMS 2 which monitors the voltage of each parallel segment in addition to the high current path. This cell configuration is capable of 280A current at 324V nominal which is adequate to power our drive-train which is consists of a DTI HV500 and an Emrax 208 motor. Other features of the design are a precharge circuit to prevent high inrush current, 120A fusing of the high current path, insulation monitoring device, a tractive system activation light, and a high voltage indicator light. The shutdown circuit works by interfacing with the high current path, which allows power outside the battery casing, by controlling two EV200 high current relays. These relays cannot close unless the whole shutdown circuit is closed. This shutdown circuit consists of shutdown switches, BMS fault relay control, IMD fault relay control, charge fault relay control, APPS, and BSPD. This battery was designed and built within the constraints of the FSAE EV rules and regulations which requires stringent requirements around the safety features which not only made us design safer control measures around the high voltage system, but also provided us the foundation of our design parameters.

S24-35	***Title***: *Openfold: Improving training time using second order optimizers* ***Team Members***: *Jayadityan Sethuraman, Nathan Chon, Humza Syed, Ethan Lee* ***Adviser***: *Professor Zhao Zhang*
Keywords	Protein folding, Second order optimizers, AI, Machine Learning, Supercomputer
Abstract	The increasing complexity of machine learning models necessitates more efficient training methods to speed up development and enhance performance. With large models, training can take from days to months. Openfold is one such model. It is a protein structure prediction model which outputs predicted 3D coordinates of the 20 different types of amino acids that can be present in a protein structure. The original model takes 11 days to train on 128 Google TPUs. Openfold takes over 2 days to converge on multiple GPUs. Our approach to this problem is to modify the model by implementing second order optimizers. Second order optimizers can theoretically speed up training by learning the complex relationships between protein structures better. Our implementation of various different second order optimizers in Openfold aims to reduce the convergence time to just over 24 hours. The optimizers were picked based on their likelihood of effectiveness. Utilizing the computational capabilities of the Perlmutter supercomputer, this approach not only seeks to enhance training efficiency but also serves as a scalable model for advancing machine learning applications in bioinformatics.



S24-36	***Title***: *StudentX* ***Team Members***: *Peter Chen, Nikhil Agarwal, Ishaan Keswani, Long Phan, Mulugeta Akalu* ***Adviser***: *Dr. Bo Yuan*
Keywords	Exchange, Share, Buying, Selling, student, market, machine learning, software engineering, semantic search, recommendation system, peer-2-peer
Abstract	Imagine if there was an online peer-to-peer marketplace dedicated to the Rutgers community or any other large university or college. This platform would be less susceptible to fraud and would give students access to a broad selection of relevant products and services from other students. While other online peer-to-peer marketplaces may offer billions of items, they often lack the sense of community and trust that many students seek. Moreover, this platform could provide students with very niche items that are in demand within the community; this can range from specific textbooks to calculators tailored for certain courses, or even furniture left by relocating students. Our platform, StudentX, aims to develop a niche online peer-to-peer marketplace for the Rutgers community, with potential expansion to other large communities and institutions. Our goal is to connect students within the community and facilitate the discovery and exchange of a diverse selection of items, whilst also helping students earn some extra money and reduce waste. Any member of the Rutgers community will be able to sign up for the app using their Rutgers email; with that, they'll be able to access our application features like direct messaging and recommended relevant products and services- powered by sophisticated Machine Learning recommendation systems. This ensures that users can confidently purchase from other fellow students, thereby enhancing security and providing a much more affordable selection of relevant products.

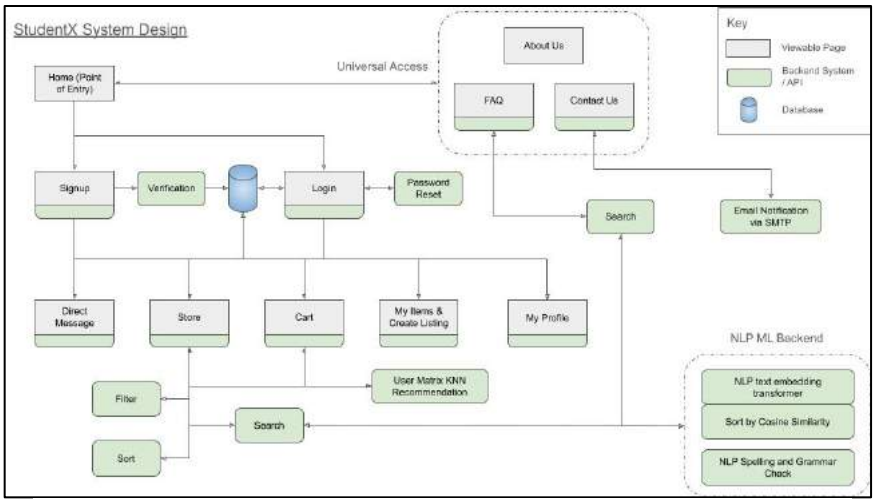
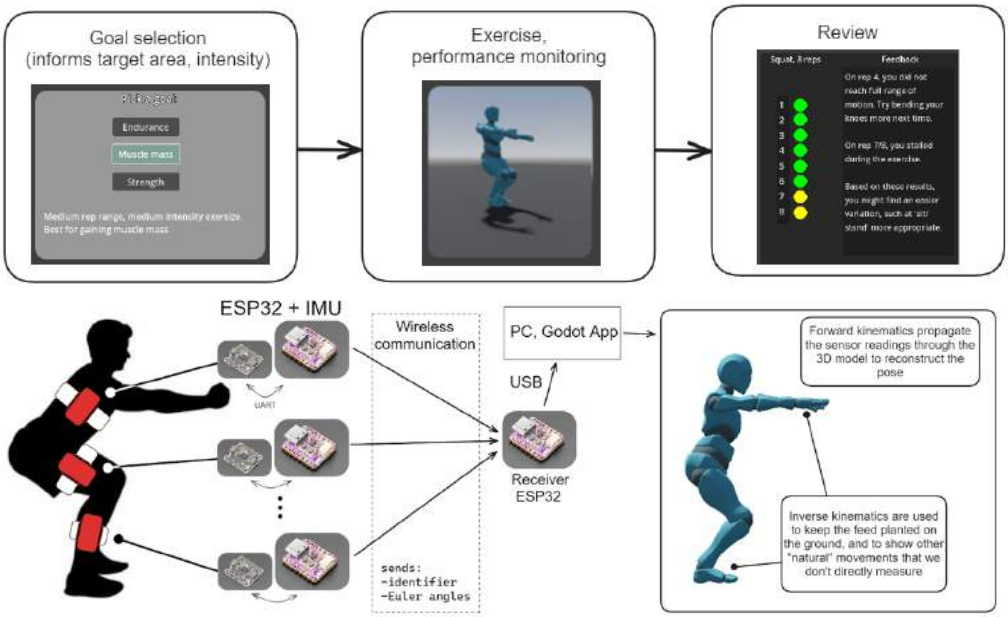


Figure 1: *High level design of our entire website.*

S24-37	***Title***: *Human Motion Estimation for Interactive Rehabilitation* ***Team Members***: *Daniel Gameiro, Marco Garcia-Palma, Ronan John* ***Adviser***: *Prof. Daniel Burbano*
Keywords	Motion Tracking, Physical Therapy, IMUs, Microcontrollers
Abstract	Sarcopenia is a musculoskeletal condition characterized by a loss of muscle and strength that affects a large portion of the elderly population globally, and can only be treated with physical therapy. However, not everyone who could benefit from PT is able to use it, either due to cost or location. The goal of our project is to provide a lower-cost, at-home alternative to PT. Our approach uses small integrated internal measurement units (IMUs) attached to the limbs in key locations, allowing the use of forward kinematics to track limb movements. The data from the sensors can then be transmitted wirelessly via a microcontroller's radio to a connected computer, which will run software guiding the user through different therapeutic exercises. The software will show the movement the user should be doing, as well as the movement the user is actually doing, and adjust the exercise if the user is having difficulty completing it. After completing the session, the user will receive feedback on their performance, allowing them to adjust their form based on it. The key advantage of estimating human motion with IMUs is that the user does not have to be observed by an external sensor. Needing to stay in front of a camera or within the bounds of base stations (as is the case with other methods) would limit the range that a person can move around in, which is not ideal when trying to track exercise activity. The results, although preliminary, indicate that this method can help patients reduce the effects of sarcopenia, and provide a way for progress to be tracked over time.



Overview of software (top) and overview of hardware (bottom).

S24-38	***Title***: *GestureLink* ***Team Members***: *Luis Castellanos, Nikita Reshetnyak, Hisham Shafi, Marlon Vergara* ***Adviser***: *Yingying (Jennifer) Chen*
Keywords	IoT, Machine Learning, Sensors, Wearable, Gesture Recognition
Abstract	In response to the inherent limitations of prevailing technologies like American Sign Language translation gloves, our innovative GestureLink glove aspires to revolutionize user interaction. By integrating sensors on each finger, this device allows individuals to execute tasks with simple finger movements. Whether it is enhancing or streamlining daily routines, our glove offers a versatile platform for anyone seeking to change their quality of life through home automation. The power of GestureLink lies in its seamless connectivity with several wireless devices. At the heart of our GestureLink glove lies a sophisticated machine learning model, meticulously trained to interpret a diverse range of gestures. By utilizing advanced algorithms, the glove's sensors discern subtle movements with remarkable accuracy, enabling users to execute various predefined actions. These actions can include toggling a TV, adjusting lighting ambiance, or securing the front door. The possibilities and expandability are virtually limitless. The integration of gesture recognition empowers users to effortlessly navigate their surroundings with unparalleled ease. All in all, the overarching goal of our project is to cater to the unique needs of individuals with limited mobility by providing a transformative solution in the form of home automation through wearable technology. By harnessing the power of wireless connectivity and advanced gesture recognition, the GestureLink glove represents a shift in user interaction, empowering individuals to reclaim control over their environment and enhance their overall quality of life.

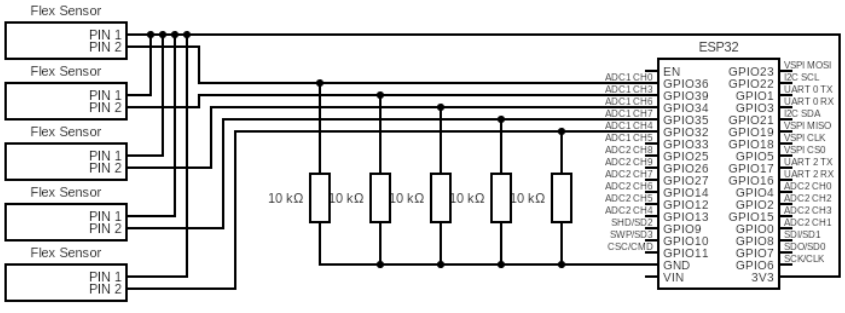


Figure 1. Circuit Diagram of the Glove

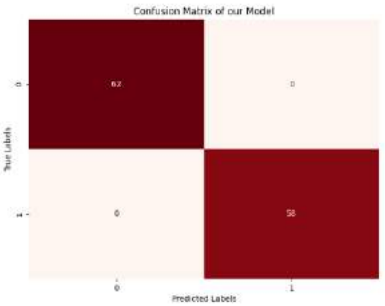
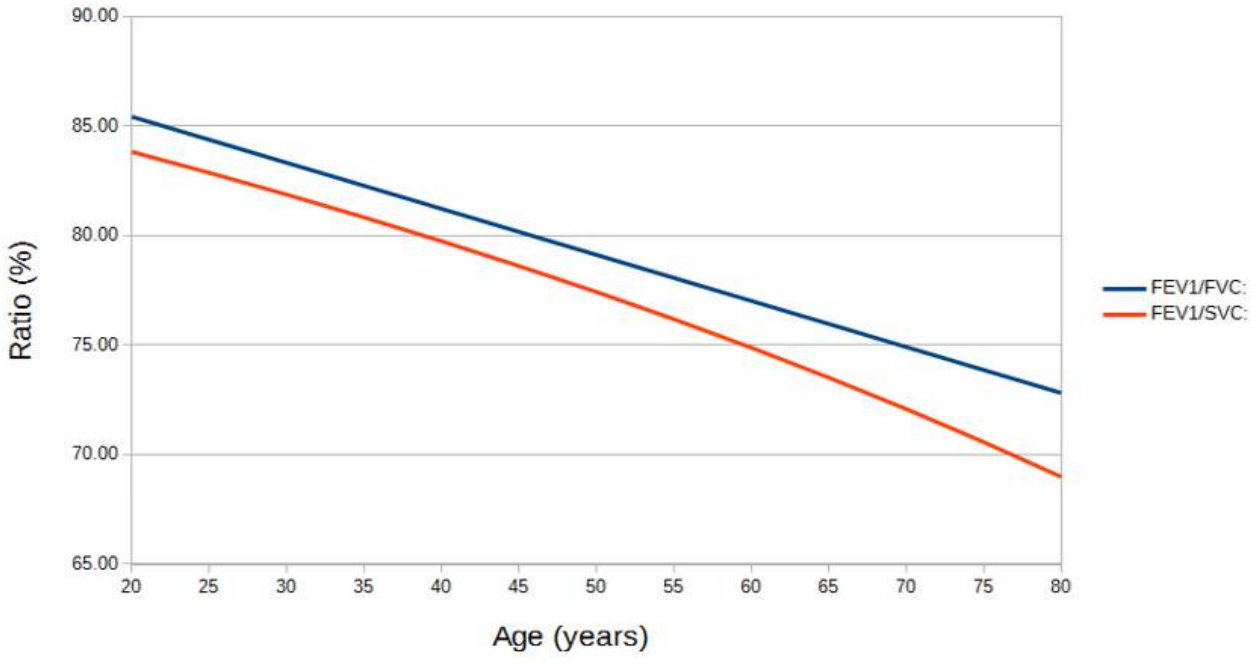
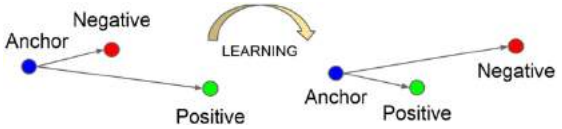
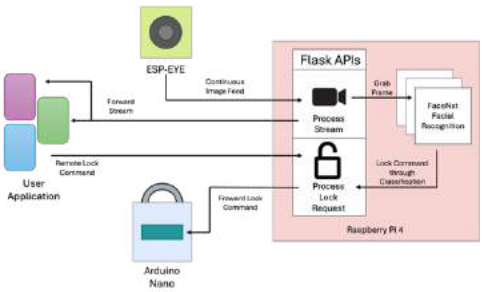


Figure 2. Confusion Matrix of our ML algorithm indicating 100% accuracy with predetermined gestures

S24-39	***Title***: *COPD Monitoring* ***Team Members***: *Connor Roof (POC), Carmine Pagano* ***Adviser***: *Professor Umer Hassan*
Keywords	COPD ; At-Home ; Monitor ; Forced Expiratory Volume ; Forced Vital Capacity
Abstract	The proposed project addresses the critical need for an at-home respiratory device to monitor and measure the progression of Chronic Obstructive Pulmonary Disease (COPD). COPD is a prevalent and debilitating respiratory condition that requires continuous monitoring for effective management. Current diagnostic methods often necessitate clinical visits, limiting the frequency of assessments and hindering timely interventions. To address this, our project will use a pneumotachometer integrated with an Arduino platform to record essential parameters such as Forced Expiratory Volume in 1 second (FEV1) and Forced Vital Capacity (FVC). These different measurements are vital when looking at the development of COPD symptoms and progression. This approach enables individuals with COPD to monitor their respiratory health conveniently from the comfort of their homes. The idea is to create a small device that can be used in an at home setting to make measuring COPD much easier and much more often. The monitor will give the user essential data regarding their own personal progression with COPD. The GUI will inform the user if their readings are critical and whether to seek professional help.



Average loss in FEV1/FVC

S24-40	***Title***: *Visage: A Home Security System* ***Team Members***: *Malav Majmudar, Shivam Patel, Shivansh Patel, Patrick Vega* ***Adviser***: *Shirin Jalali*
Keywords	Computer Vision, Machine Learning, Image Processing, Embedded Systems, Biometric Authentication
Abstract	In today's evolving Internet of Things (IOT) market, we have yet to see a mainstream and consumer-friendly option for home security that utilizes facial recognition technology for house entry. Most options out there today include RFID triggers, fingerprint scanners, passcode entry, or mobile applications for unlocking doors. Visage deviates from these methods by removing the need for any other item besides your person, simplifying the process, and allowing for a streamlined system altogether. This solution also integrates front door security by having a high-resolution camera built into the door. This approach allows for the entire doorbell scheme to be combined with the front door lock to create one all-purpose device for home entry. Using existing door sizing guidelines makes the product simple to install, utilizing standard handle and peephole bore sizes. Furthermore, there are numerous vulnerabilities involved with today's IOT systems, including weak encryption, device vulnerabilities, and data leaks. We tackle this issue by providing an in-home hub to manage all communications and data processing. Being able to compute information close to the data source allows for a more secure and efficient approach to handling data involved with smart home systems. By leveraging edge AI, our solution provides an access point for all computations and device instructions to avoid information leaving your home. Being able to control what private information leaves and enters your house creates a closed environment for your IOT systems, avoiding many of the common vulnerabilities associated with these devices.  Figure 1: Triplet Loss  Figure 2: Visage System Design

S24-41	***Title**: Levity* ***Team Members**: Daniel Maevsky & Yashovardhan Bamalwa* ***Adviser**: Dr. Richard Howard, Dr. Narayan Mandayam*
Keywords	Volumetric Display, Acoustic Levitation, Ultrasonic, Wave Interference, FPGA, CAD
Abstract	This project aims to implement a miniature volumetric display by leveraging well-established principles of acoustic levitation and human persistence of vision. Acoustic levitation has many practical applications, ranging from containerless processing of microchips to enabling to handling of extremely high purity materials, where even contact with clean lab equipment can contaminate the material beyond repair. Our purpose for acoustic levitation is to create volumetric display capable of projecting arbitrary 3D computer models, such as those produced by popular programs like Blender or Rhinoceros 3D, into 3D space, allowing users to visualize and more intuitively understand the design they are making. This has staggering implications for fields like architecture, where the traditional approach of constructing a physical scale model is very laborious, preventing the design process from being rapid and iterative. Other applications include almost anything requiring a visualization, from industrial system design to education. We envision a future product that is small and portable enough to sit on the users' desks and become an integrated part of their workflow. At the push of a button, a new design file can be uploaded to the device and the visualization is created within seconds.

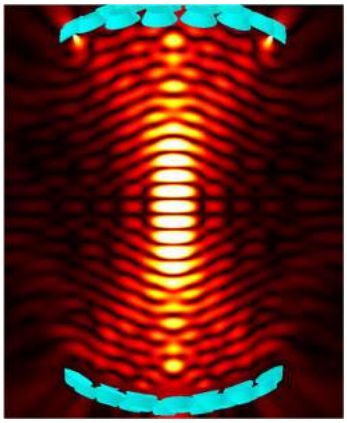


Figure 1: Center-focused Wave Pattern

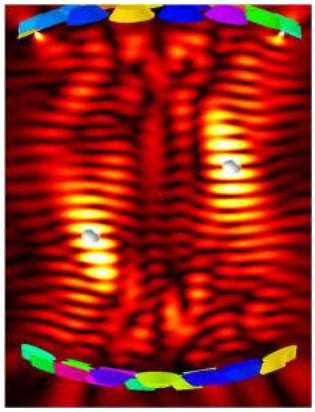
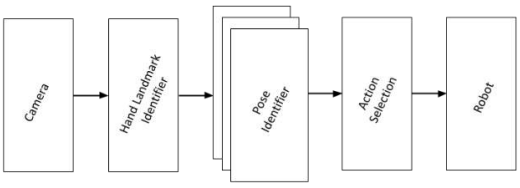
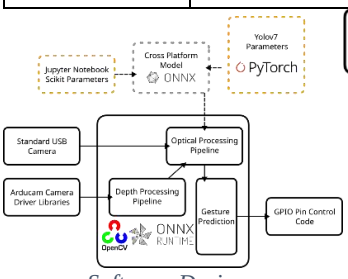


Figure 2: Control over phase and amplitude, create different pattern

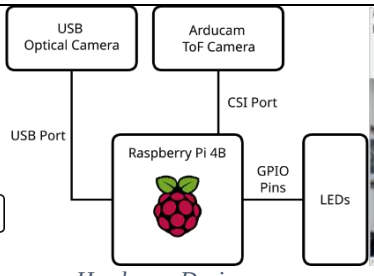
S24-42	***Title***: *Hand ANalyzed Dynamics; HAND* ***Team Members***: *Samuel Marran, James Artuso* ***Adviser***: *Sasan Haghani*
Keywords	Robotics, Machine Learning, Sign Language
Abstract	Studies have shown that the addition of a physical component in the process of teaching sign language can greatly enhance the retention rate. This, coupled with an interactive experience, results in a superior learning environment. However, there are currently no products available that utilize this. Our project is meant to fill that void by proving real-time communication with a robotic agent. By coupling a computer vision model with a robotic hand, out prototype has been able to participate in games of rock-paper-scissors to simulate the act of sign language teaching. Rock-paper-scissors is the perfect game to demonstrate the viability of this method due to its call and response nature. The robot prompts the human to make a gesture which the robot interprets and responds to. The process begins with the robot prompting the human to begin a game of rock-paper-scissors on an external monitor. During the game, the robot uses a camera to record and parse the human participants hand for landmark features. These features are then sent to a time-series deep learning model to quickly identify the pose the human is making. Finally, based on the estimated pose the robot responds with the winning sign. This processing is done with minimal latency to produce a seamless game experience. Overall, through rock-paper-scissors, our project has shown that introducing robotics into American Sign Language education can result in a fun and enhanced learning experience.   Fig. 2 A flow chart of the image processing pipeline showing the multistage process to determine HAND's state. Fig 1. HAND shown in the "scissors" state. This is one the many states in which HAND can position itself

S24-43	***Title**: HealthSync Band* ***Team Members**: Javil Patel, Visshwa Magesh, Brennan Alviar, and Khush Diora* ***Adviser**: Professor Jorge Ortiz*
Keywords	IoT, Health, Artificial Intelligence, ETL pipeline, Arduino
Abstract	The ease of being able to access complex health data of an individual's body will now be accessible with the use of our device. Our device will be wearable IoT device is equipped with sensors such as heart rate monitors, Oxygen sensors, and temperature gauges. In addition, we plan to collect health data using machine learning to identify abnormal health patterns, predict potential health issues, and provide timely alerts. The skin temperature sensor and heart rate sensor will be able to predict how stressed a person. We plan to keep a database of the individual's health records over time, and be able to raise a flag, or concern whether they may be vulnerable to a disease, or critical condition in the future. All in all, improve health monitoring and preventive care. This would be different from other wearable watches by openAI API to gain insights in which a person's health can be improved and how they can lower their stress levels. Based on the latest data that is sent, chatGPT should analyze the three sensors' data simultaneously in real-time and give feedback/recommendations on the UI. We will be using various health monitoring sensors, along with a microcontroller, such as an ESP32 within our wristband to extract the data from one's body. Then, the data will be transferred via Wi-FI or Bluetooth to our backend server which then will be stored in a PostgreSQL database. Additionally, we will be using our databases to cross-references a person's health with previous health conditions to determine whether someone's health is vulnerable.

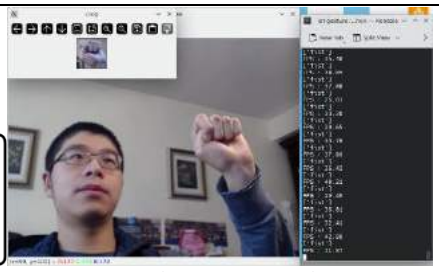
SP24-44	***Title***: *IoT Gesture* ***Team Members***: *Jimmy Huang and Charlie Li Wong-Jaramillo* ***Adviser***: *Shirin Jalali*
Keywords	Gesture Recognition, Machine Learning, Optical technology, Human Computer Interaction, Real Time Processing
Abstract	The IoT Gesture Recognition system represents an approach to enhancing human-computer interaction through the development of a non-intrusive, responsive gesture mechanism. Utilizing the cost-effective and widely accessible Raspberry Pi Model 4B as its computational core, the project leverages advanced image processing and machine learning algorithms facilitated by OpenCV and ONNX runtime frameworks. This system differentiates itself by showing optical technology to accurately detect and interpret human hand gestures, enabling users to interact with technology seamlessly without the need for inconvenient wearable devices. Aiming to address the urgent need for more accessible technology, particularly for individuals with limited mobility, our project prioritizes affordability, accessibility, and user friendliness. Through meticulous hardware selection and software optimization, the system achieves real time processing capabilities, maintaining an average frame rate of 21-22 FPS with reliable accuracy within a 1-meter range. The development journey underscored significant challenges, including optimizing the gesture recognition algorithm to function efficiently on low-resource devices and ensuing the system's responsiveness under varying environmental conditions. Despite these hurdles, our collaborative efforts have culminated in a prototype that not only meets our initial objectives but also sets a new benchmark for similar low-cost, high-impact technological solutions. Our projects implications extend beyond its immediate functionality, serving as a beacon for future research and development in the realm of accessible and intuitive user interfaces. By sharing our insights and experiences, we hope to inspire and guide others interested in pursuing innovations that bridge the gap between humans and technology, make everyday interactions more engaging and inclusive.



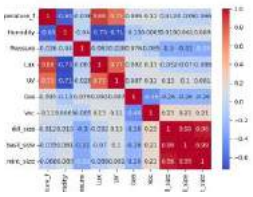
Software Design



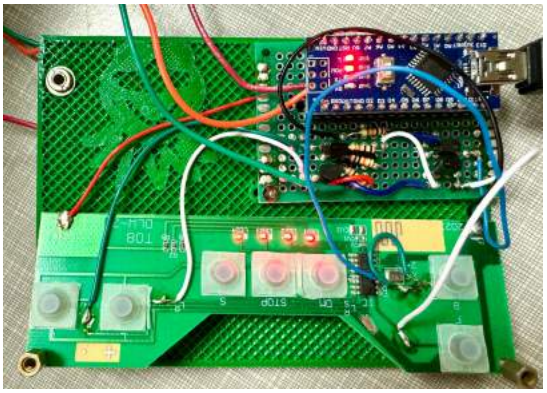
Hardware Design



Design Demonstration

S24-45	***Title**: EctoEden* ***Team Members**: Julio Contreras, Jake Giannotto, Zinobia Khan, Keith Lehman, Avni Patel* ***Adviser**: Jorge Ortiz*
Keywords	Hydroponic Farming, IoT Devices, Edge Computing, Real-Time Data processing
Abstract	This project aims to revolutionize hydroponic farming by implementing IoT devices and machine learning into a convenient Android app. We built a custom hydroponics system with integrated sensors for real-time monitoring of critical variables to optimize plant growth effectively. Though initial implementation plans were centered around direct contact with the university farm, the new system allows for controlled experimentation at home with a higher degree of attentiveness and thorough, rapid care. The data collected is stored in a Google Cloud database and is processed through Google's Vertex AI, which enables nearly instantaneous feedback to optimize decision-making for novice farmers at home. This rapid processing capability is essential for adapting to the dynamic conditions of hydroponic farming and making timely adjustments that can significantly improve plant health and yield. Our mobile application uses this near real-time data processing to provide timely notifications to farmers through push notifications directly on their Android devices. The Machine learning model will be trained through quantitative research data of yield between a control group and an experimental group; we seek to highlight the efficiency gains fostered through optimizing crop growth conditions. The overarching goal of this research project is to demonstrate the effectiveness of edge computing in enhancing agricultural productivity and to offer a sustainable and innovative solution for home-based hydroponic systems. By pushing the boundaries of traditional farming, we aim to provide a scalable model that promotes sustainable agricultural practices and fosters a greater understanding of plant behavior in diverse hydroponic environments.  Confusion Matrix to show accuracy of DNN model

S24-46	***Title***: *Mini Busch Car* ***Team Members***: *Aarushi Vashistha, Abraham Weitzman, Akash Gadicherla, Maanas Gopi, Peter Tran* ***Advisors***: *Sasan Haghani, Demetrios Lambropoulos, Jingang Yi*
Keywords	SLAM, Autonomous, Machine Learning, Computer Vision, LIDAR
Abstract	Due to the rising popularity of delivery robots (for food, packages, medical supplies, etc) and the hefty cost of existing options, we are aiming to make delivery robot technology significantly more affordable. We believe we can create an autonomous robot capable of room-to-room navigation within a building while avoiding any obstacles along the way. We researched the capabilities of Simultaneous Localization and Mapping (SLAM) for self-navigation and localization. Combined with the Robot Operating System (ROS2) and the ros_arduino_bridge, our main processing unit can control the car based on the SLAM data, allowing for autonomy. A website was made so that users can send destination commands to the robot as part of our delivery system. We acquired readily available and affordable technology, such as a micro-computer for primary processes, a pre-fabricated RC car, and an Arduino, for controlling the motors and monitoring the direction of the car. Furthermore, a LIDAR was used for room mapping via SLAM, which gives it the ability to navigate as well as real-time obstacle avoidance; and lastly, we used webcams to identify that the car is in the correct place and has reached its destination. Using all of this technology together, we can create a self-driving delivery robot that is extremely affordable and accessible.



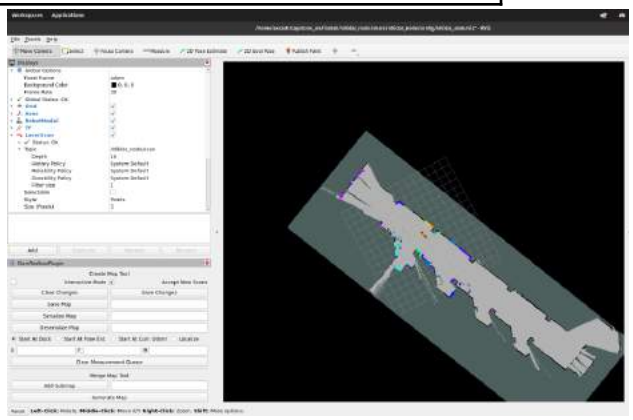
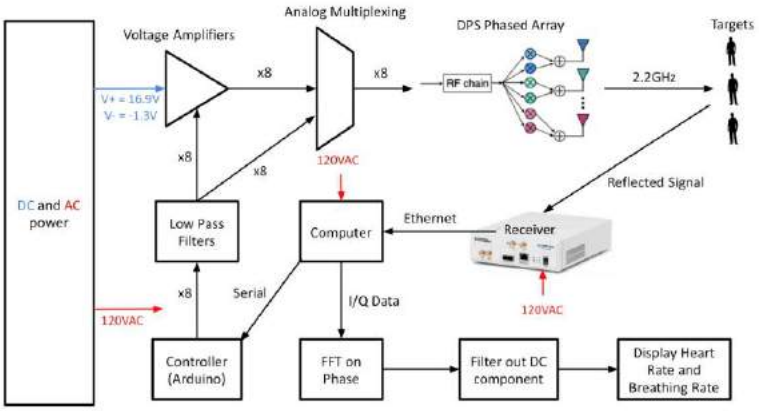


Fig. 1 (Left) Hacked RF controller with arduino nano
Fig. 2 (Center) Our robot with the hacked controller and LiDar sensor
FIg. 3 (Right) Map of ECE hallway using LiDar and SLAM

S24-48	***Title**: Radar Based Vital Sign Monitoring with Automated Beam Steering* ***Team Members**: Daniel Gore, Daniel Petronchak, Felipe Valencia, Nithish Warren, Gavin Young* ***Adviser**: Athina Petropulu*
Keywords	Phased array, vital signs, monitoring, automation, wireless.
Abstract	Hospitals commonly monitor an infant's vital signs after birth to quantify the status of its body during incubation. Conventionally, this is done by adhesively connecting biometric devices to every infant in the hospital nursery. By eliminating the need for physical connections and using a single device to simultaneously monitor every infant within a nursery, infants will experience more comfort during incubation, and the cost of vital sign monitoring largely decreases. To monitor vitals wirelessly, a double phase shifter (DPS) phased array will be used to repeatedly steer a beam between desired targets. A plain phased array could be used in this context; however, its ability to target a beam at a precise location is limited. Equipping the antenna array with DPS produces a highly focused beam that can localize closely spaced targets. After targeting the beam, a receiver will record the infant's vitals (heartbeat and breathing rate) over a finite sampling period. To automate this process, we implemented a programmable controller equipped with voltage amplifiers to computationally adjust the control voltages at each phase shifter. Doing this causes a shift in the beam's direction, which depends on the target's location and any unwanted neighboring targets that need to be suppressed (nulls). Finally, using Fast Fourier Transforms (FFTs) and filtering, the frequency information of the infant's vitals can be recovered. To test the effectiveness of this system, we ran an experiment on two human targets. The device successfully recovered each target's vital sign frequency information by automatically steering a beam between them. Our results show that the automated wireless vital sign monitoring system could imply promising applications in pediatric medicine, especially since the system is fully contactless and inexpensive if scaled down in size.



System Diagram for the Radar Based Vital Sign Monitor

S24-49	***Title**: Cloud-Connected Automation and Optimization for Drones* ***Team Members**: Aryan Patil, Atharva Pandere, Shreyas Ramachandran, Vijay Chandhar Marimuthu Anur, Ravi Raghavan* ***Adviser**: Maria Striki*
Keywords	Embedded Engineering, Path Optimization, Software Engineering, UAV, Radio Communication
Abstract	This project explores drone technologies by introducing an innovative drone automation system. The core aim is to engineer a system capable of navigating user-defined trajectories by allowing users to draw on a digital map using their devices or using a Point of Interest(POI) system via advanced path optimization techniques. The project also aims to add to the novelty by incorporating Long Range Radio Protocols, enabling automation and control in areas with lower connectivity. When armed with the appropriate equipment, the framework can be adapted to various applications, including agriculture, aerial photography, surveillance, and entertainment. This novel drone navigation system brings drone automation into the hands of more people, revolutionizing the drone ecosystem. The project addresses hardware and software components, tackling the technical challenges associated with the real-time interpretation of user-drawn paths and their conversion into precise flight commands. Additionally, this project tackles the algorithmic challenges associated with path optimization, particularly the traveling salesman problem. The project not only pushes the boundaries of user-friendly drone navigation but also advances the field by overcoming the complexities of translating nuanced input into actionable and reliable flight maneuvers.  **Figure 1**: Software UI  **Figure 2**: Drone

S24-50	***Title**: Sickle Cell Disease (SCD) Patient/Physician Match Tool* ***Team Members**: Jinhyeok Kim, Yunhyuk Chang, Zhiyuan Li, and Jiebin Liang* ***Adviser**: Prof. Sasan Haghani and John Canevari (Novo Nordisk)*
Keywords	Sickle Cell Disease, Healthcare, Mobile Application, Machine Learning, Matching Algorithm
Abstract	Sickle cell disease (SCD) is a lifelong genetic blood disorder that contorts the shape of red blood cells into a sickle shape. This results in blockages in blood vessels that cause various complications such as chronic debilitating pain and a shortened lifespan. Approximately 100,000 people in the United States suffer from the disease – the majority being from the African American population. Due to its rareness and systemic racial disparities, funding and research for SCD treatments are often neglected in the industry as it is seen as unprofitable. Thus, SCD patients frequently receive insufficient treatment and struggle to find providers who can provide expert care. Our solution, the SCD Patient/Physician Matching Tool, addresses this problem by pairing patients with physicians specializing in SCD treatment. The tool will be provided in the form of a mobile application that utilizes machine learning to understand the clinical and behavioral situation of the patient and recommend a physician or provider that scores high on various quality measures that fit the patient's specific needs. To provide optimal matches, the tool considers hard skills such as medical qualifications, and soft skills such as personality preferences for the patient to find the most comfortable care. On top of finding matching providers, the tool performs data logging to combat the lack of data in the study of SCD and a daily symptom logging feature to assist patients with dealing with lifelong conditions and improve their quality of life.

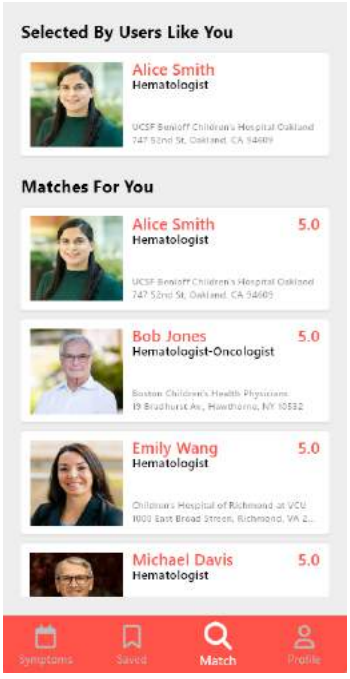


***Fig. 1** Mobile App*

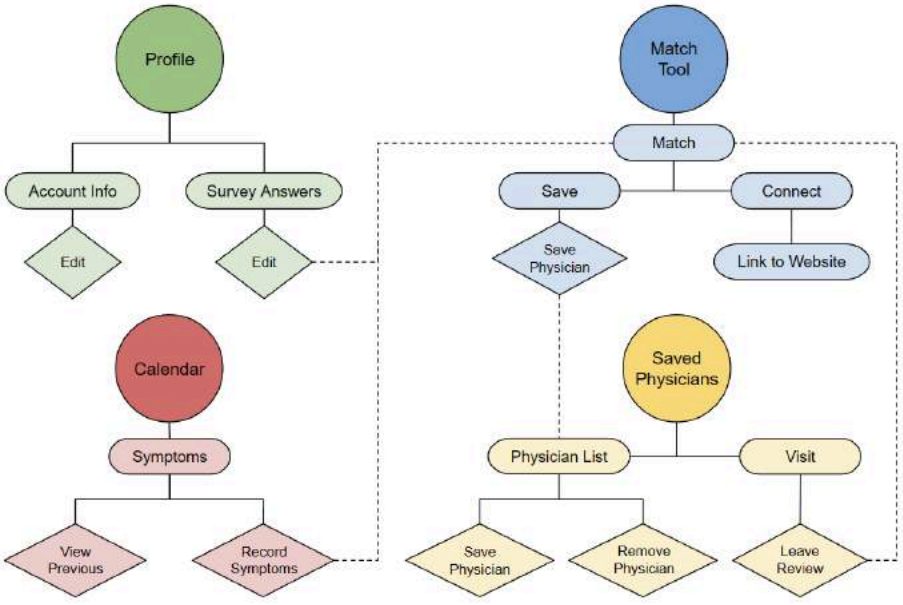
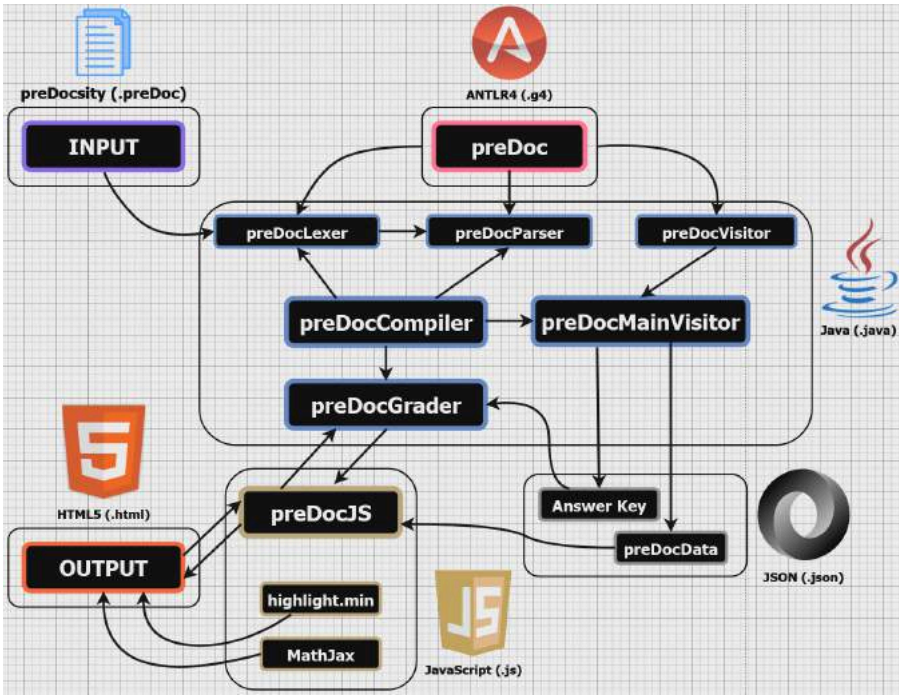


***Fig. 2** User Flow Diagram*

S24-51	***Title***: *preDocsity* ***Team Members***: *Andrei Leiva* ***Adviser***: *Professor Dov Kruger*
Keywords	New Formatting Grammar, Educational Tool, Enhanced Markdown Specification
Abstract	Markdown is a lightweight markup language – or a text formatting language – typically used to stylize text documents and as such typically only creates non-interactive documents or documents without complex elements like LaTeX equations. The capstone project preDocsity aims to repurpose the concept of Markdown as a lightweight markup language into a dynamic document formatting language capable of various new elements in documents previously not possible through Markdown alone. New features displayable in the language are external code integration (where code in external files can be included in the created document without having to copy and paste its entirety in the document), interactive assignment elements, and compatibility with LaTeX equations. The project also aims to make the syntax uniform to a standard and unambiguous – especially when used in a more complex formatting structure – which are two issues that Markdown has with its own grammar. In essence, the concept of the markup language is being shifted from a text formatting language used as a template to structure pages or documents like HTML files and repurposed into an educational document creation/formatting language that offers an alternative way to distribute assignments and learning material without having to worry about maintaining a constant connection to the internet.



Seemingly simple, multiple computer languages behind the scenes come together to format the text document into an equivalent HTML file

S24-52	***Title**: TransTax: Multilingual & Currency Software* ***Team Members**: Rahul Hegde, James Chan, Ahmed Fouad, Daniel Chen, Vrishin Patel* ***Adviser**: Dr. Jorge Ortiz*
Keywords	Large Language Model, Currency Conversion, Multilingual Translation, Web Application
Abstract	TransTax Multilingual & Currency Software is an innovative solution designed to streamline international business transactions through sophisticated translation and currency conversion tools. This project tackles the challenge of accurately translating complex financial documents, such as tax documentation and invoices, which demands precise understanding of financial terminology and context-specific nuances. Additionally, it addresses the need for real-time currency conversion in cross-border transactions. Current market solutions often fall short in handling specialized financial language and lack integration with real-time currency data, creating a gap in software offerings for the financial sector. TransTax aims to fill this gap by developing a software specifically tailored for financial documentation in multilingual and multicurrency contexts. The primary objective is to facilitate compliance and ease of operations for international businesses, focusing on countries with distinct financial regulations like Saudi Arabia, UAE, and Japan. The approach involves leveraging advanced language models to create an algorithm capable of understanding and translating financial jargon accurately. The software will also feature a robust currency conversion system with real-time updates, integration with existing accounting systems, a user-friendly dashboard for transaction insights, and automated compliance updates.

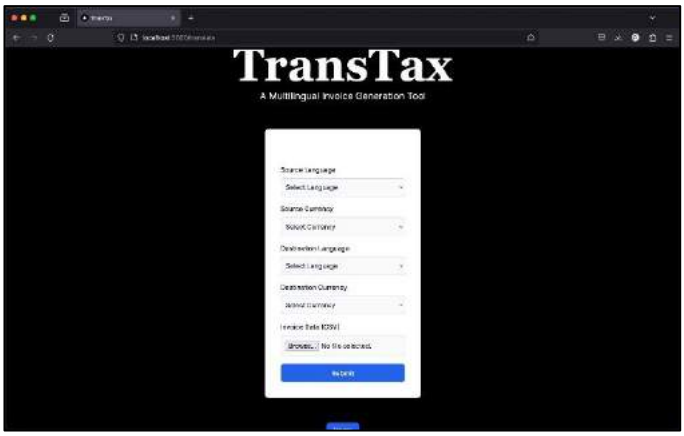
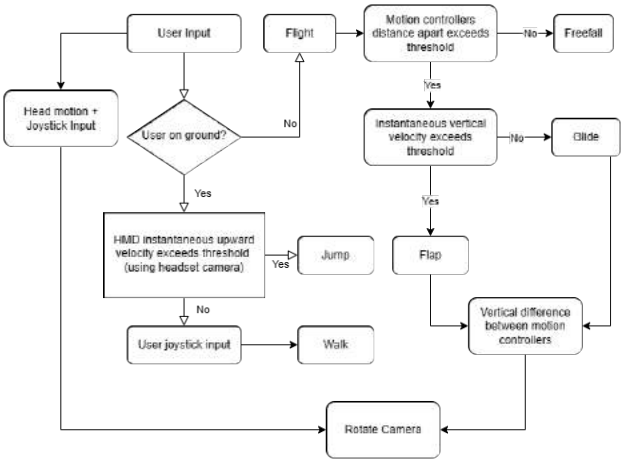


Figure 1—Invoice database upload form.

Figure 2—Invoice auto-translated from English to Japanese.

S24-53	***Title***: *Multimodal Virtual Reality Flock* ***Team Members***: *Ryan King, Kerry Li, Rohan George* ***Adviser***: *Maria Striki*
Keywords	Virtual Reality, Locomotion, Open Source, Flight
Abstract	Flock is a VR environment where users flap their arms to fly - the intention was to tap into a primal desire shared by humanity since time immemorial: the dream of flight. From the earliest myths and legends to the modern era of aviation, the idea of soaring through the skies has captivated our imagination. With Flock, we're offering a virtual experience that allows users to embody that dream in a tangible way. In flock, users can use a predefined set of intuitive motions to fly around virtual reality by flapping their arms, rolling/tilting to control angle and direction, and jumping to jump. This set of novel locomotion implements is the heart and motivation of Flock, as conventional virtual reality flight experiences primarily focus on the simulation of flying airships and airplanes, whereas we seek to have users feel like birds. Created entirely using free and open source software, such as the game engine Godot and openXR, Flock provides users with the unique opportunity to navigate through an infinite and procedurally generated virtual landscape. This novel technology can be used in recreational, therapeutic, and commercial projects, such as physical therapy, exercise, or a bird racing game. Flock is not without its issues as several accessibility issues have been identified. Specifically, motion sickness or a fear of heights have been reported during testing. While impossible to completely remove, we have attempted to mitigate it by implementing several techniques such as a dynamic vignette, snapped rotations, and designing controls in an ergonomic fashion that prevent the disconnect between real life action and perceived action. Overall, Flock pushes a novel approach in virtual reality locomotion. We offer users a real journey through boundless skies as a bird, and that it may inspire future virtual reality projects.

Control Scheme



User Intent Identification

S24-54	***Title**: HomeBud: Small-Scale Smart Watering System for Indoor Plants* ***Team Members**: Izabela Bigos, Victoria Chen, Kristina Jokic, Billie Liang, Kasey Tian* ***Adviser**: Sasan Haghani*
Keywords	Internet of Things (IoT), Indoor Plants, Automation, Bluetooth, Mobile App Development
Abstract	Indoor plants are known to benefit their owners in a variety of ways. Plants can be beneficial within a home, such as being used for ingredients for cooking or as insect repellants. Unfortunately, caring for plants requires regular maintenance and can be difficult for people who have busy schedules and/or lack experience. We have developed a system based around an Arduino Uno R4 that aims to tackle both of these problems by automating the plant watering process and including a lamp to ensure that the plant is getting the appropriate amount of daily light. The Arduino is connected to a soil moisture sensor, which indicates when water needs to be added to the soil via a pump system connected to a refillable water tank. The entire system can be controlled using an app, which allows for monitoring statistics over time as well as determining target soil moisture and daily light amounts. There are various watering schedule settings that can be tailored for the type of plant being cared for. When users might not know exactly how much water or light their plants may need, they can use included presets for common categories of plants. The user is able to control several separate plant pots within the app, and the app will alert them periodically to check that the water tank is refilled. This system should facilitate maintenance and care, allowing more people to reap the benefits of keeping indoor plants.

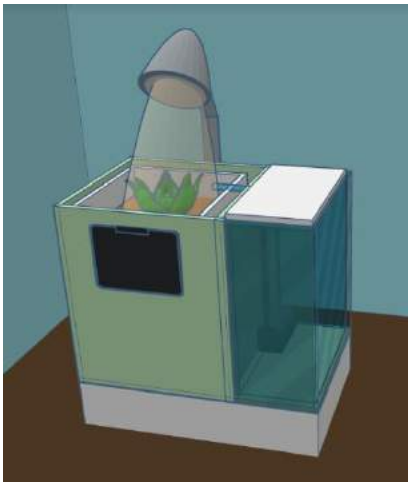


Figure 1: 3D model of the system

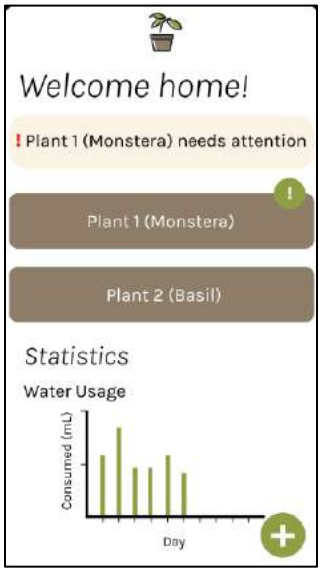


Figure 2: Home Page of app

Figure 3: Detail Page for 1 device