PARTNERS' DAY

UC SANTA CRUZ | Baskin Engineering

2022-2023

CORPORATE SPONSORED SENIOR PROJECTS PROGRAM
& SENIOR DESIGN SHOWCASE

INTRODUCTION

This publication highlights the 12th year of the **Corporate Sponsored Senior Projects Program (CSSPP)** at the Baskin School of Engineering at UC Santa Cruz.

CSSPP provides a select group of students with a unique opportunity to work on real-world engineering projects as the culmination of their undergraduate education. Throughout the academic year, students interact with teammates and hold frequent meetings with their sponsors, getting feedback on the solutions they have developed and guidance on the work in progress. By working with mentors at corporate partner companies, students learn important skills, take on intriguing challenges, and begin to understand what it means to be a professional engineer.

This is a special year for the Baskin School of Engineering, one in which we celebrate the twenty-fifth anniversary of the naming of the school for Jack Baskin, an entrepreneur and major philanthropic supporter of UC Santa Cruz and the Santa Cruz community.

In this year of celebration, we appreciate our corporate sponsors for supporting CSSPP at Baskin Engineering, trusting and mentoring our students, and providing them with challenging projects to work on. We also appreciate our students, who have worked hard and enriched our lives through their energy, intellect, and determination. This class of students is special in that they have had to rise above unique challenges throughout their time at UCSC, including working in a distributed environment over many quarters, dealing with disruptive weather patterns, and other significant distractions. I am enormously proud of our students for their perseverance, and grateful to our corporate partners for remaining dedicated to the program amidst many of these same challenges.

This publication also includes this year's Senior Design Showcase projects from student teams in the Computer Science and Computer Engineering programs, as well as our programs housed within the the department of Electrical and Computer Engineering, all of whom worked on faculty/student initiated projects. As with our CSSPP projects, students working in our senior design program demonstrated a keen commitment to their projects and their teammates.

On behalf of my colleagues at the Baskin School of Engineering, I want to express the great pride we all take in the work of our students and their faculty mentors, and reiterate my gratitude to our corporate sponsors. A great deal of work goes into all of this programming, and I would like to close by thanking the staff and faculty who make it possible for our students to thrive in the Baskin School of Engineering and become prepared for successful careers as Baskin engineers.

Alexander L. Wolf
Dean, Baskin Engineering

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CORPORATE SPONSORED SENIOR PROJECTS PROGRAM 2022-23

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SPONSORS

Special thanks to our sponsors for their generous support of the Corporate Sponsored Senior Projects Program. Their time, experience, and financial support were immensely beneficial to our students' experience and success with their Senior Design Projects.

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KEYSIGHT TECHNOLOGIES

Retyrn Corporation

UA INC.
UNIVERSAL AUDIO

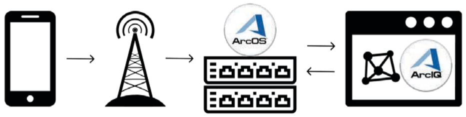
Capstone Project

Arrcus Mobile User Plane Integration

Tommy Dang, Tejas Kaladi, Nistha Kumar,
Sidharth Khabiya, Nishant Khanorkar

Abstract

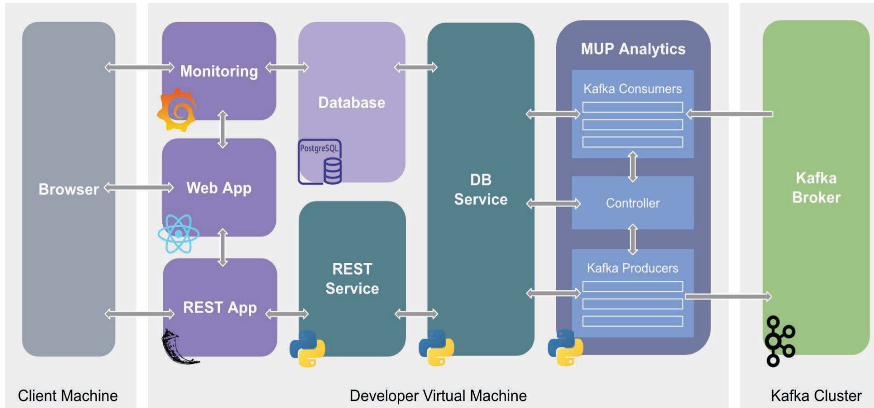
Arrcus is a computer networking company that develops and provides a network operating system. Their software, ArcIQ, gathers information about their network and provides analytics on its devices. Our team is responsible for integrating the Mobile User Plane (MUP), which consists of mobile devices connected to the Arrcus network, into ArcIQ and identify the anomalies.



Technologies

- Kafka: message queue used for real-time data processing and communication between devices.
  - Producer: Publishes data to topic
  - Consumer: Reads data from topic
- TimescaleDB: Relational database designed specifically for handling time series data.
- Rest API: Interface used to design and interact with web services.
- Grafana: Open-source data visualization platform.

Architecture



Results

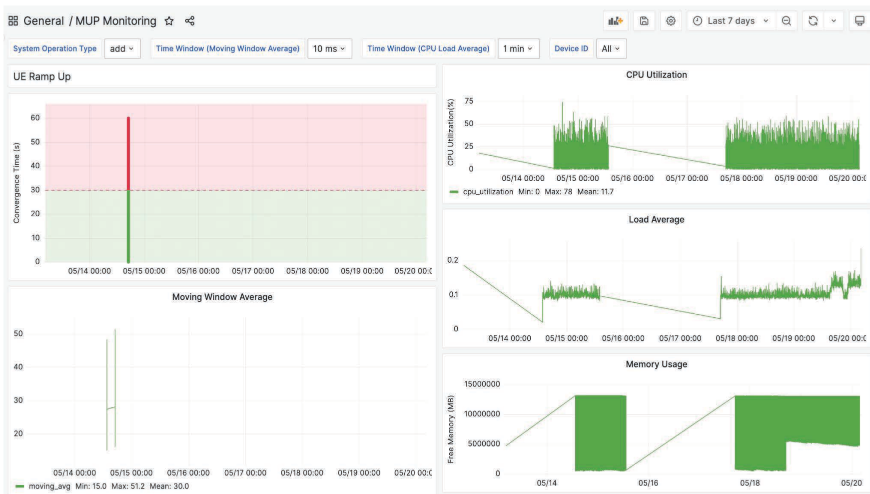
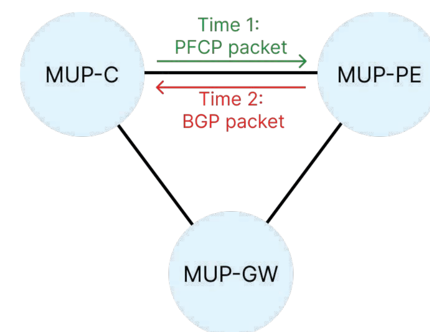


Fig: Dashboard displaying Convergence Times (left), System Statistics: CPU & Memory Usage (right)

Overview

We developed a network analysis software that detects anomalies in packet transmission. The anomalies are related to packet transit times and discrepancies in packet delivery between nodes. The objective is to calculate convergence times, which represent the duration between packets arriving at two different nodes. These convergence times are then graphed and evaluated against a threshold to identify anomalies.



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Sponsors: Ravi Vaishampayan, Alpesh Patel, Lakshman Swaroop and Utsav Kopargaonkar
Teaching Staff: Richard Jullig and Golam Muktadir

Capstone Project

Project Vulcan

Kyle Lim, Bayley Barreuther, Jonathan Aguirre, Troy Schultz, Gavriel Beniyaminov

Abstract

- The manufacture and distribution of electric vehicle charging stations, hardware component testing is an arduous and costly task.
- Small defects from manufacturing can cause eventual failures in deployment.
- Our project aims to detect these defects with computer vision using thermal cameras.
- Through measuring the heat gradient over a simulated operating environment, we can classify EV charging components into pass / fail using historic trends.

Approach

- Developed a web GUI using HTML, CSS, JS to allow engineers to create testing profiles for operators.
- Seek Thermal Mosaic Core thermal camera was chosen for its cost, accuracy, and it's ability to be interfaced with Python.
- Constructed the Vulcan testing API utilizing Python to interface with the thermal cameras and perform tests through ChargePoint's proprietary hardware testing framework FactoryStand.

Acknowledgments

ChargePoint
Adam Glueck
Peter Vuong
Frank Lin
Michael Robak

UCSC
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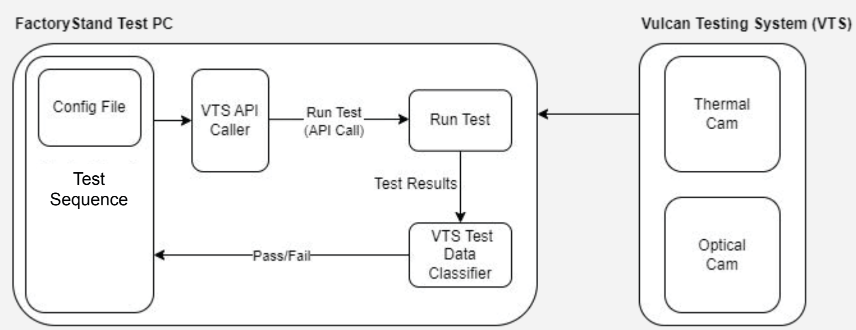
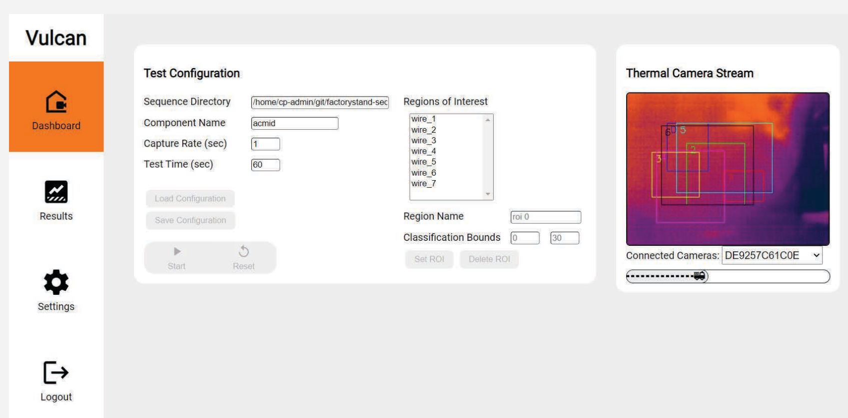
Richard Jullig
Russell Evans

Overview

ChargePoint has more than 18,000 EV charging stations located all over the world. These chargers become defective from manufacturing or misuse, causing operators to be sent to fix them. Rather than having to replace chargers, Project Vulcan allows the engineers to check which components are defective, increasing efficiency and lowering cost. Manufacturing defects in these chargers are currently detected when out in the field. Project Vulcan remedies this problem by assisting engineers to catch these defects while still in the factory, before they are delivered and deployed.

Architecture

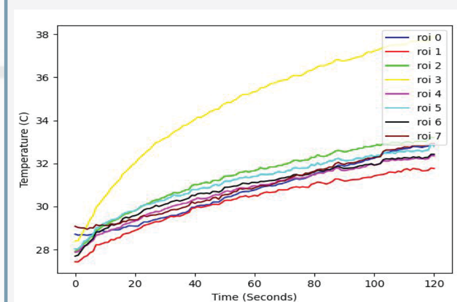




Results

This project started off as a proof of concept amongst a multidisciplinary team of engineers to see if it was possible to detect manufacturing defects in ChargePoint's EV products through the use of thermal imaging and computer vision. It has gone through multiple iterations and architectural restructures to get to the point where it is now.

- Vulcan has now evolved into a factory deployable testing system that can be interfaced with through ChargePoint's proprietary hardware testing framework.
- Vulcan can be used to gather thermal data over a set period of time from various user specified regions of a component and determine if it is operating correctly based on predetermined hyperparameters.



Conclusion

Vulcan will allow for a massive reduction in the time and cost it takes to test the safety of ChargePoint's products. Not only does improved safety ensure product reliability but it also will help strengthen ChargePoint's brand image making them even more dominant in the EV charging market.

Baskin Engineering

Capstone Project

BOROS: Test Automation

Adam Barness, Esther Chung, Henry Estberg,
Parhuam Jalalian, Tanmay Mittal, Jackson Tran

chargepoint

ABSTRACT

The goal of this project is to design and build a **regression test system** with hardware in the loop. The system under test is the software ChargePoint uses for **testing EV charging hardware** in their factories. For this project, we're building a way to validate the test system software itself. Software is in constant development, and new versions are released frequently. This regression test system is meant to validate the released software and flag any problems that may arise when it is deployed to a known good system. This way ChargePoint can automate ensuring that the builds that they use on the factory line are stable.

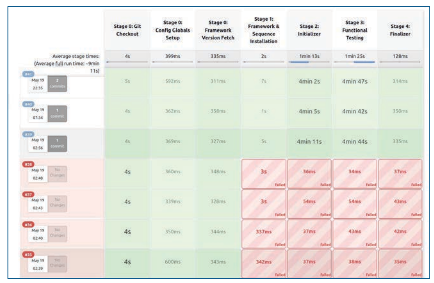
DESIGN

1. Test Developers make a change to GitHub. The Jenkin server detects these changes and runs the regression test. The Jenkin server fetches Jenkins scripts which will run the job on the test fixture PC.
2. The test fixture Pc fetches the test framework, scripts, and an embedded software image. The framework is used to flash the software image to the test fixture PC and to run the test scripts.
3. After running the test scripts, the framework will generate a test report to be sent back to the Jenkins server. The Jenkins server is then able to process the report and generate a formatted report with data visualization of the test data.

OVERVIEW

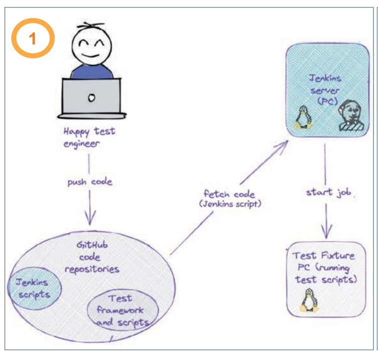
ChargePoint is constantly developing new EV charging tech and updating existing models to make a better user experience. With this comes a lot of testing demand in their factory to ensure new features and frameworks consistently provide the interface experience that customers expect. Our team plans to automate and standardize the work that comes with these software testing demands.

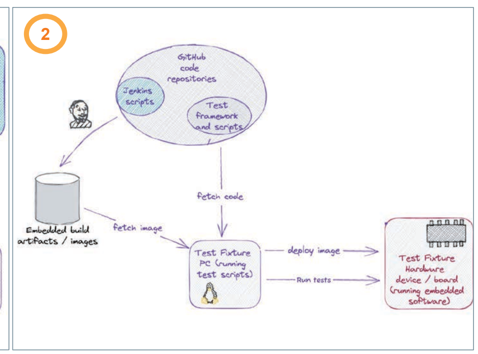
CLOSE LOOK

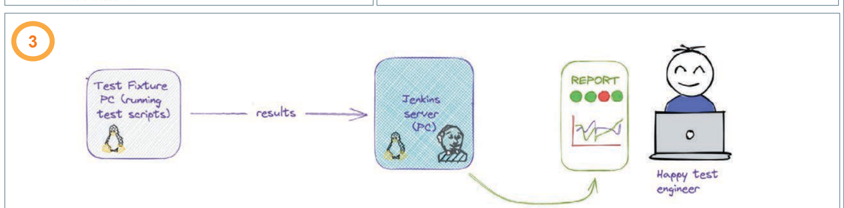


	Stage 0: Git Checkout	Stage 0: Config Globals Setup	Stage 0: Framework Version Fetch	Stage 1: Framework & Sequence Installation	Stage 2: Initializer	Stage 3: Functional Testing	Stage 4: Finalizer
Average stage times: (Average full run time: ~9min 11s)	4s	399ms	335ms	2s	1min 13s	1min 25s	128ms
#41 May 19 22:35 2 commits	5s	592ms	311ms	7s	4min 2s	4min 47s	314ms
#40 May 19 07:34 1 commit	4s	362ms	358ms	1s	4min 5s	4min 42s	350ms
#39 May 19 02:56 1 commit	4s	369ms	327ms	5s	4min 11s	4min 44s	335ms
#38 May 19 02:48 No Changes	4s	360ms	348ms	3s failed	36ms failed	34ms failed	37ms failed
#37 May 19 02:43 No Changes	4s	339ms	328ms	3s failed	54ms failed	54ms failed	43ms failed
#36 May 19 02:40 No Changes	4s	350ms	344ms	337ms failed	37ms failed	43ms failed	42ms failed
#35 May 19 02:39 No Changes	4s	600ms	343ms	342ms failed	37ms failed	38ms failed	35ms failed

ARCHITECTURE







RESULTS

Automation Infrastructure:
We've automated testing processes that were highly manual tasks for ChargePoint before. This is done in a way that allows easier scalability than the manual alternatives.

Test Report:
We've designed an automated method to convert ChargePoint's test data to a consistent test report format (XML) that can then be consumed by Jenkins.

Data Visualization:
We've implemented tools for ChargePoint's testing team to better visualize their test data.

CONCLUSION

The BOROS team provided ChargePoint with a framework that allows them to easily test the software and hardware of their Falcon devices as they are produced in the factory.

Our project is designed to be extended to other ChargePoint products in the future in order to provide the same features across ChargePoint products. This framework will increase the efficiency of running and interpreting a large number of necessary tests in the factory as ChargePoint manufactures various EV charging devices.

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Capstone Project

Wafer Temperature Controller

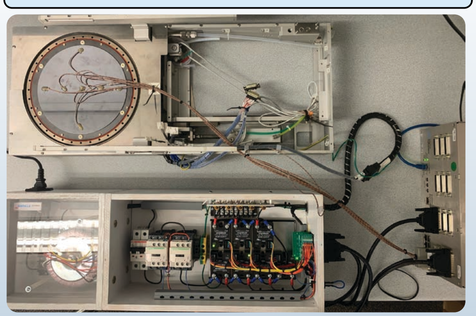
Neville Hiramanek, Jaidev Gopakumar, Ana Mallinson, Harshawn Singh, Maxton Lenox

Baskin Engineering

Digital Dynamics® The Industrial IOT Company

Overview

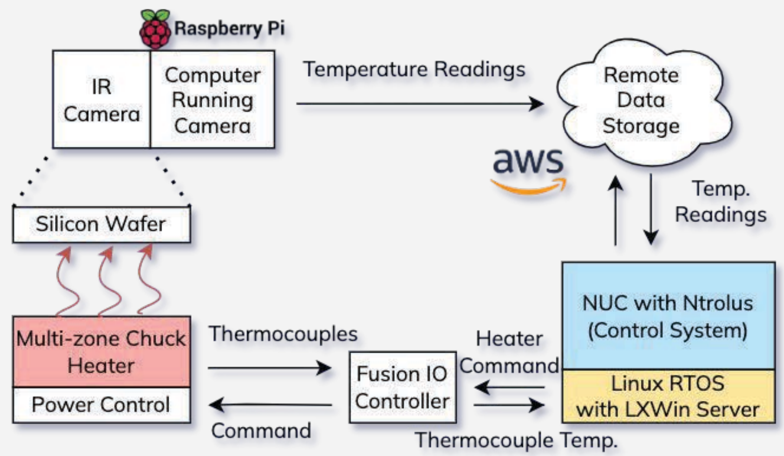
In order to manufacture embedded circuitry, **silicon wafers** must be heated for chemical reactions to occur. We create a feedback control system to quickly heat a wafer to a specific temperature using a multi-zone chuck heater.



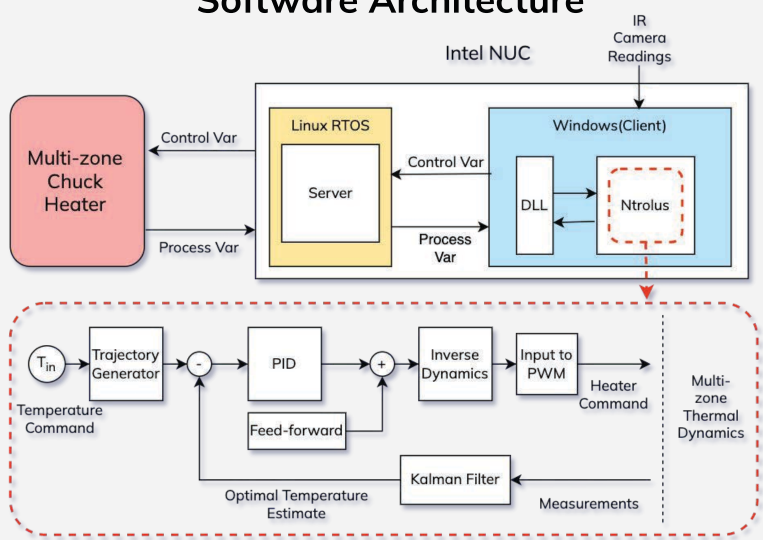
Approach

After creating a mathematical model in MATLAB and simulating our initial control system, we fit the system to the real-world using experimental data from the **infrared (IR) camera** (measures wafer) and **thermocouples** (sensors in heater). Further, the data helps account for differences across zones to evenly heat the wafer.

Hardware Architecture



Software Architecture



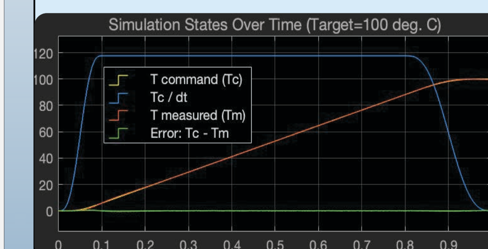
Model-based Feedback Control System - designed in MATLAB & Simulink

Conclusion

We use thermocouple and IR measurements to drive the wafer feedback control system, heating a wafer quickly and evenly using a multi-zone chuck heater. In the future, we would like to improve our system's speed and accuracy, creating a prototype worth turning into a product.

Results

- Implemented internal system communication in C and Python
- Integrated IR camera to measure wafer temperature



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Keysight Cellular Testing

Shawn Armstrong, James Kohls, Jonah Lavi, Luka Kolev, Sebastian Kropp, Shayan Bathaee, Sahil Gupta

Overview

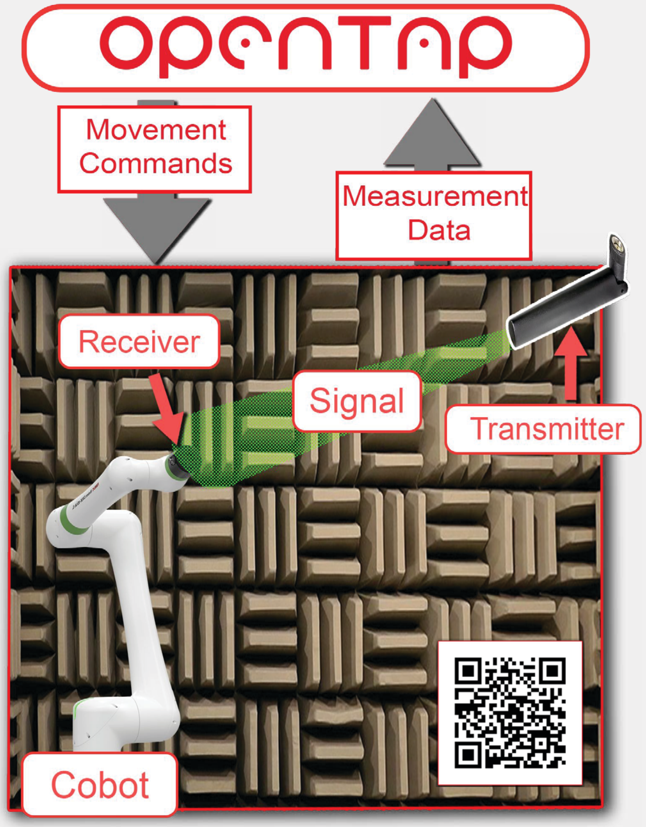
Testing frameworks and standards are still in development for cellular communication. Without proper testing standards, companies cannot assess bandwidth demands and performance issues of cellular devices. By extending OpenTAP's testing functionality to integrate collaborative robots, our software allows test engineers to precisely position cellular receivers with more flexibility, mitigating associated problems.

Abstract

Current testing of cellular connectivity consists of a single receiver that can rotate in an anechoic chamber. To upgrade this setup, we replace the rotating receiver with a robotic arm that can move the receiver with more reliability and flexibility. Our work consists of creating an OpenTAP plugin for multiple cobots, which allows the user to control the movement of a robotic arm holding the receiver through OpenTAP's graphical testing interface.

Background

This project consists of an OpenTAP plugin built to control a robot arm (**cobot**). **OpenTAP** is an open-source testing framework developed by Keysight Technologies. A **plugin** is a collection of programs that extends the functionality of OpenTAP. The goal of our plugin is to allow test engineers to position a cellular receiver with any **cobot** entirely through OpenTAP.



Analysis

OpenTAP plugins are commonly developed in either C# or Python. We developed our plugin in Python due to our familiarity with it, and OpenTAPs abundance of Python documentation.

Our use of Docker allows developers to run our plugin on any operating system by creating a mini emulation of the necessary software/hardware requirements called a container.

By including ROS2 (robot operating system) into our project, developers can also interact with the cobot and other robots programmatically.

Results

Our finalized project implements the following features:

- Move the cobot
- Abstracted move w/ buttons
- Send commands from files
- Gather data from the cobot
- Run on any operating system
- Integrate ROS2 for extended programmatic use.

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Alan Copeland, Brennen Direnzo, Ivan Diep, Jeff Dralla

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Baskin Engineering
Capstone Project

Retyrn

Amaan Sheikh, Anish Pahilajani, Franz Eugenio,
Jennifer Lin, Mahesh Vegiraju, Nicholas Hong

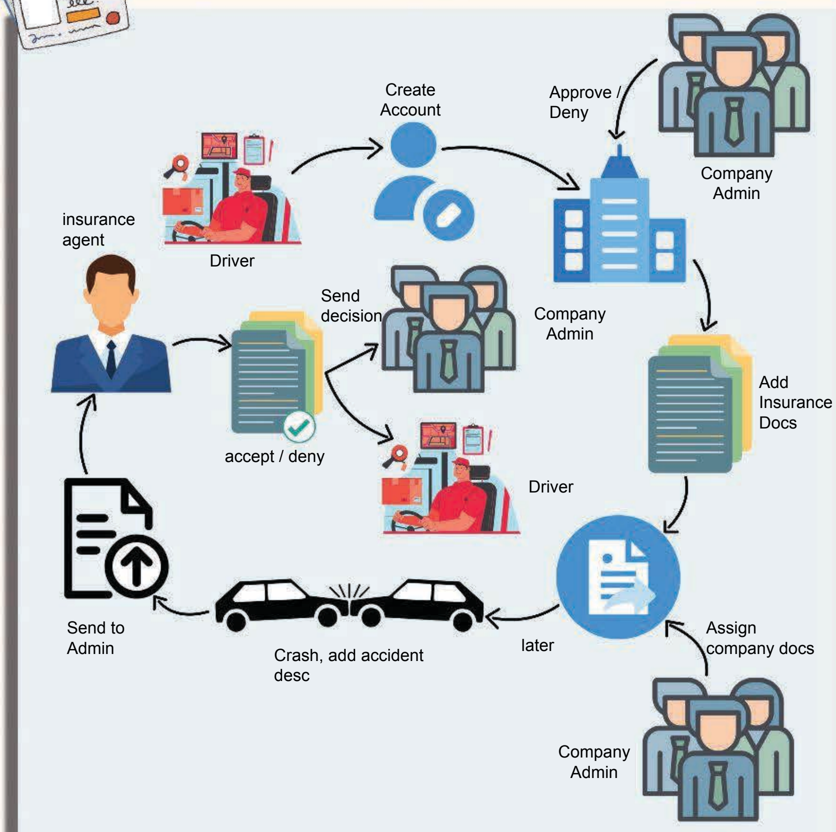
Summa

Retyrn is a company that aims to simplify the process of filing insurance claims for individuals and corporations. Our team has developed a web application that allows users and companies to store all their essential documents in one place, making it easier to file claims. With Retyrn's streamlined process, users can simplify their claim filing process and corporations can use the platform to manage claims filed by their employees.

Approach

The web app uses React for the frontend, FastAPI for the backend, and PostgreSQL for the database. Alembic is used for database migration. To support scalability, Kubernetes and Docker are utilized to create a dynamic backend container for each active user. This approach enables quick database updates since the platform is built from scratch.

Illustration



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Retyrn Team
Thomas Mulligan, Allen Rosenbaum
Troy Van Zile, Moidin Mohuidin

UC Santa Cruz
Richard Julig, Golam Muktadir
Frank Howley, Patrick Mantley

Key Features

- **Wallet:** Store relevant documents and information for quick access
- **Sharing:** Documents can be shared between companies and their employees, as well as between employees and their trustedcontacts, allowing for secure and controlled sharing of information both within and outside the company
- **Management:** Companies manage their employees permissions and see relevant claims

Conclusion

The current market of this system is mainly trucking corporations and individuals. In the future this can be expanded to other types of businesses. As the user base grows, the backend can also be transitioned to microservices for increased scalability.

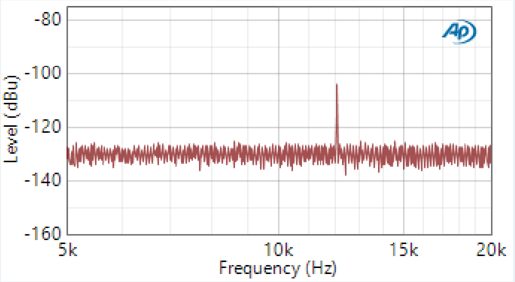
Universal Audio LED Array

Timothy Lee, Sebastian Liu, Robert Cedillo
Electrical Engineering

Overview

The Audible Issue:

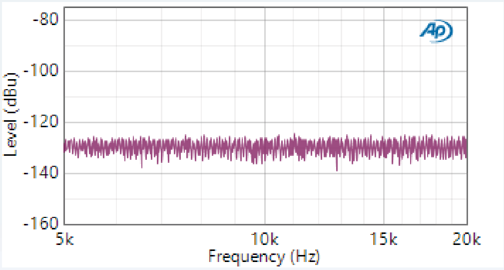
High quality audio devices are susceptible to PCB noise such as EMI, crosstalk, and digital return currents. Universal Audio's (UA) line of audio products experience noise from front panel displays with PWM driven LEDs. These LEDs induce high cyclical currents into audio components which could cause audible tones.



LED Noise Spike at 12 kHz (PWM Frequency)

Universal Audio's Existing Solution:

UA eliminates the noise using shift registers configured with a time delay algorithm which prevents cyclical currents. Although effective, implementing this solution for future products would be time consuming as it requires fine tuning in the software and hardware. Therefore, UA is interested in exploring more modular solutions to the PWM noise.

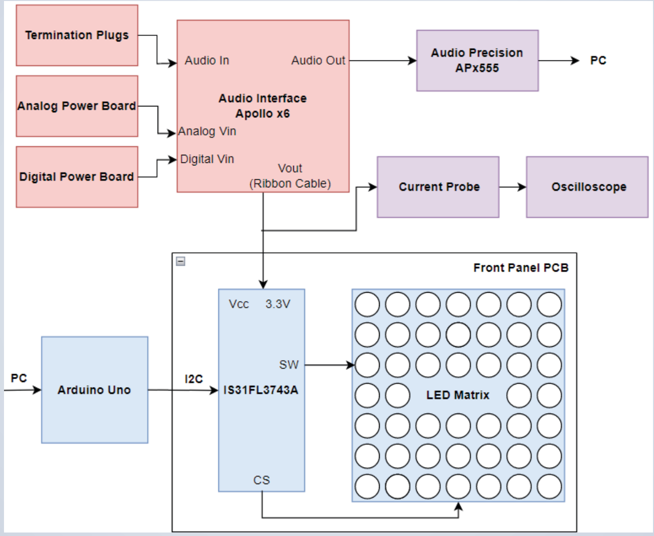


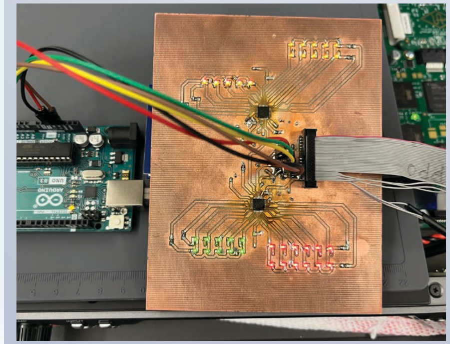
UA's Solution Eliminates the LED Noise

Design

Prototype PCB:

An experimental front panel PCB was created to interface with the Apollo x6 (UA's audio interface in the top right corner) and Arduino for FFT data collection using an Audio Precision APx555. The scaled-down version below employs LED drivers with noise reduction features that can support an array of 100+ LEDs. This prototype will potentially eliminate the existing shift register design and noise reduction algorithm.





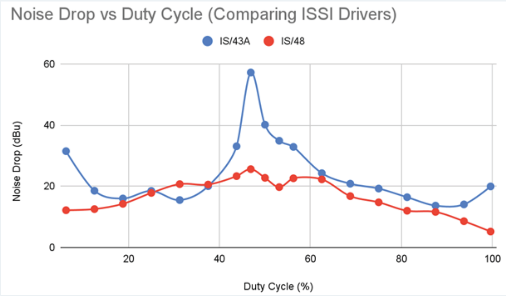
Test Jig PCB: Scaled-Down Prototype

Noise Path Analysis:

By analyzing the Apollo x6's board layout, LED noise path, and power distribution we identified potential refinements for grounding in the existing design. Improving the system's ground isolation through PCB layout redesign was not feasible. However, separating the power supplies for the analog and digital boards contributed to noise reduction.

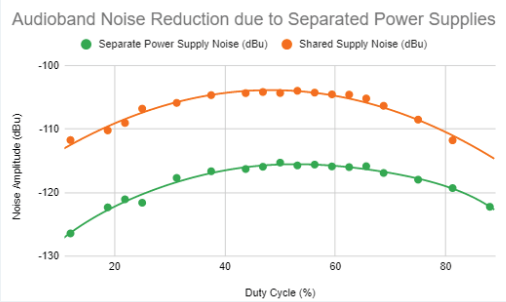
Results

LED Drivers: We compared three candidate LED drivers and concluded that the IS31FL3743A driver from Lumissil exhibited the most effective noise reduction features (spread spectrum technology and operational phase delay).



IS/43A Driver has the Best Noise Reduction (Blue)

Separate Power Supplies: Separating the power supplies yielded significant noise reduction with an average of 11dBu at various PWM duty cycles



Separate (Green) vs Shared (Orange) Noise

Conclusions

The data from this project has the potential to reframe UA's future system designs with spread-spectrum LED drivers and optimal grounding in mixed-signal systems. Along with the data, we composed a report which identifies opportunities for improved PCB layout and offers credible recommendations for future boards.

Automated Testing System For 610B Preamplifier

Zoe Levin, Andy Li, Benjamin Vander Klay, Gradey Steele, Mack Vinsonhaler
Department of Electrical and Computer Engineering

The Problem

The 6176 Channel Strip is a high-quality audio recording preamplifier and compressor. To test the 6176 unit, Universal Audio technicians manually turn knobs and switches on the front panel of the product and run audio tests. This process is time-consuming for technicians and is only viable for completely assembled products.

Our solution is to create an automated test bench that emulates the front panel settings of the preamp side of the 6176 unit (the 610B) and automatically runs audio tests. Such a device would save time for technicians and be applicable to individual boards rather than completely assembled products, allowing for improved quality assurance post-manufacturing.

610B Controls

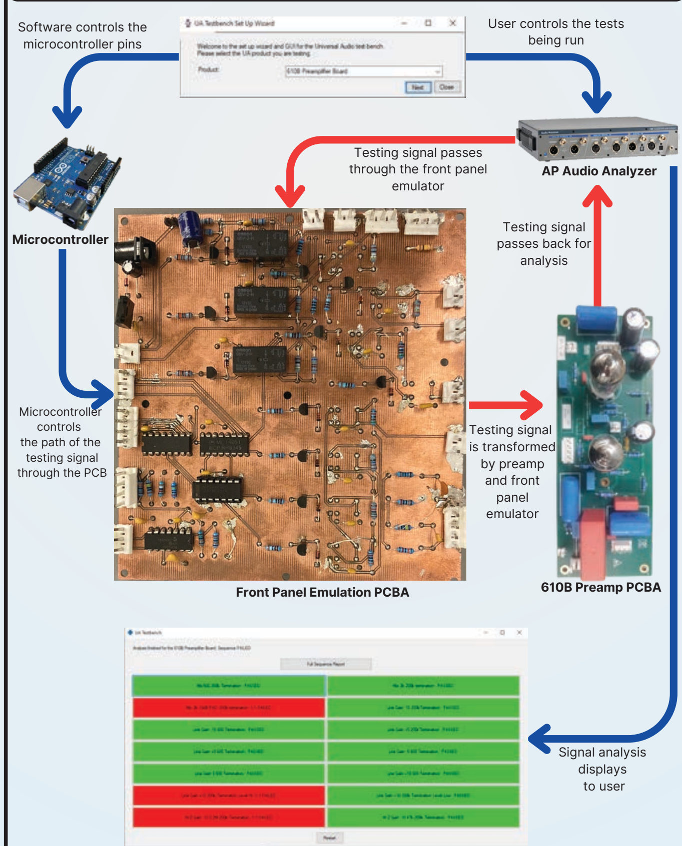
The Approach

- Create an application that allows the technician to choose the product they are testing, start and end the automated testing process, and see the results.
- Create a PCB that can emulate front panel settings which are selected using a microcontroller in conjunction with relays.
- Create a polished product that houses the front panel emulator and allows for quick setup by the technician.

Key Features

- User interaction time in the testing of the 610B board is less than two minutes.
- The results of the tests are shown with an easy to read report and graphic.
- Readily adaptable to at least two other Universal Audio products with potential for more

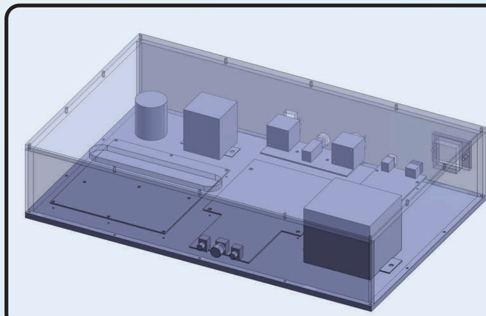
System Overview



Adaptability

Many design choices were made to ensure the product would be adaptable to test other Universal Audio boards:

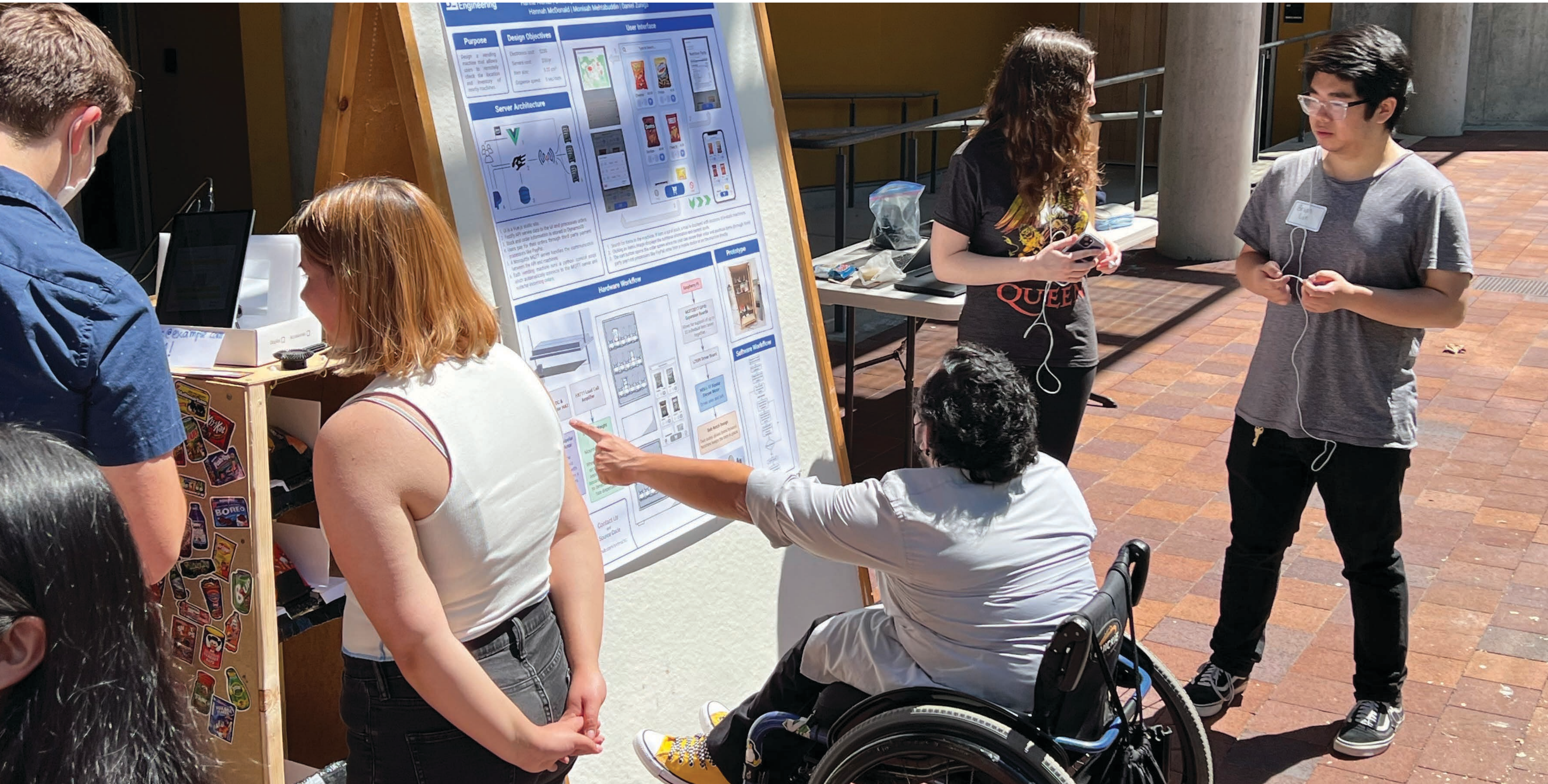
- Microcontroller can be configured to emulate different types of switches
- Microcontroller configured completely through the Test Bench Windows Application
- Products can be added to the user interface
- Saved testing reports have product identifiers



Chassis that houses the I/O board, our control board, microcontroller, power supply board, and audio transformers.

Acknowledgments: **UC Santa Cruz:** Stephen Petersen, Tela Favoloro, Azzam Qureshi **Universal Audio:** Arfel Hernandez, Mike O'Brien, Mahmoud Khoshdelazad, Dan Freeman

We are very pleased to include faculty-selected posters for the Senior Design Projects that were done without industry sponsors. Some of these projects were instigated and/or sponsored by research at Baskin Engineering, while others were created by students with the assistance of faculty mentors and TAs.



Baskin Engineering

Automated Spice Rack

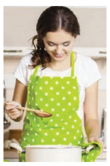
Shenghao Jia, Yi Jiang, Kevin Kuang, Maxwell Kunes, Nicholas Lee, Alexander Nivelle, Paul Shand
CSE 123 Team 8, Spring 2023

UC SANTA CRUZ

Purpose

Our automated spice rack efficiently organizes and locates spices, providing a practical solution for managing the large quantity of spices in modern home kitchens.

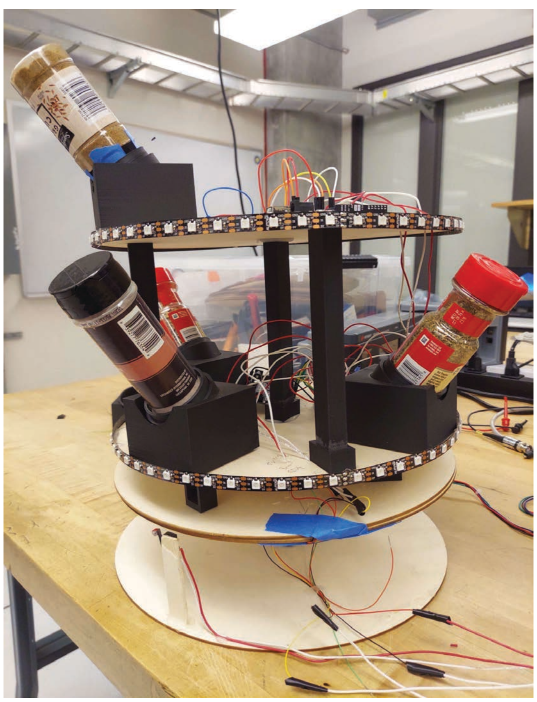
Target Market



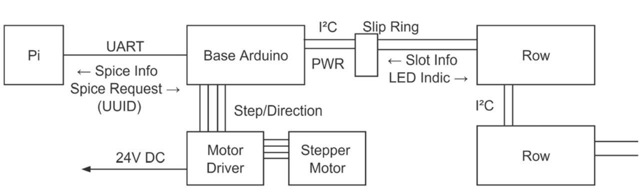
Tiffany | Home Cook
The automated spice rack helps Tiffany declutter and keep track of her spice bottles at home.

Tony | Chef
The automated spice rack enhances Tony's cooking efficiency by effortlessly locating a wide variety of spices, benefiting him as a professional chef at home and work.

Functional Prototype

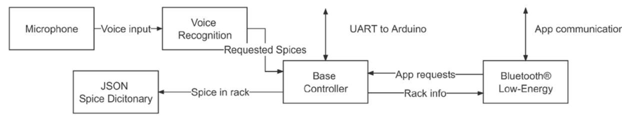


Hardware Design



- Base Raspberry Pi communicates with Arduino Mega
- I2C used to communicate between base Arduino and rack rows
- Base Arduino controls stepper motor and LEDs to indicate requested spice
- Slip Ring is used to pass electrical signals and power through rotating shaft

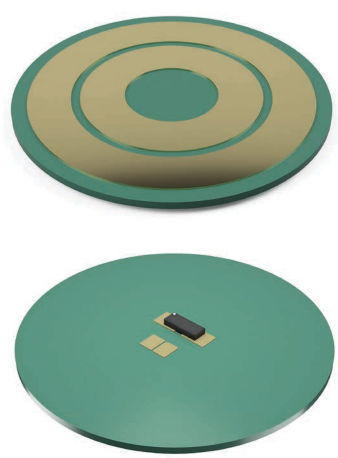
Software Design



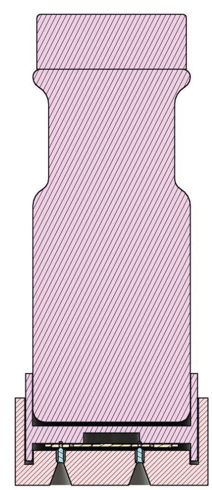
- Bluetooth Low Energy provides communication with smartphone app
- Voice recognition allows for speech input to request spices
- Base controller communicates commands to Arduino and tracks available spices

Aesthetic Rendering

Prototypes



Bottle Identification PCB



Split View of Spice Bottle & Slot

Contact: mkunes@ucsc.edu

Want to know more?
Look at our website!

Rug Slug

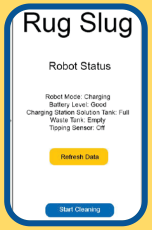
"Let the slug do the dirty work"

Garrett Cregier, Kaixin Yu, Nikko Echeveria, Giovanni Ramirez, Tyler Wong
Department of Computer and Electrical Engineering

Baskin Engineering

App

- The app connects to the robot via wifi
- The user can tell the robot to clean and look at the robot's status through the app



Spot Beacon

- The spot beacon is placed at the stain and guides the robot using IR

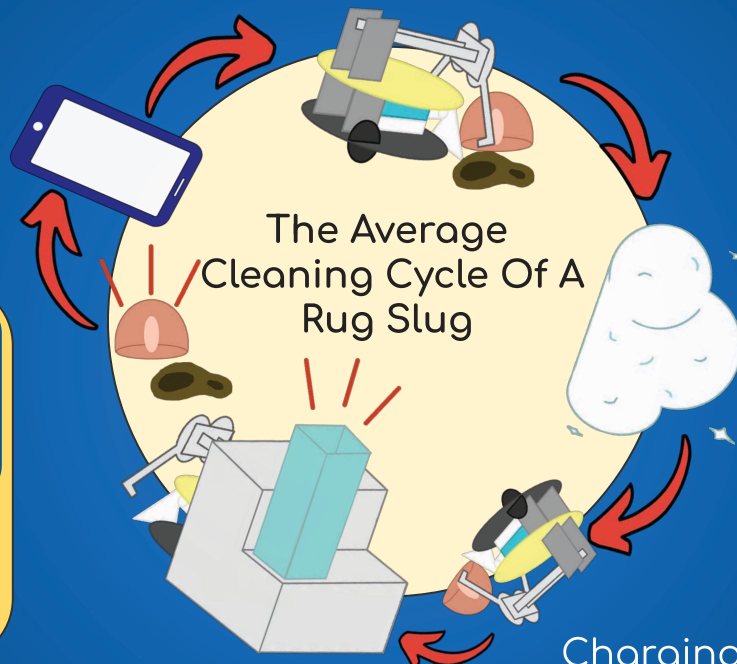
- It emits IR light at a frequency of 2.5kHz, a distinct frequency which helps the robot find the beacon as opposed to any other IR light

Current Progress

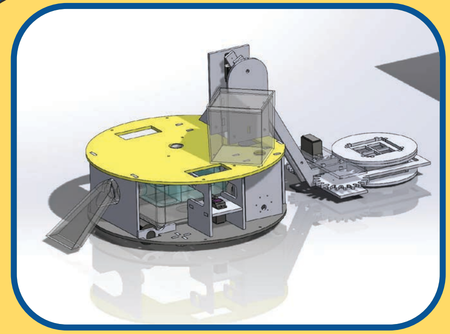
- With this prototype, we have been able to validate our spot location and our charging/solution refilling strategies
- We are now moving into developing the cleaning capabilities of the system

Problem

Carpets are easily stained and take effort to clean using current carpet cleaning tools



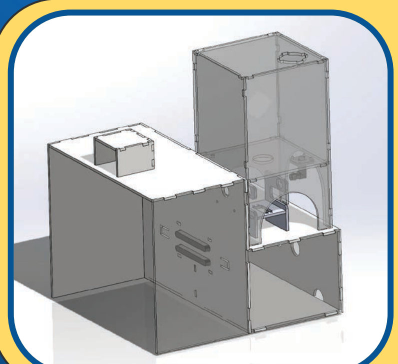
Carpet Cleaning Robot



The robot can grab the spot beacon using its claw

- It navigates towards the spot beacon using an IR sensor for the beacon and IR sensors for walls
- The robot is able to navigate correctly. The cleaning system will be tested in our next phase of development

Charging Station



- The charging station both charges the robot and refills it with heated cleaning solution
- It has an IR beacon on top to help the robot navigate back after cleaning a stain
- It senses when the robot is docked using a bumper switch on the charging plates
- We have proven through testing that the charging station successfully performs all intended functions

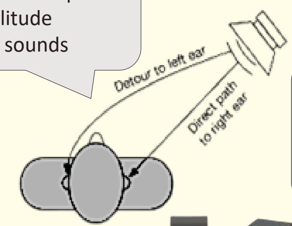
SoLo Tech – Sound Localization

A Wearable Haptic Feedback Device for the Hearing Impaired

Riley Altman, Heather Garavetto, Sylvester Olivas, Alex Swanson

Department of Electrical and Computer Engineering

Biological sound localization uses two ears to compare time and amplitude differences of sounds

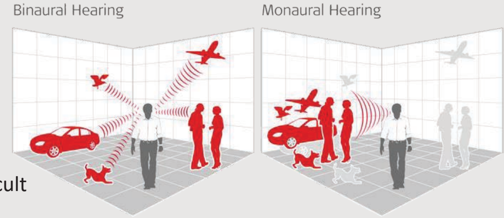


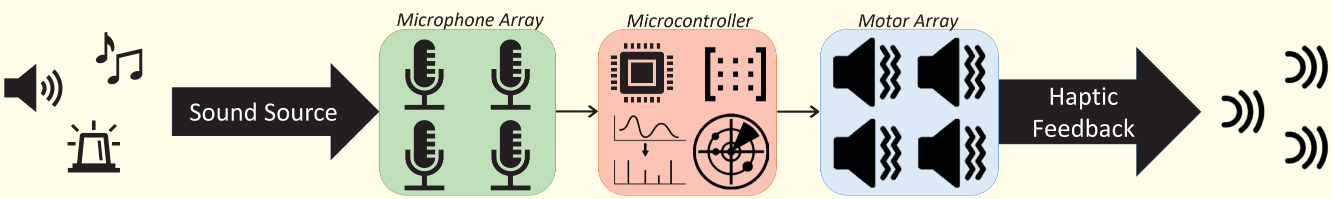
Scan for:
- Contact
- References
- User Manual
- And more

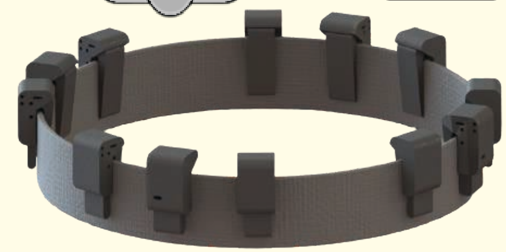
Why is this needed?

Poor sound localization affects people with hearing impairments:

- Drastically increased danger of everyday activities
- The inability to hear an approaching car presents a threat
- Everyday tasks, like locating someone calling your name, are much more difficult







Haptic Feedback Belt Prototype v1.0

Audio Processing

The range of audible frequencies for humans is approximately 20 Hz-20 kHz, but most sounds from everyday life fall below 8 kHz. For this reason, it was necessary to implement a low-pass filter which serves two purposes:

- Filtering out high frequency sounds which are unlikely to be of any interest to the user (coil whine in faulty electronics, ultrasonic signals)
- Preventing alias fold-over

The user is also able to adjust the sensitivity of the microphone array using a dial on the belt.

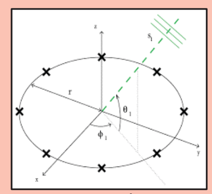
Conclusion

- We created a vibrotactile haptic feedback belt that collects audio information from the environment and reports it to the user via vibration in real time
- Testing of our current implementation shows average haptic feedback recognition error at 7.5°, and average sound localization accuracy error at 12.1°

Sound Localization

DOA (direction of arrival) algorithm:

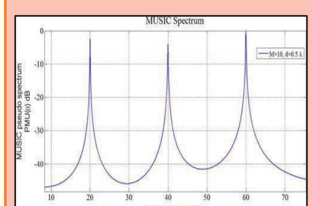
- Used to localize sound
- Uses phase/amplitude information



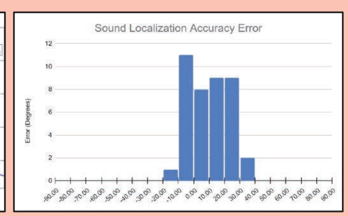
Mic array layout

MUSIC (Multiple Signal Classification) algorithm:

- A popular DOA algorithm
- Effective at localizing multiple sounds
- Uses linear algebra techniques to:
  - Separate the noise vectors from the signal vectors
  - Can be used to estimate where a signal may be present



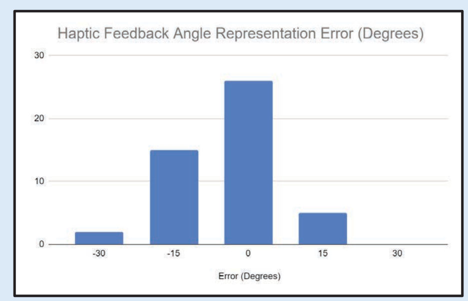
Est. power for each angle



Error of rudimentary DOA algorithm

Haptic Feedback

- The device utilizes 8 vibration motors and their corresponding motor drivers to provide vibrotactile haptic feedback with a representation resolution of 15°
- The output of the sound localization algorithm is used to calculate which motors are active and their corresponding strengths
- The strength of a motor's vibration corresponds to its distance from the angle of arrival. The closer a motor is to the DOA, the stronger the vibration



Angle Recognition Error

Telemetry Ground Station:

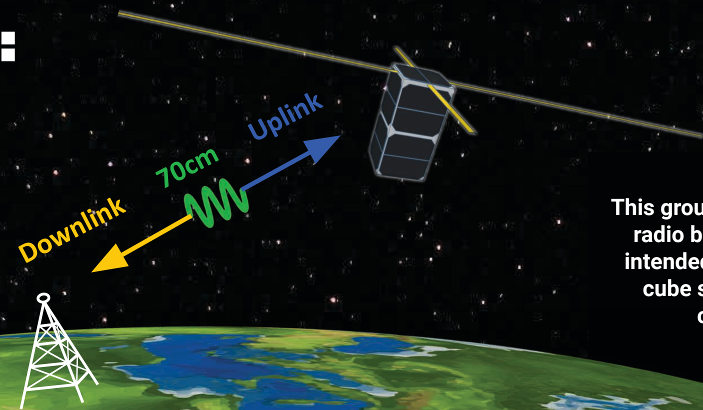
ORBITAL COMMUNICATIONS & CONTROL

Spencer Balliet (EE), Dev Dhruv (EE), Zenan Vong (EE)

Baskin Engineering
Electrical and Computer Engineering

What is Telemetry?

Satellite telemetry is the communication link between a ground station and satellite. The ground station oversees the operation and condition of the satellite. The satellite fulfills its mission and will update the ground of any new developments. Communication is constrained by link losses to & from LEO and the ground, as well as FCC requirements to minimize interference with other radio operators.



Telemetry Ground Station

This ground station will operate in the 70cm amateur radio band as a half-duplex system. This system is intended for operation in conjunction with SlugSat's cube satellite. The ground station will oversee the condition of the satellite, relay data from the satellite's science payload, and command the satellite as necessary.

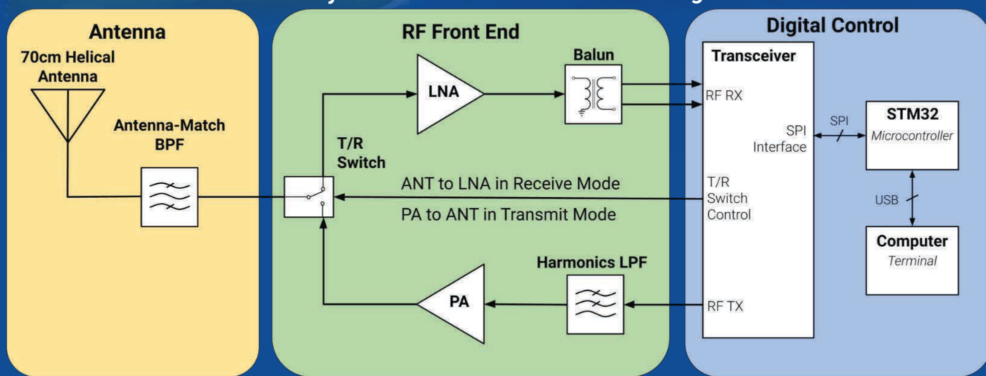
Antenna

- Circularly polarized antenna maintains signal power no matter the relative orientation with satellite
- Out of band signals attenuated by antenna and BPF
- BPF impedances matches antenna to front end for maximum power transfer

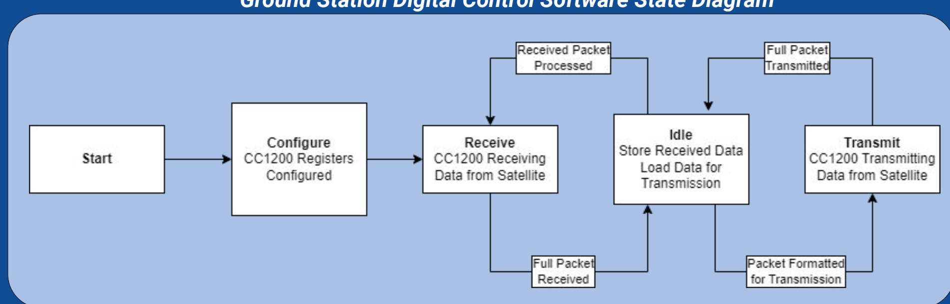
Digital Control Hardware

- Transceiver converts payloads to/from 4-GFSK
- 4-GFSK modulation maximizes data rate from allocated bandwidth and permissible signal rate
- Microcontroller parses commands from a terminal and operates the transceiver

Telemetry Ground Station Hardware Block Diagram



Ground Station Digital Control Software State Diagram



Progress

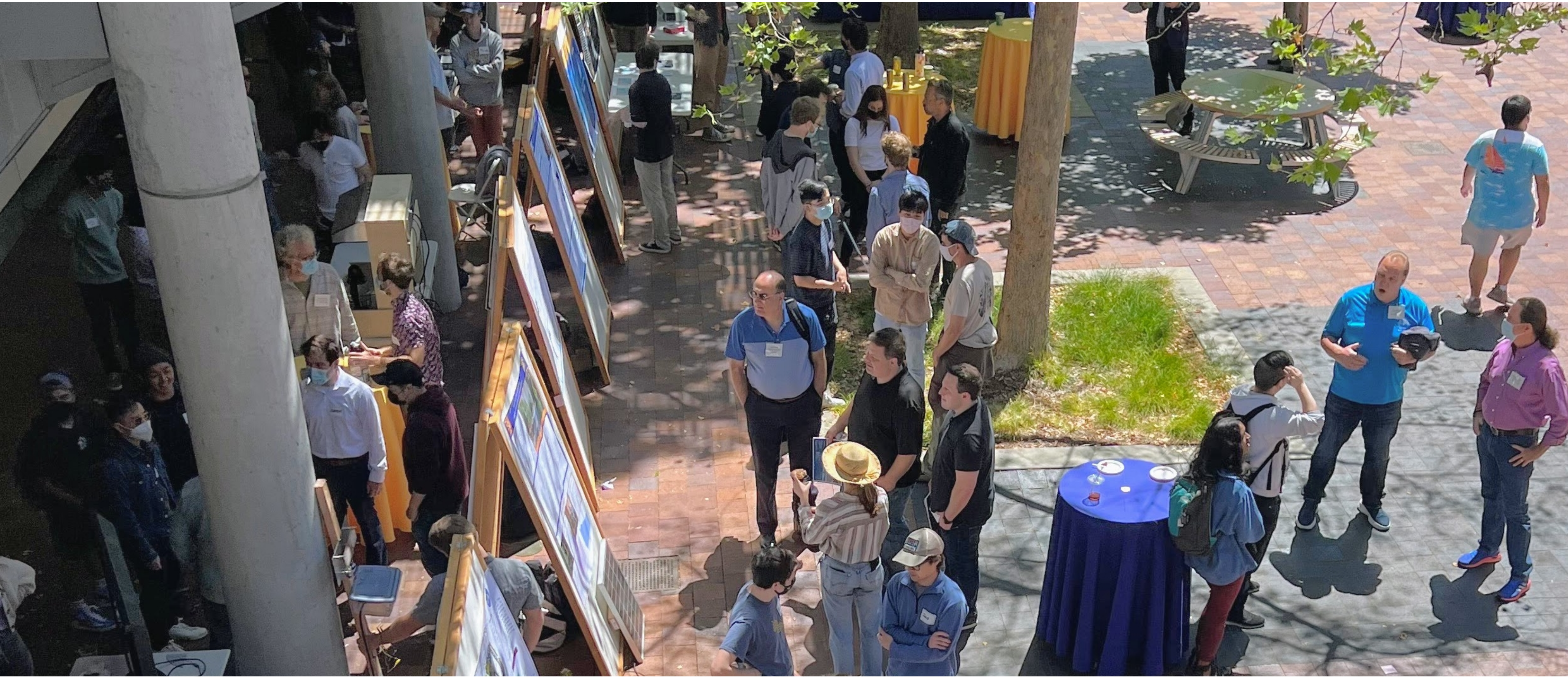
- Ground station constructed & characterized to exceed projected minimum amplification necessary for uplink & downlink to LEO
- Transceiver integrated to front end, and terminal has been interfaced for operator control

RF Front End

- T/R Switch routes signal flow for half-duplex operation & protects LNA from PA output power
- LNA boosts receive power over minimum sensitivity of transceiver, adding 6dB of downlink margin
- PA amplifies transmission to cut through link losses to LEO, while adding 4dB of uplink margin
- Harmonics LPF helps meet FCC §97.307(e) spurious emission regulations by attenuating harmonic power from direct digital synthesis to -40dBc and lower

Ground Station Software

- Transceiver communicates with a Microcontroller via SPI
- Transceiver is configured to communicate on the 70-cm band with 4-GFSK modulation
- Operator can input a message for transmission and initiate reception of satellite information



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