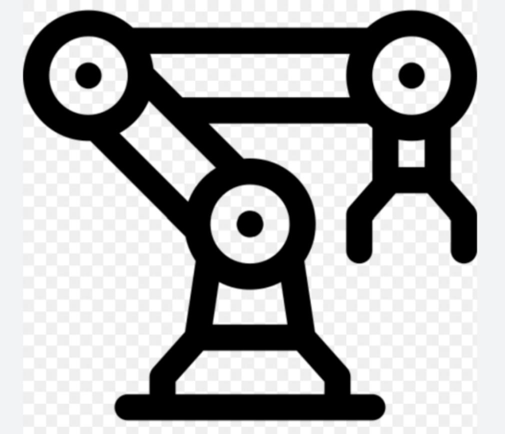
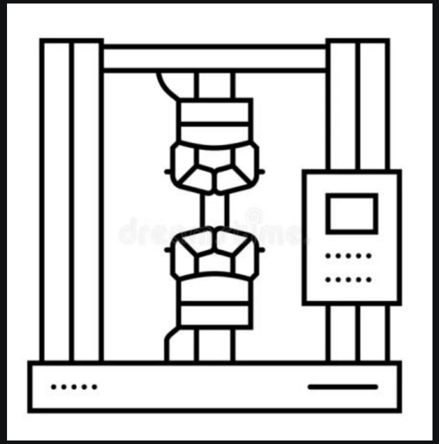
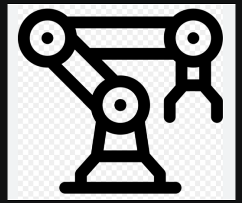
Portfolio by

Betool


Q-Arm Robotic 4 DOF Arm



About

Current robotic arm used for research, education pick-and-place operations is costly, unreliable and lacked the open framework needed for customization and expandability in academic settings causing bottlenecks in research and testing.
A high-precision robotic system was required to perform the complex tasks set by the faculty.

Task

To troubleshoot, re-engineer a 4 DOF robotic arm capable of advanced kinematics calculations, precise positioning within ±2mm accuracy, and seamless integration with existing manufacturing workflows. The system needed to handle payloads up to 2kg while maintaining repeatability standards.

Responsibilities

Implemented forward and inverse kinematics algorithms using MATLAB and Python, designed custom servo motor control systems with PID feedback loops, developed CAD models in SolidWorks with stress analysis simulations, and programmed real-time motion planning algorithms for smooth trajectory execution. Also redesigned the grippers and created a modular platforms for developers.

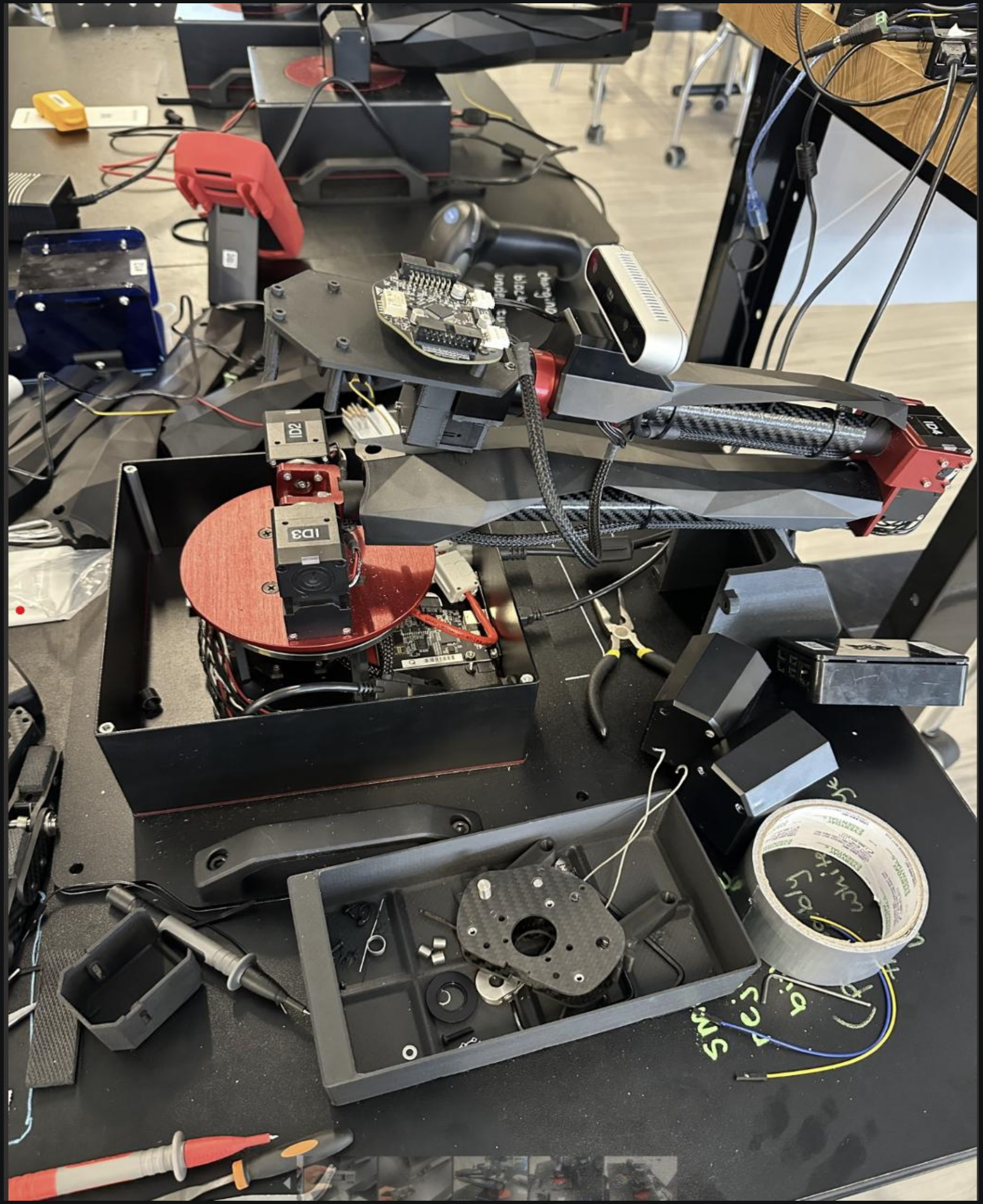
Result

Achieved ±1.5mm positioning accuracy, 60% cost reduction compared to commercial alternatives, successful implementation and scaling the design to 30+ robotic arms and demonstrated 99.2% operational uptime over 3-month testing period with comprehensive documentation for future scaling.
My greatest accomplishment for this project was diagnosing and resolving current spikes in the gripper during shoulder joint movement. I revers-engineered the power distribution, isolated shared paths, and redesigned the system to consistently reduce current draw from 400–700 mA to ~130 mA. I also developed a predictive failure tool to proactively flag overload conditions, helping prevent damage to the QArm with an estimated savings of $4,500 per unit.

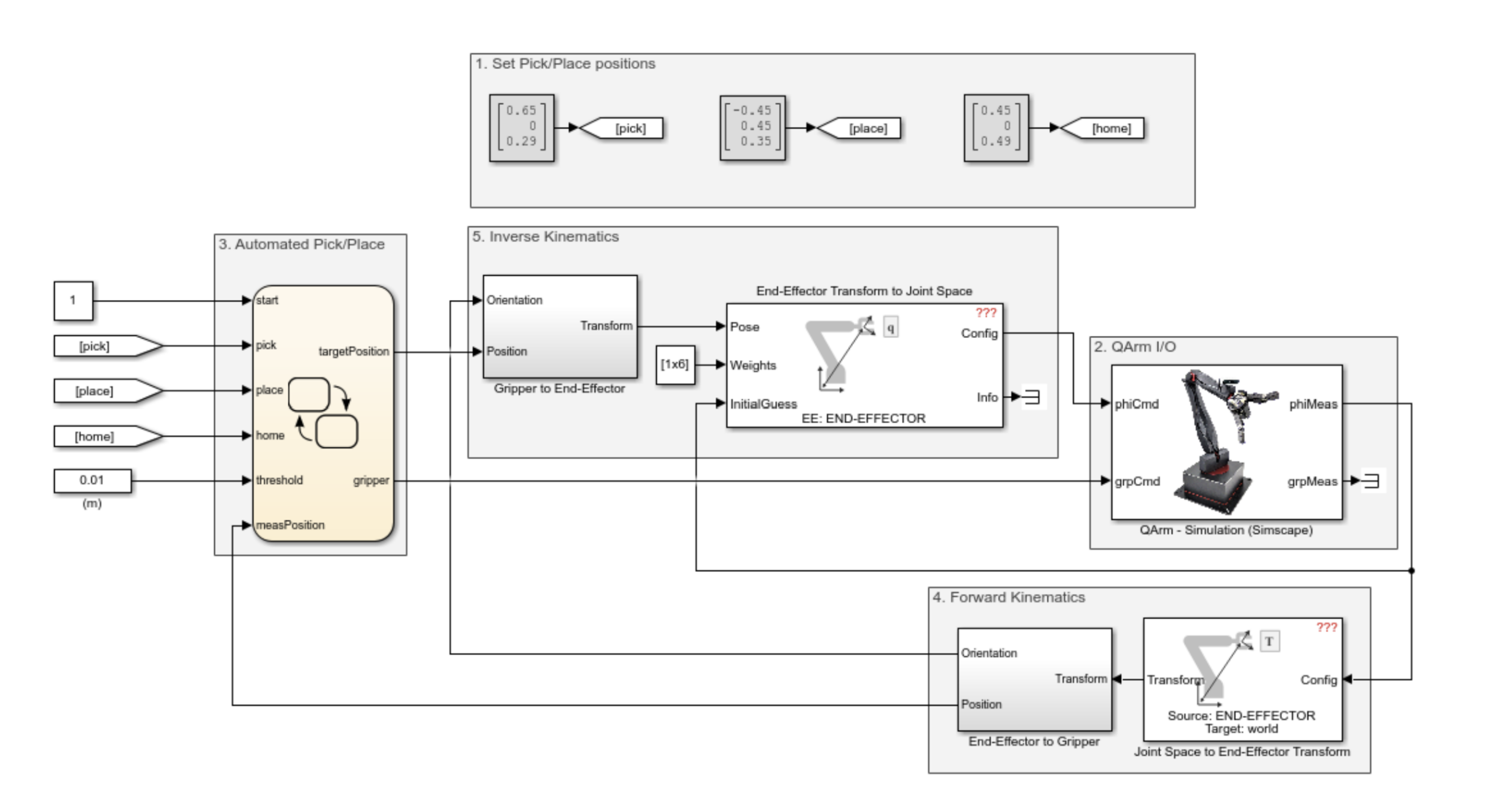
Skills

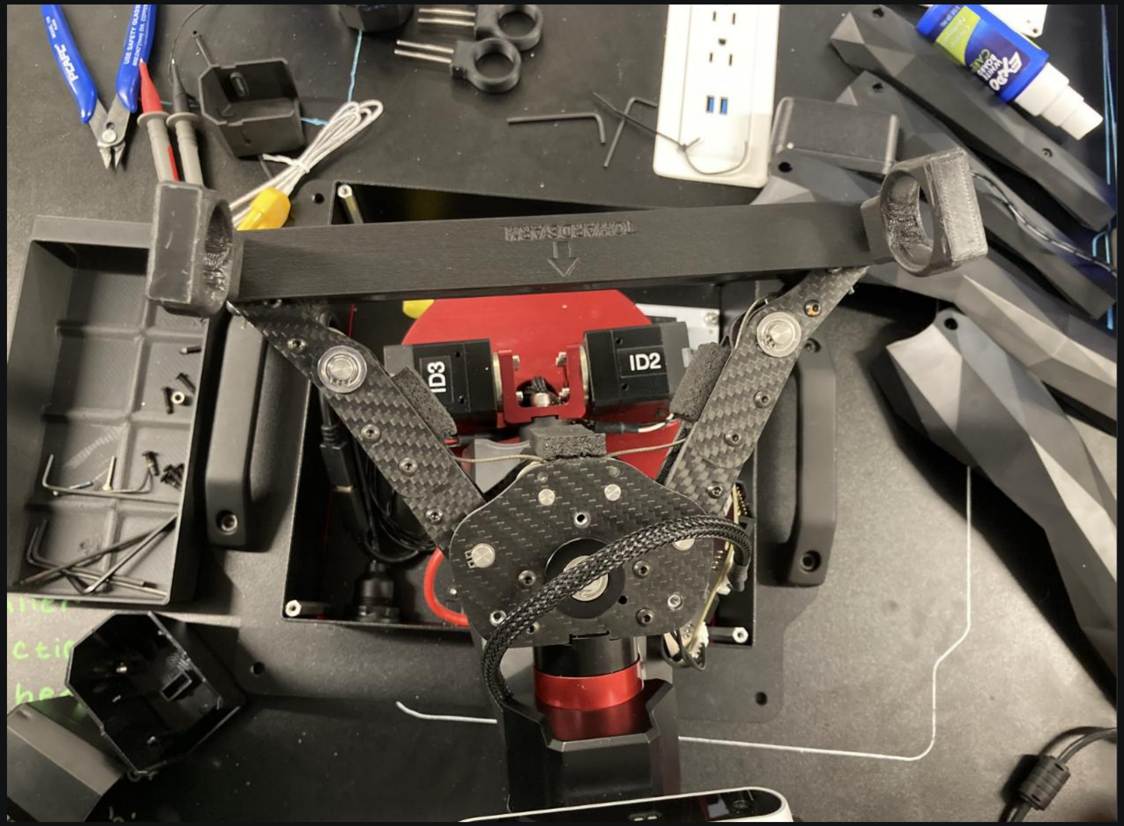
- 3D Printing
- Python
- SolidWorks
- GD&T
- Raspberry Pi
- Motor and Actuator Testing and Implementation
- Worm and Spur Gear Design
- Failure Mode Analysis
- Rapid Prototyping

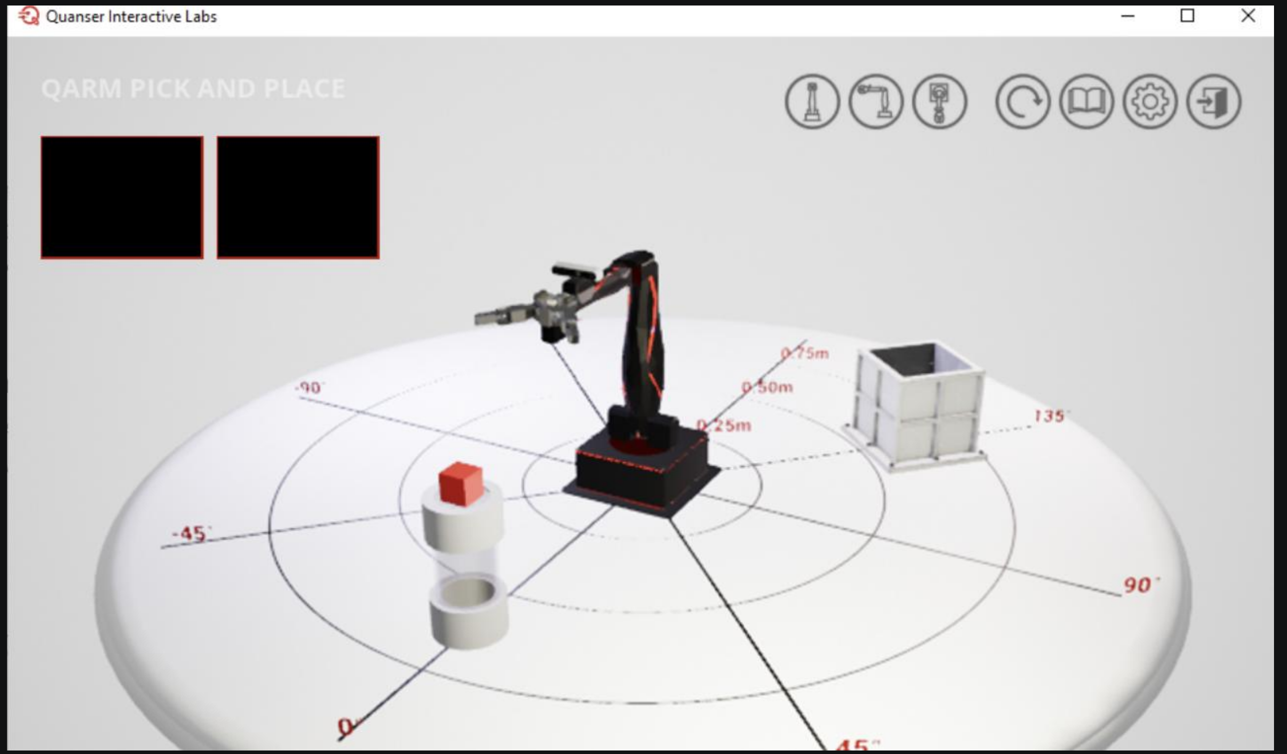
Dissecting and Testing the Q-Arm

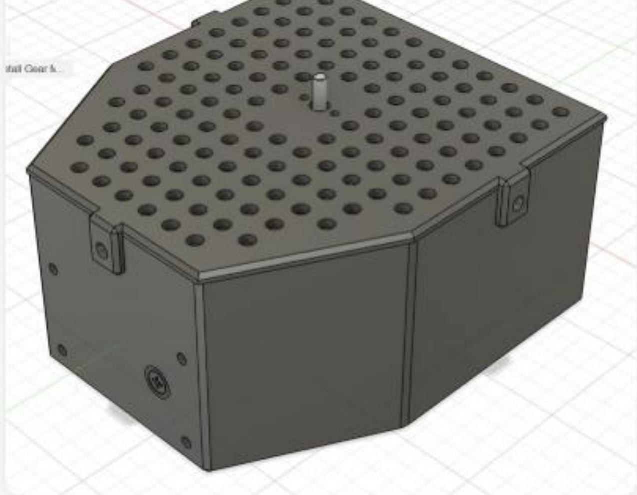


Performing Physical and Software Testing







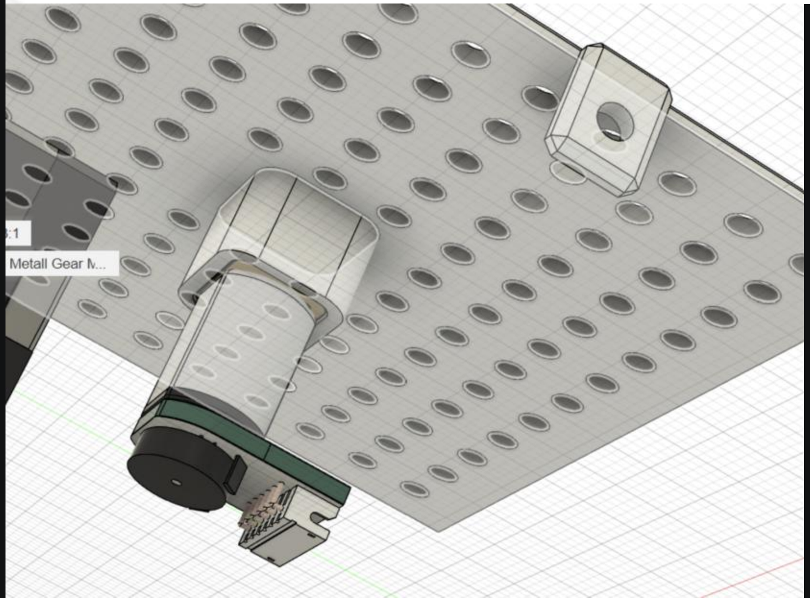


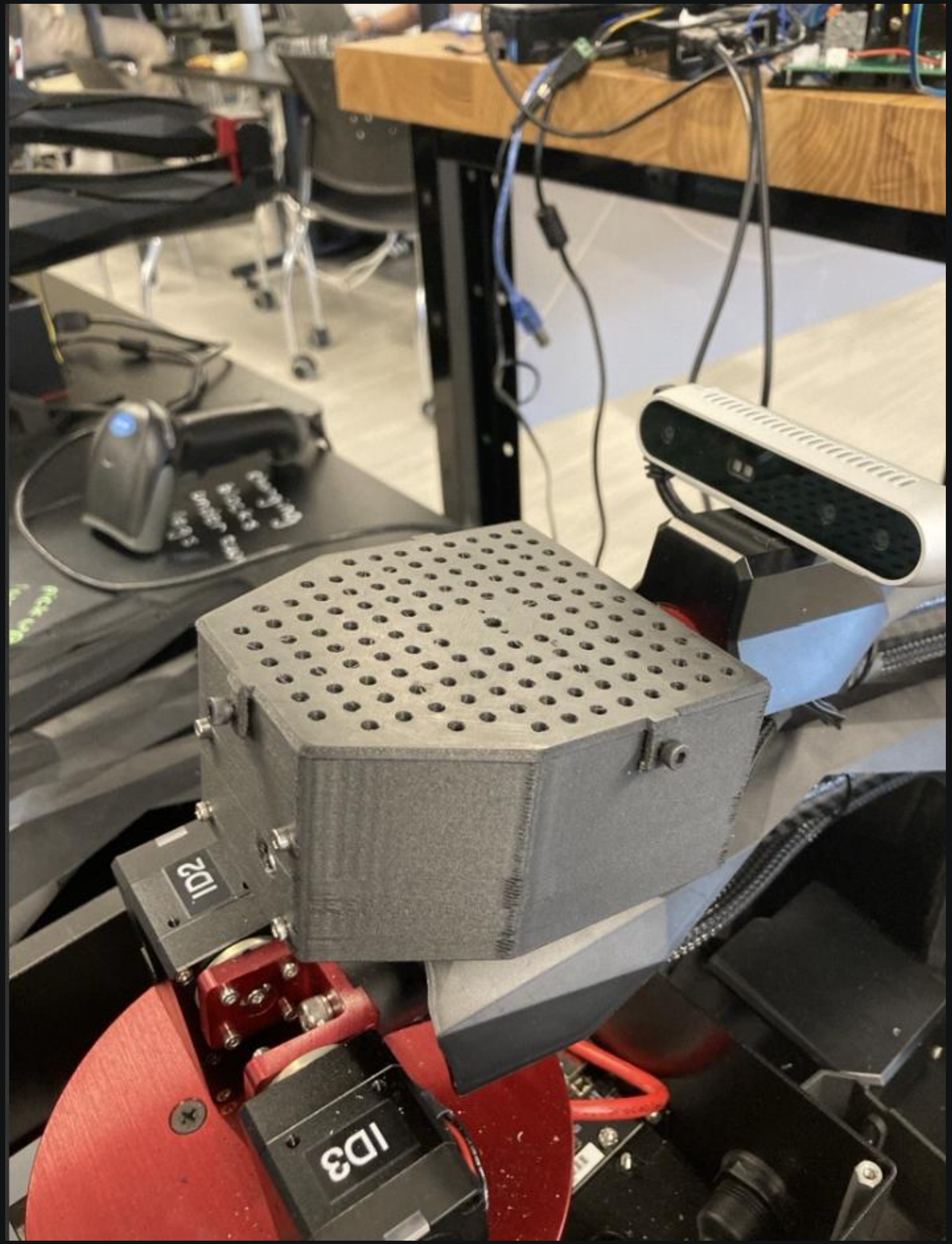
```
restart:

m__p := 0.03; # kg, mass of payload
g := -9.81; # m/s^2
μ__s := 0.35; # static friction, just a guess for PLA
τ__m := 0.1176798; # N*m, torque output of motor
l__f := 0.09; # m, length of finger

F__N := τ__m / l__f; # N, Normal force applied by gripper
F__z__net := m__p * g + μ__s * F__N; # N, Net force in z-direction experienced by payload at max friction
```

$$m_p := 0.03$$
$$g := -9.81$$
$$\mu_s := 0.35$$
$$\tau_m := 0.1176798$$
$$l_f := 0.09$$
$$F_N := 1.307553333$$
$$F_{z_{net}} := 0.1633436666$$

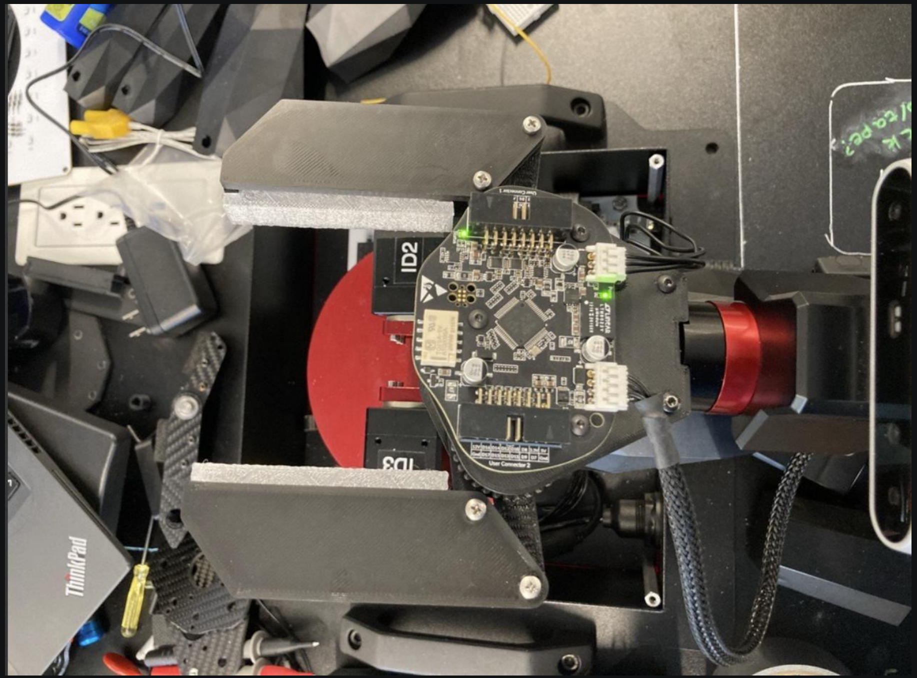




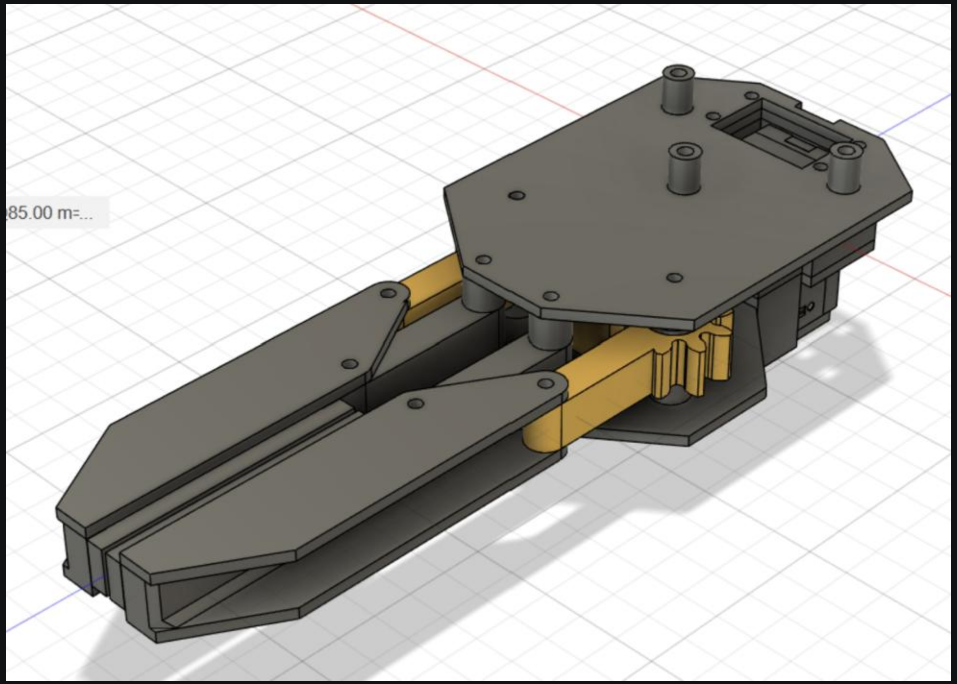
I Designed a modular plate for developers

to test their designs and conducted calculations to select an optimal motor

Different Iterations for Gripper Design

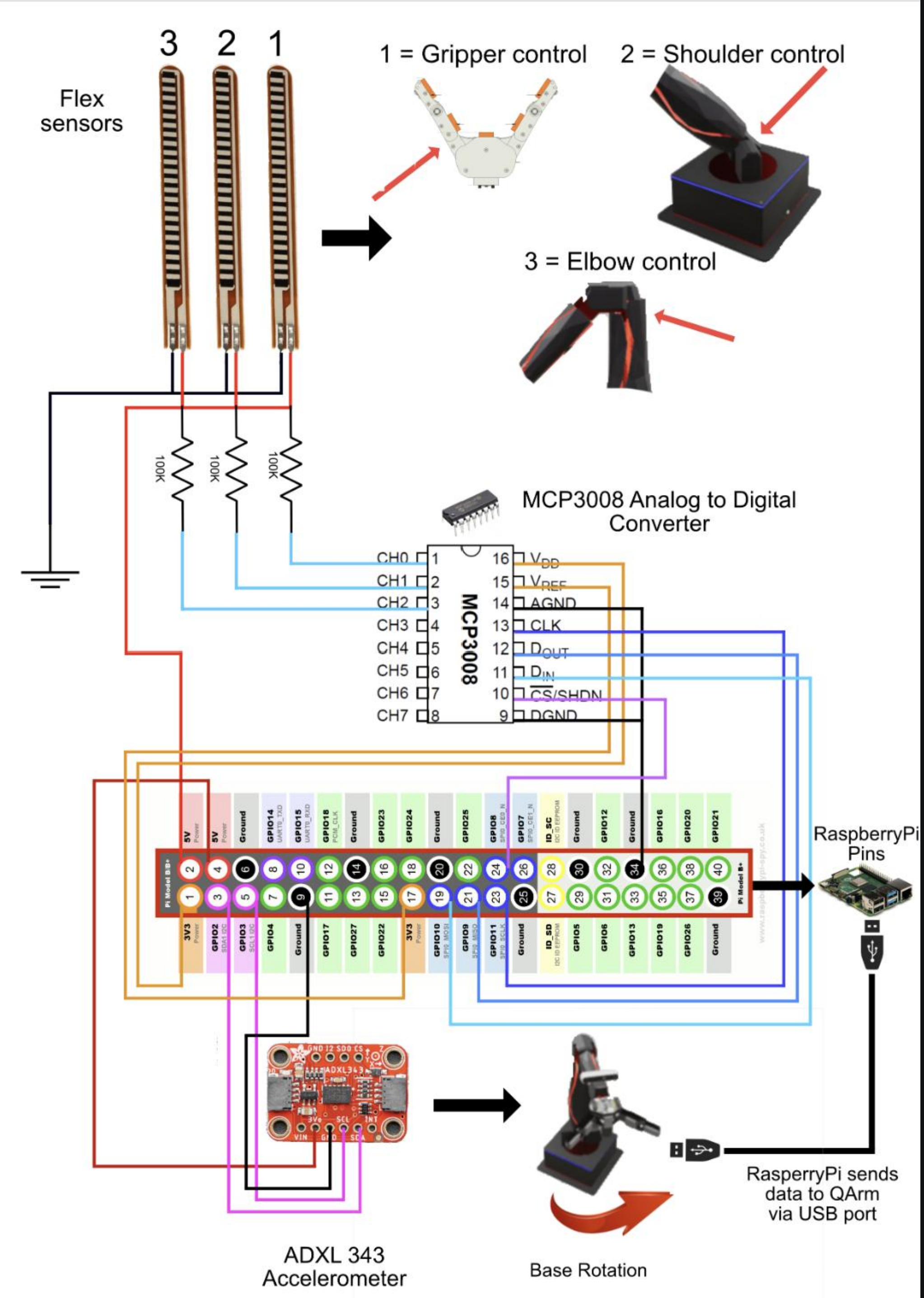


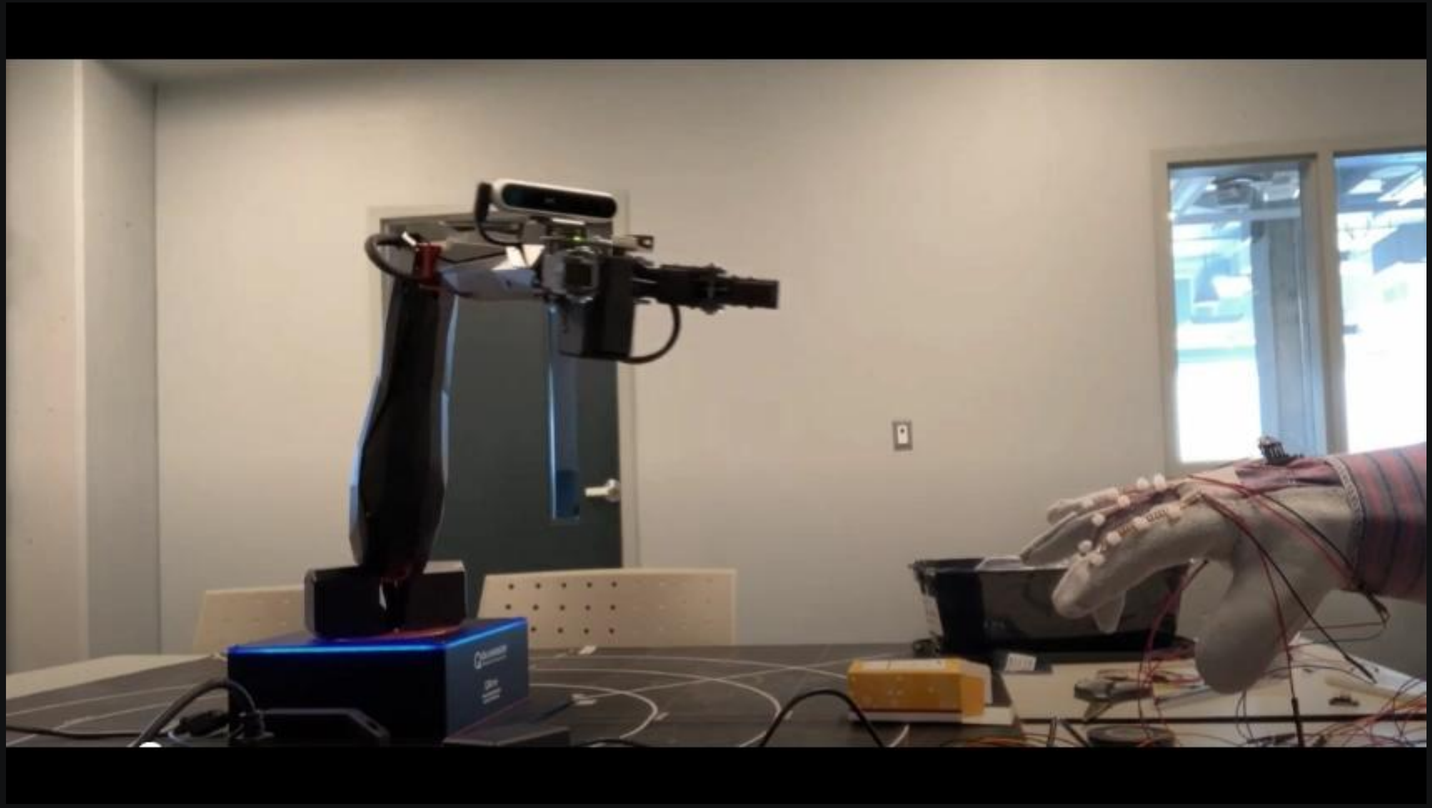
Worm & Spur Gear



Rack and Pinion

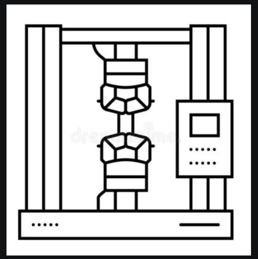
Designed Lab Schematics for Teleoperation





The Final Modular Design of the Arm

Custom Tensile Tester: Material Property Innovation



About

Standard tensile testing equipment costs exceeded $50,000, making material property testing inaccessible for research labs and small manufacturing companies. Existing solutions lacked customization options for specialized materials and testing protocols required for emerging composite materials.

Task

Develop a custom tensile testing machine capable of applying controlled loads up to 10 KN, measuring strain with high precision, generating standardized test reports, and accommodating various specimen geometries while maintaining ASTM D638 compliance standards.

Responsibilities

Designed mechanical load frame using finite element analysis, integrated high-precision load cells and extensometers, developed LabVIEW control software with real-time data acquisition, implemented automated specimen gripping systems, and created comprehensive calibration protocols ensuring measurement traceability.
Rigorous testing protocols, quality assurance procedures, documentation standards, and performance verification against original requirements and industry benchmarks.

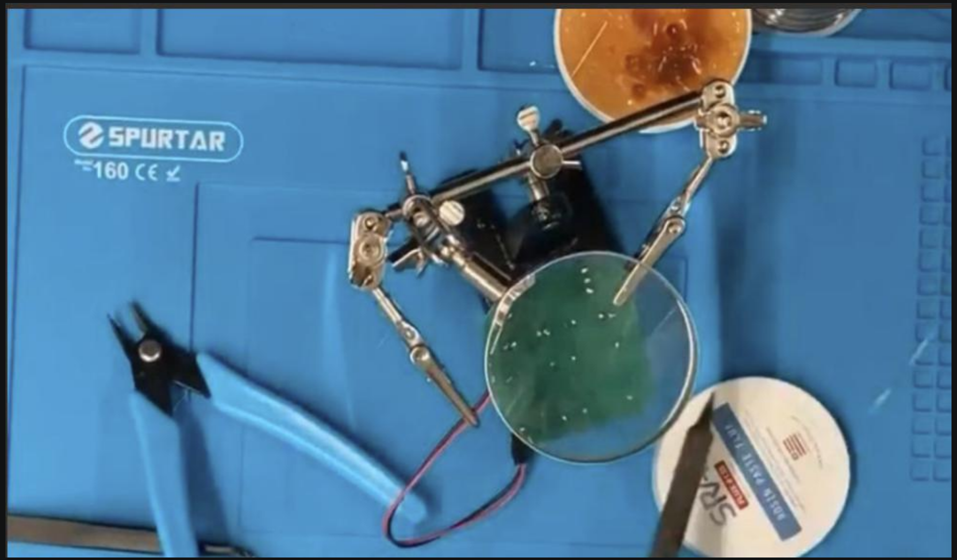
Result Impact

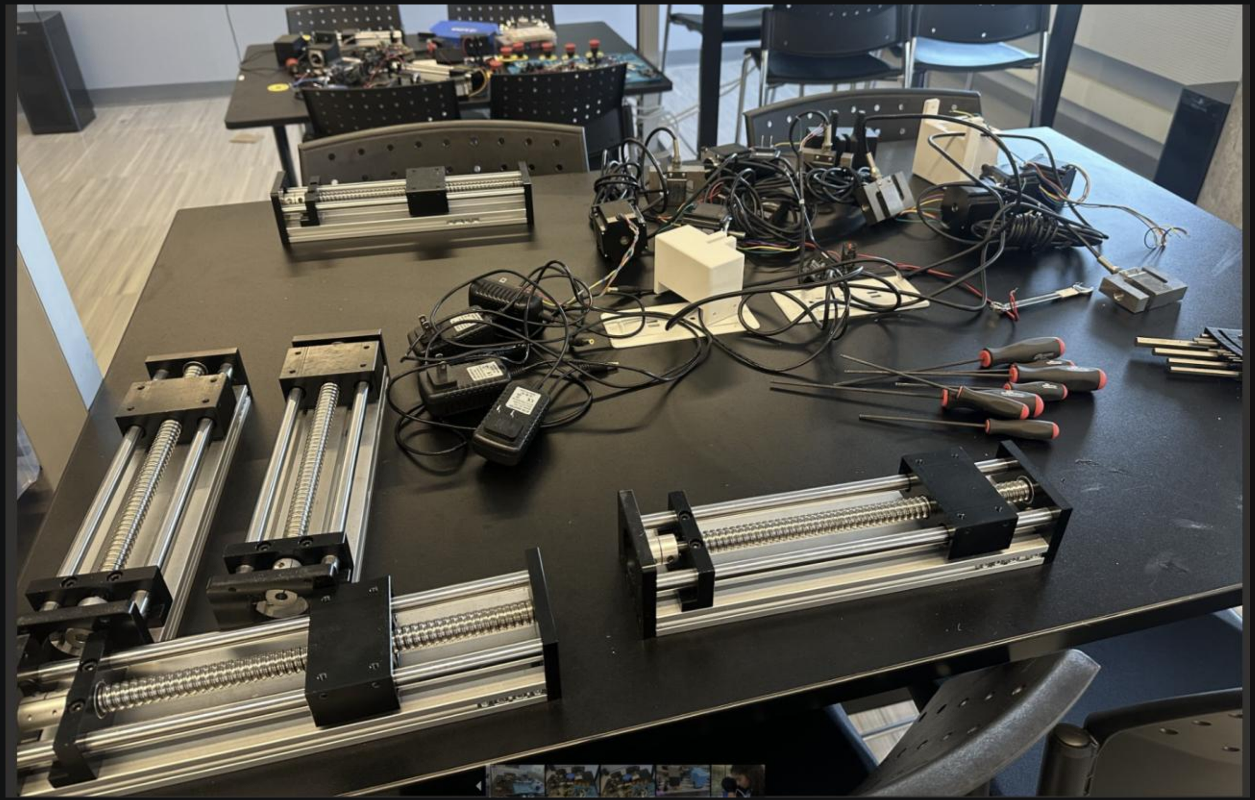
Delivered 85% cost savings compared to commercial systems, achieved ±0.1% load accuracy and ±0.01mm displacement resolution, enabled testing of 15 different material types, and provided data that is supporting published research papers on composite material properties.

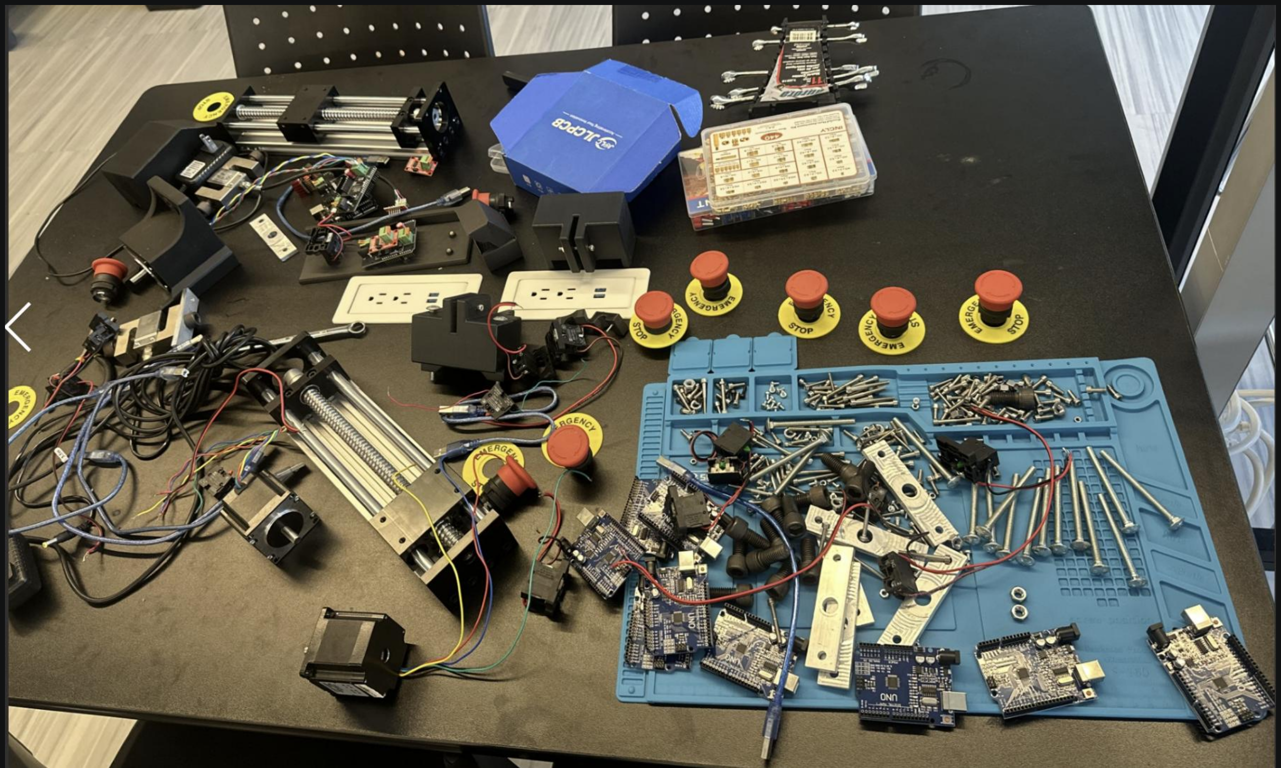
Key Technical Achievement: Successfully validated against certified reference materials, demonstrating measurement uncertainty within ISO 17025 requirements for mechanical testing laboratories.

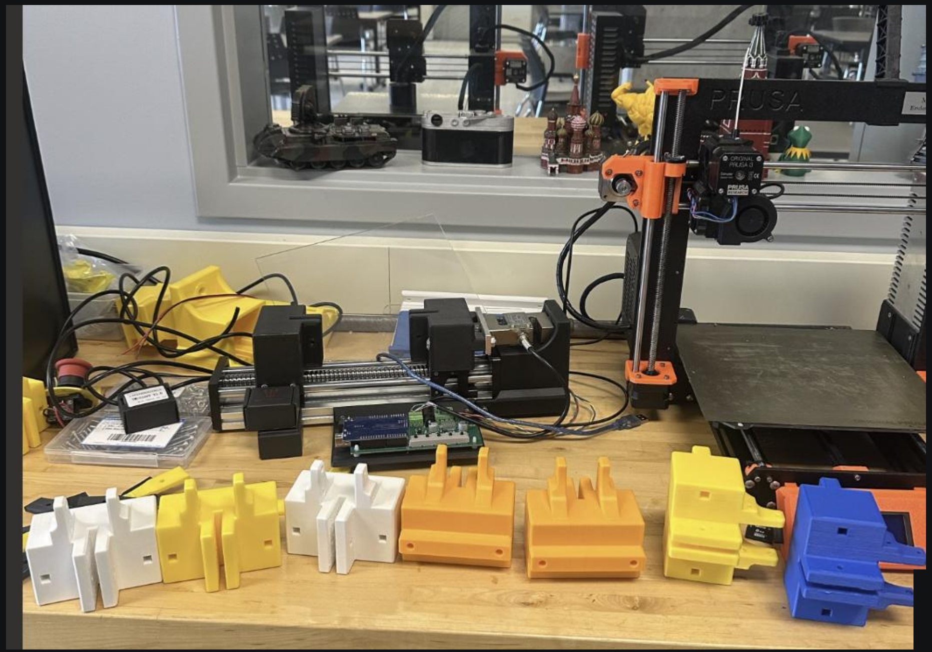
Skills

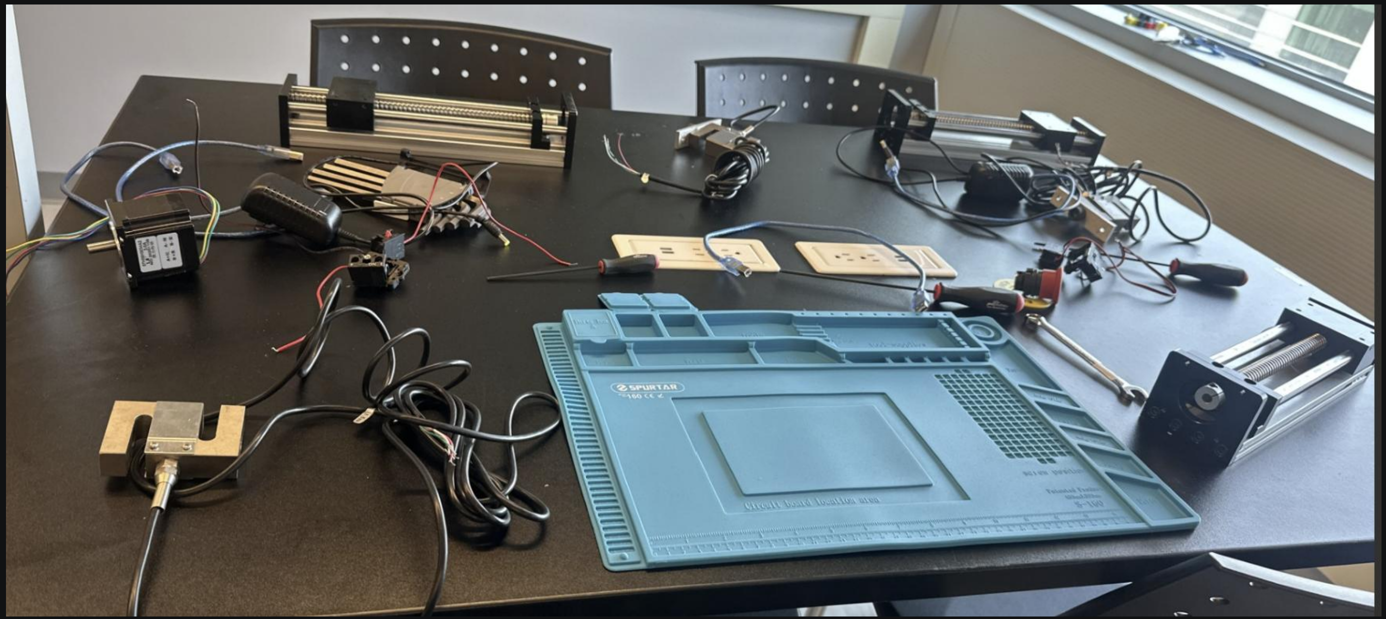
- 3D Printing
- MATLAB
- KICAD
- SolidWorks
- GD&T
- Raspberry Pi
- Motor and Stepper Testing and Implementation
- Failure Mode Analysis
- Rapid Prototyping

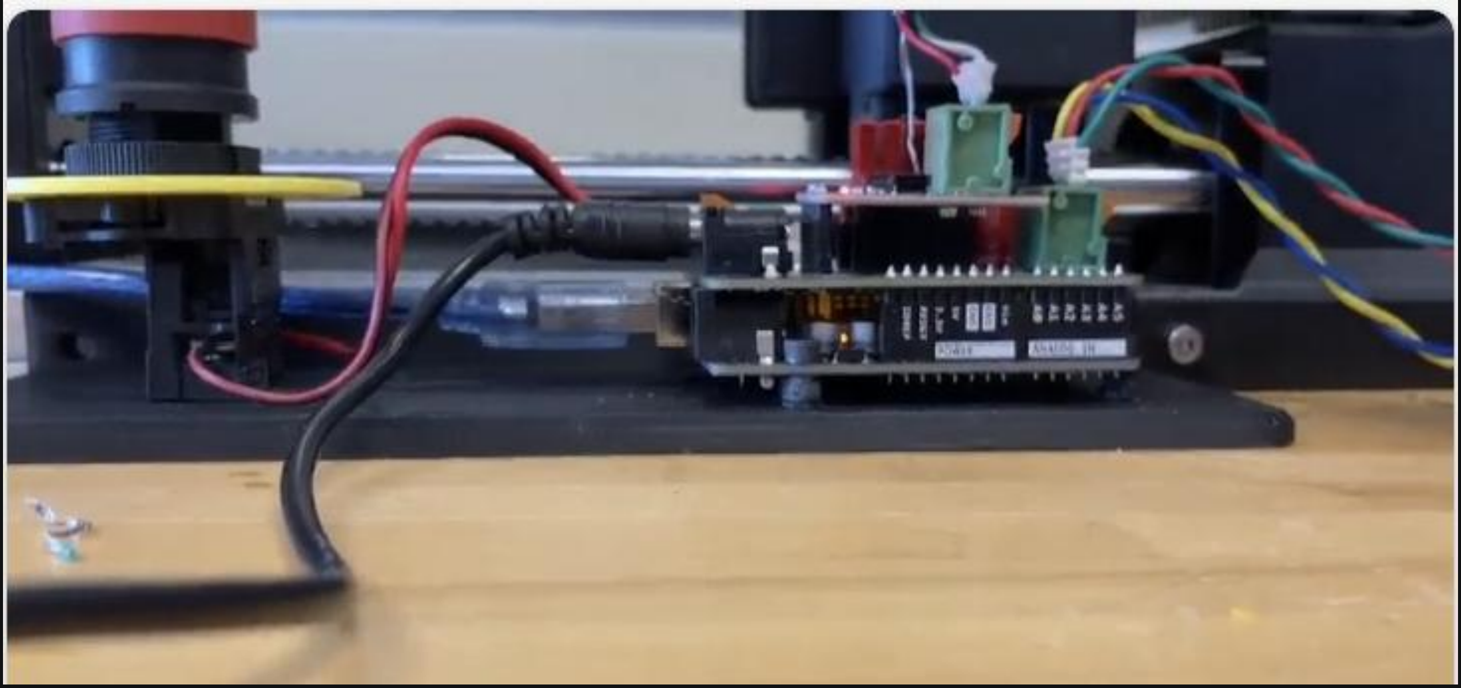

SPURTAR
160

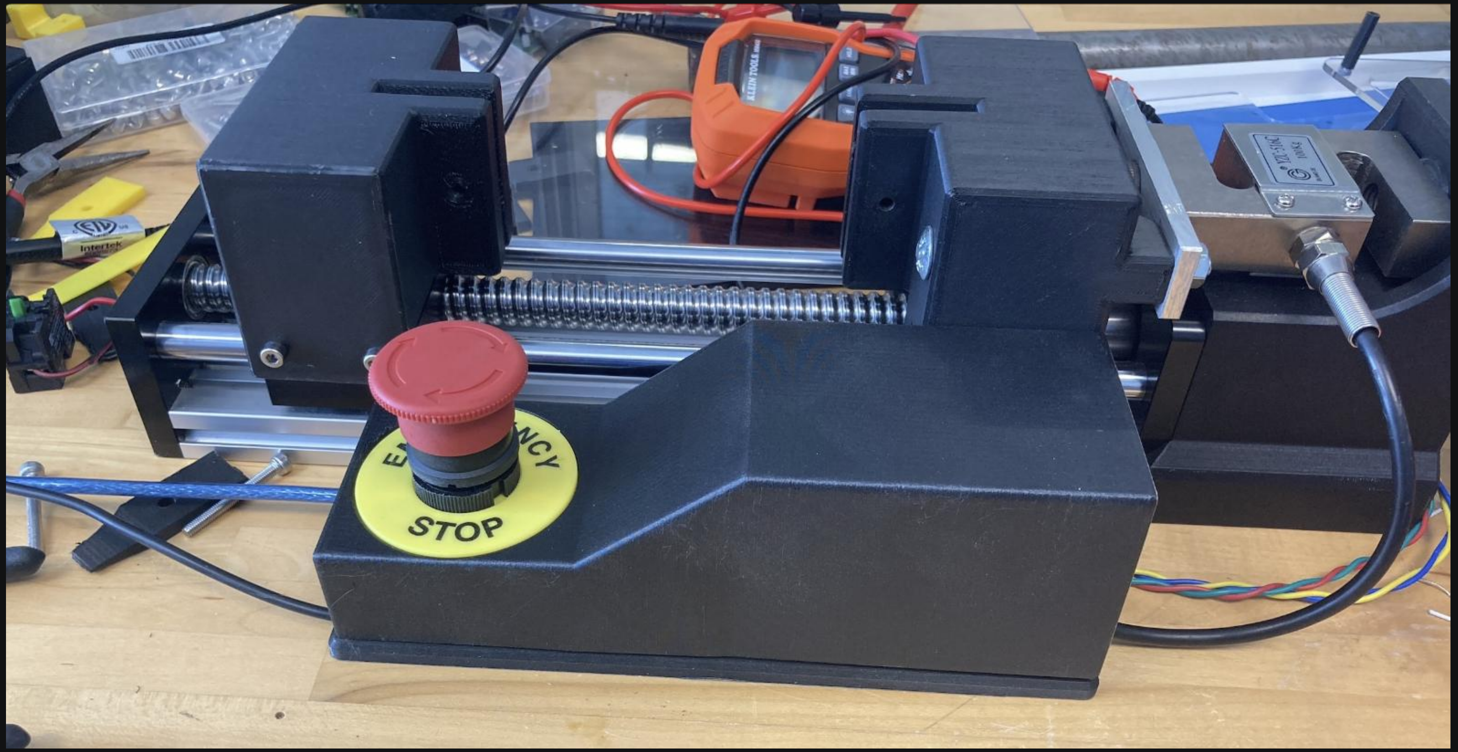


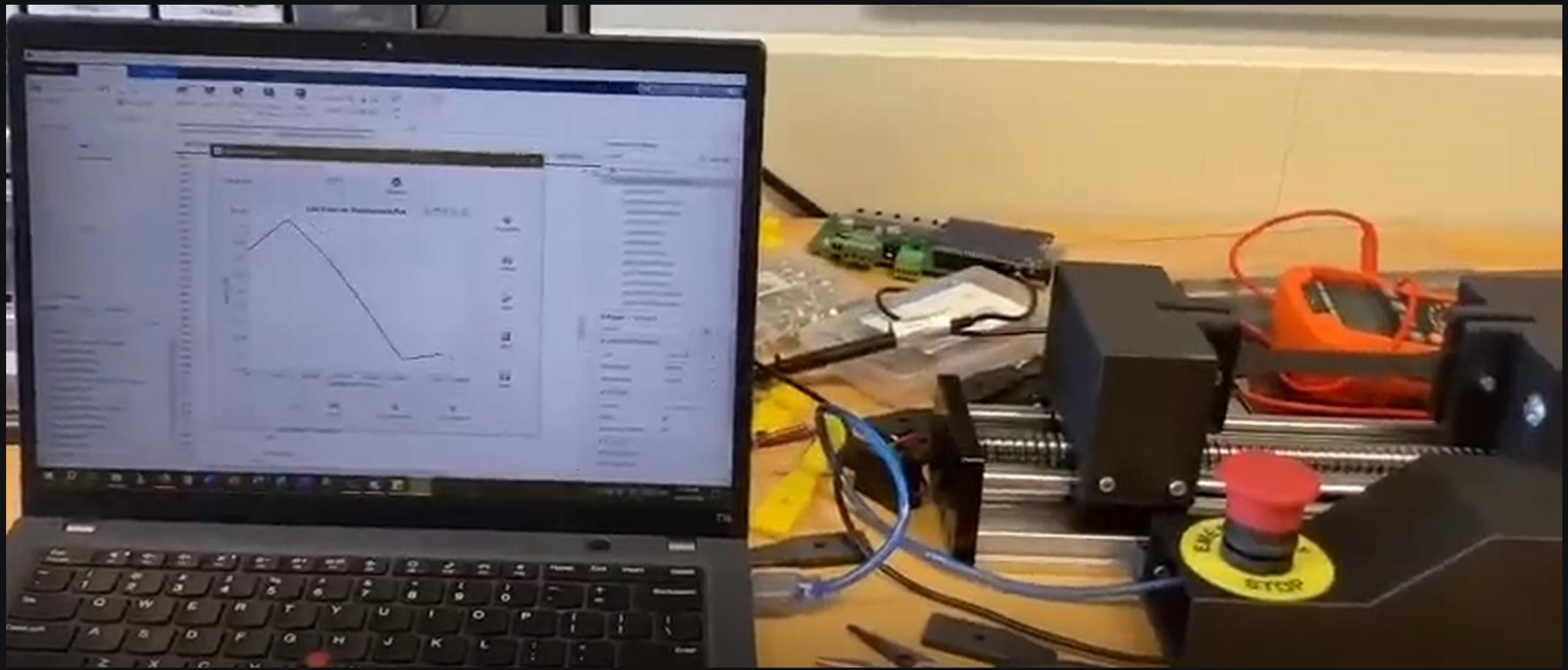

STOP
EMERGENCY

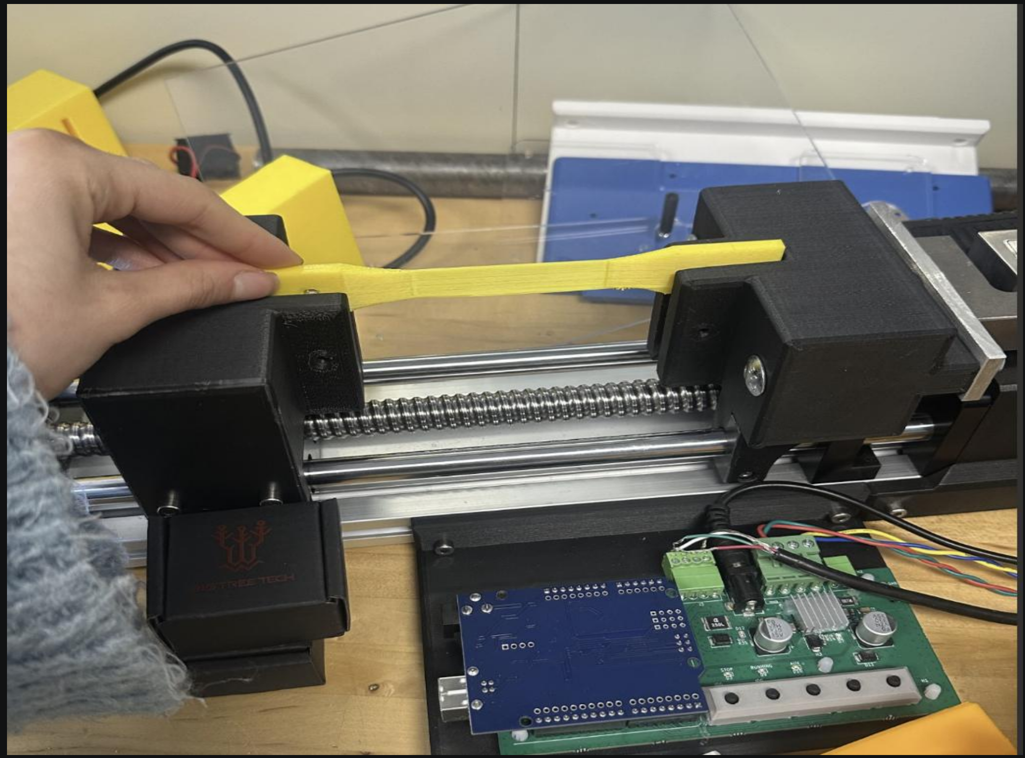

PRUSA

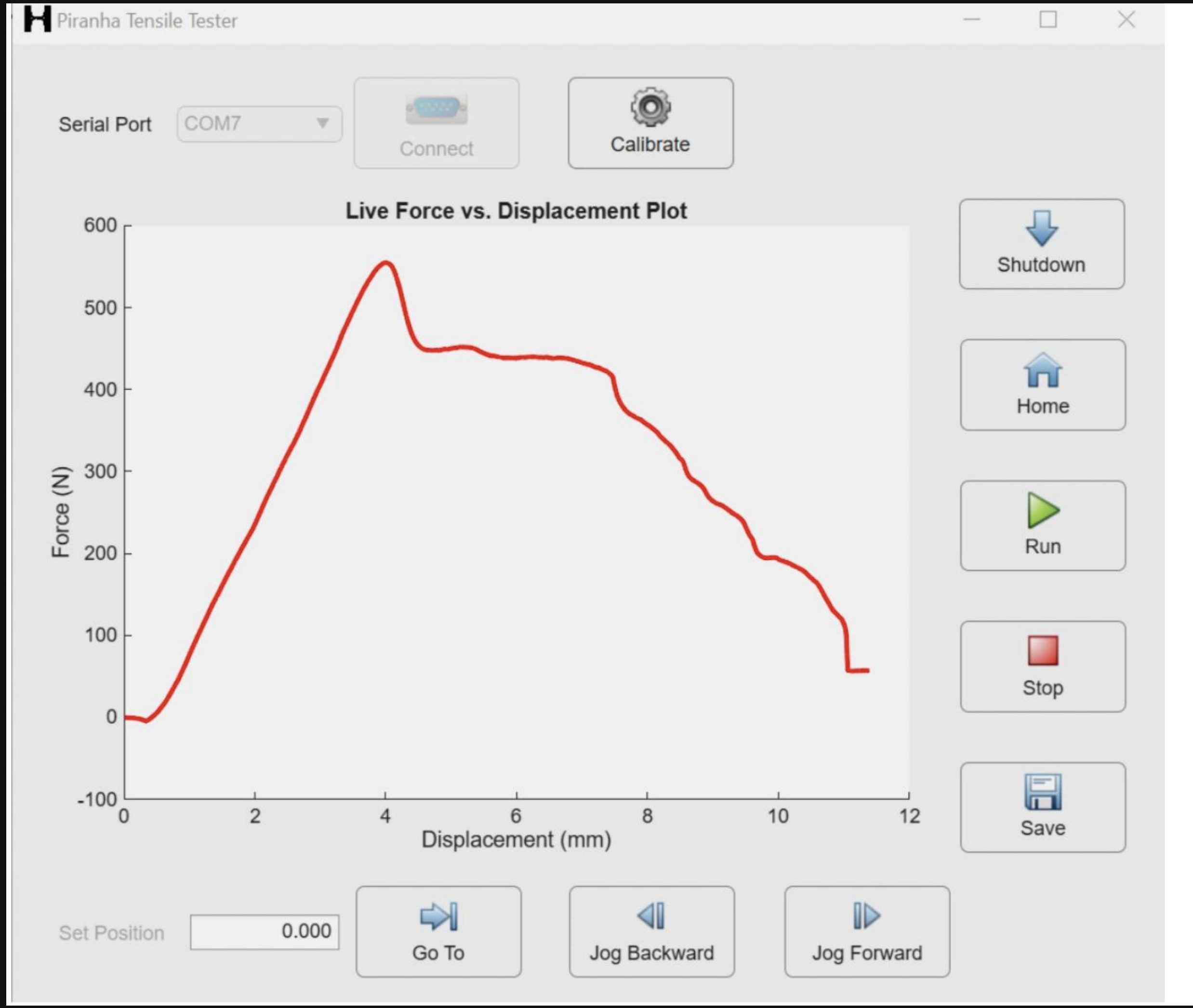




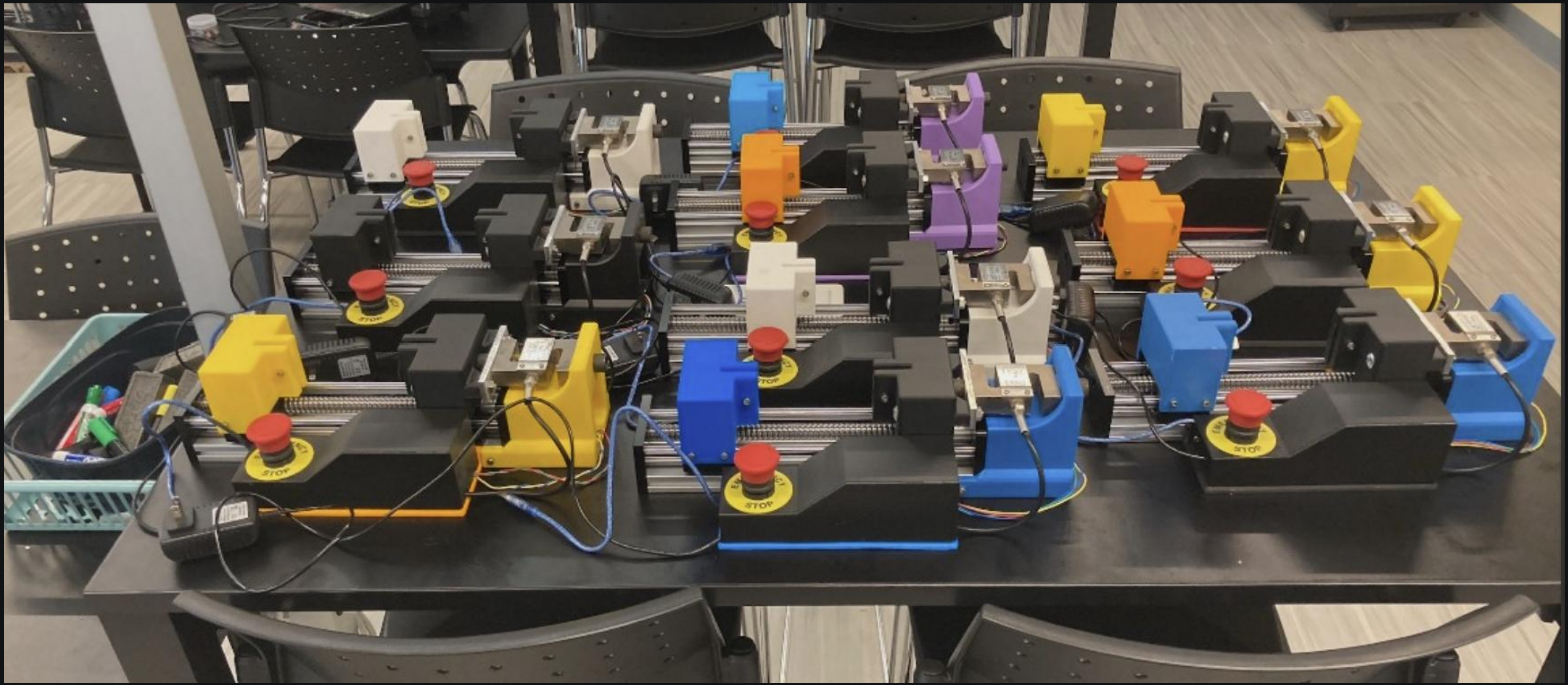

STOP






Piranha Tensile Tester
Serial Port
COM7
Connect
Calibrate
Live Force vs. Displacement Plot
Force (N)
600
500
400
300
200
100
0
-100
0
2
4
6
8
10
12
Displacement (mm)
Shutdown
Home
Run
Stop
Save
Set Position
0.000
Go To
Jog Backward
Jog Forward

Final Design Scaled Testers to 40+ Sets



Octet-Lattice Structure: Helmet Design Revolution

About

Traditional helmet designs struggled to balance protection, weight, and comfort. Conventional foam padding systems provided limited impact distribution and poor ventilation, while meeting safety standards required bulky, uncomfortable designs that have negative impact on the environment.

Task

Engineer an innovative helmet structure using octet-lattice geometry to optimize strength-to-weight ratio, improve impact energy absorption, enhance ventilation, and maintain compliance with DOT and SNELL safety standards while reducing overall helmet weight by minimum 25%.

Responsibilities

Utilized topology optimization algorithms to design octet-lattice internal structure, performed comprehensive FEA simulations for impact scenarios, prototyped using selective laser sintering with titanium alloy, conducted drop-tower impact testing, and validated thermal management through CFD analysis. Analyzed 20+ samples.

Result

Achieved 32% weight reduction while improving impact energy absorption by 18%, enhanced ventilation airflow by 45%, passed all required safety certifications, and demonstrated 40% improvement in user comfort ratings during extended wear testing with 50 participants.

Innovation Highlight: The octet-lattice design principles developed in this project is a patent pending method currently being piloted by two major helmet manufacturers for their next-generation product lines, demonstrating real-world commercial impact.

Skills

- 3D Printing
- ANSYS
- FEA
- SolidWorks
- NTOPOLOGY
- Material Testing
- Failure Mode Analysis
- Rapid Prototyping
- Python


Applications of 3D Printed Octet Lattice
Structures in Personal Protective Equipment


Applications of 3D Printed Octet Lattice
Structures in Personal Protective Equipment
Ayodeji Abiodun • Matthew Bunce • Catherine Mabano • Betool Mohsen • Matthew Spataro
octet
Background
• Personal protective equipment (PPE) is a crucial part of preventing impact-related injuries in many facets of society, spanning from industry to sports (professional and recreational).
• There is a call for technological improvements in PPE to be pursued – with mass investments into PPE being made by the National Football League, and interest being shown in innovative helmet start-ups like HEXR®.
• Stereolithographic acrylate polymer resins in octet-truss conformations researched by Bolan and Bardelcik are of potential use in PPE.
Approach
• Octet-truss structures of various thicknesses and strut lengths were explored to find the most suitable application via research conducted by Bolan and Bardelcik.
• Optimal ethanol wash and ultraviolet curing times were considered following stereolithographic printing.
• Helmet cross-sections were created and tested using nTopology finite element analysis software, ignoring edge effects and stress concentrations for computational achievability
• Compression tests were used to acquire stress-strain behavior
1
2
3
1.50mm
1.00mm
0.50mm
Figure 1: Prototype Helmet with test scale cross-sections of varying octet-truss thickness
Figure 2: Static FEA Analysis of Helmet Cross-Section
Design
• Phrozen® Nylon-Green Tough Stereolithographic resin will be used, with a truss length of 9.0 mm and thickness of 1.50 mm
• A solid inner layer was designed to reduce the dependency on supports, lowering cost and simplifying stereolithographic printing
Figure 3: SLA-Printed Cross-Section Before (left) and During Curing (right)
Conclusions
• The testing performed on the helmet cross-sections gives some evidence proving octet-truss structures printed using stereolithography has the potential for implementation into PPE
• Advanced impact testing on a helmet prototype is needed, and MIPS technology should be integrated
• Refine ergonomics and consider custom size printing

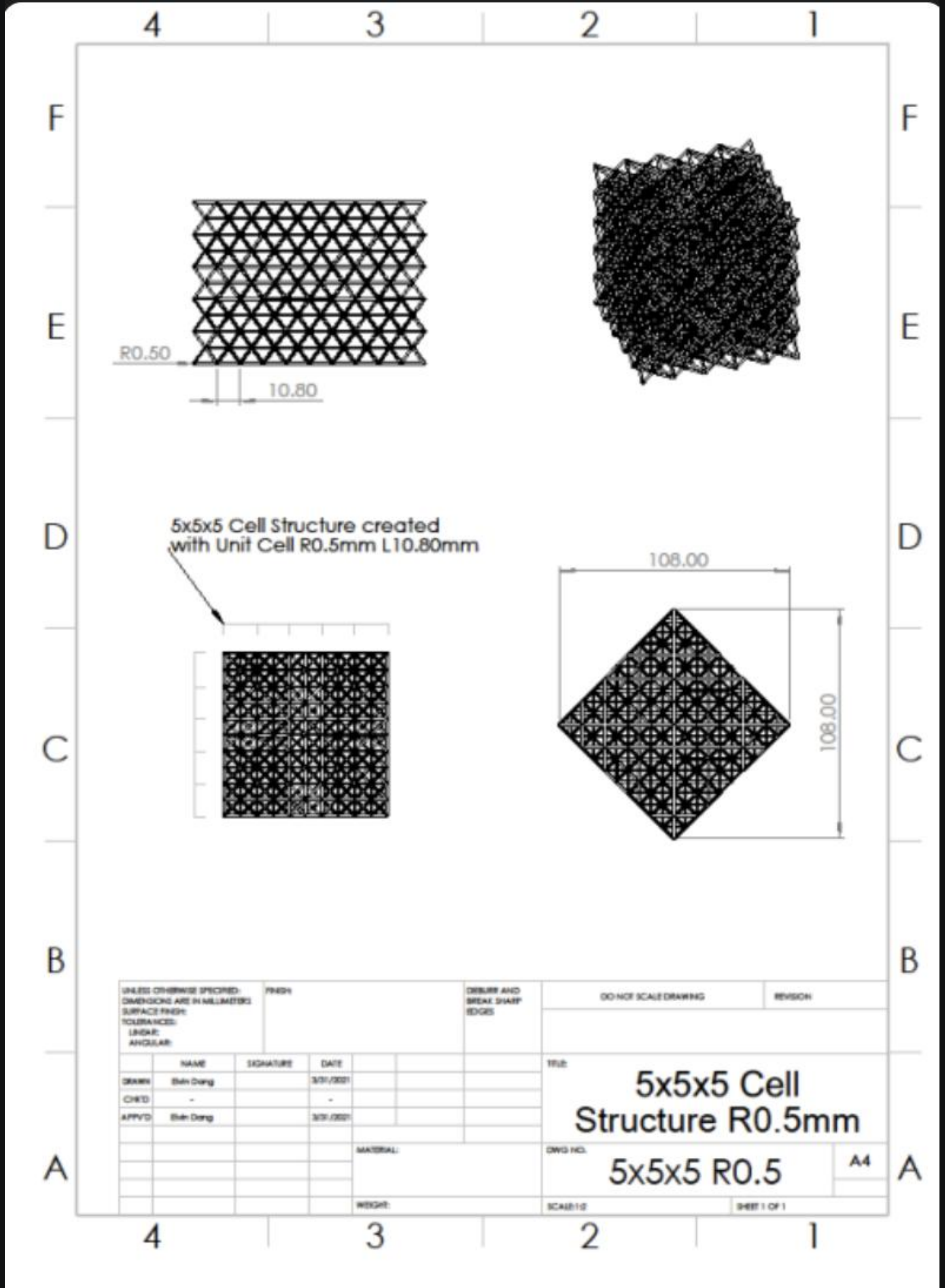


Figure 45: Radius 0.5 mm 5x5x5 Cell Structure SolidWorks Drawing

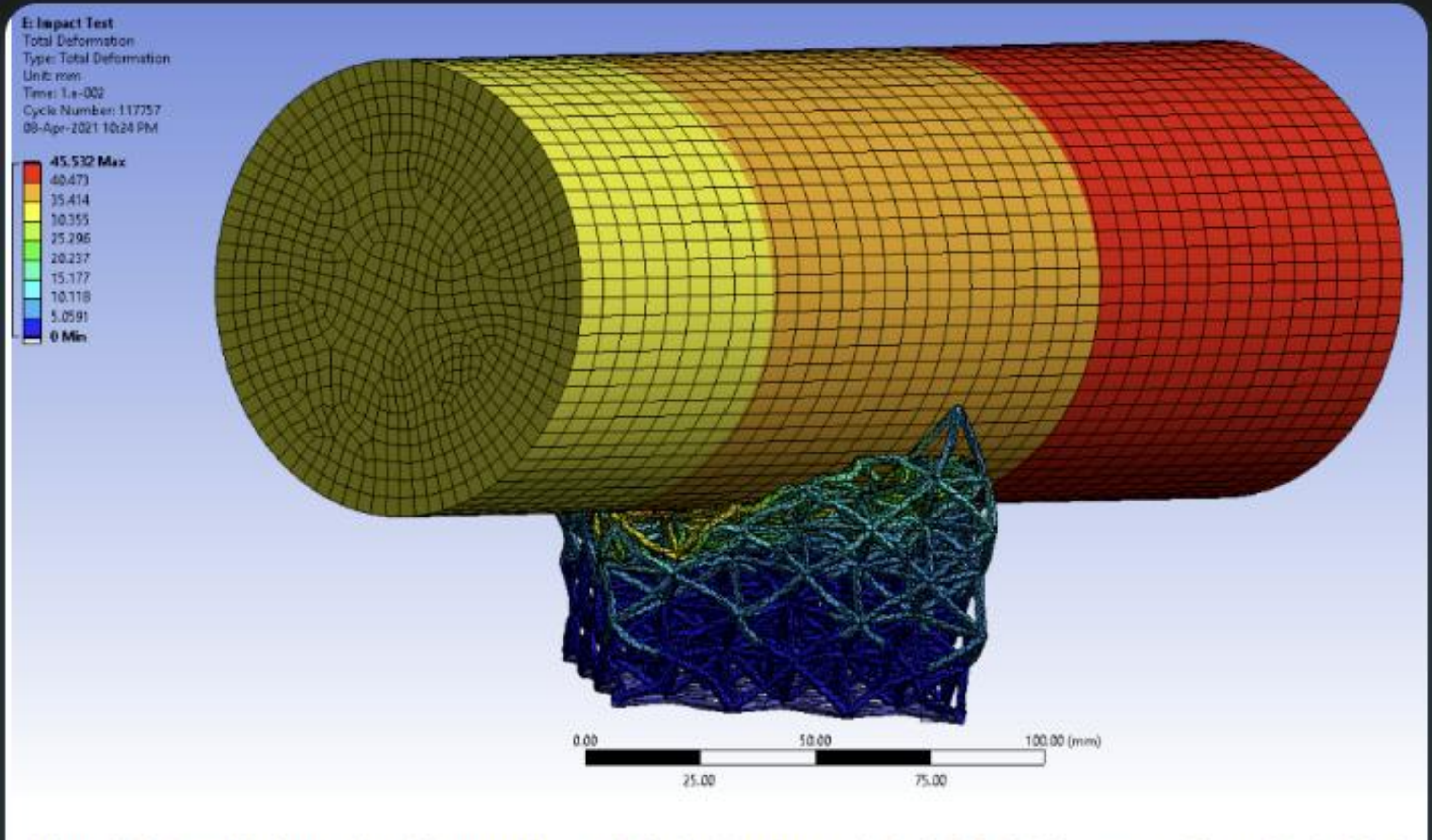
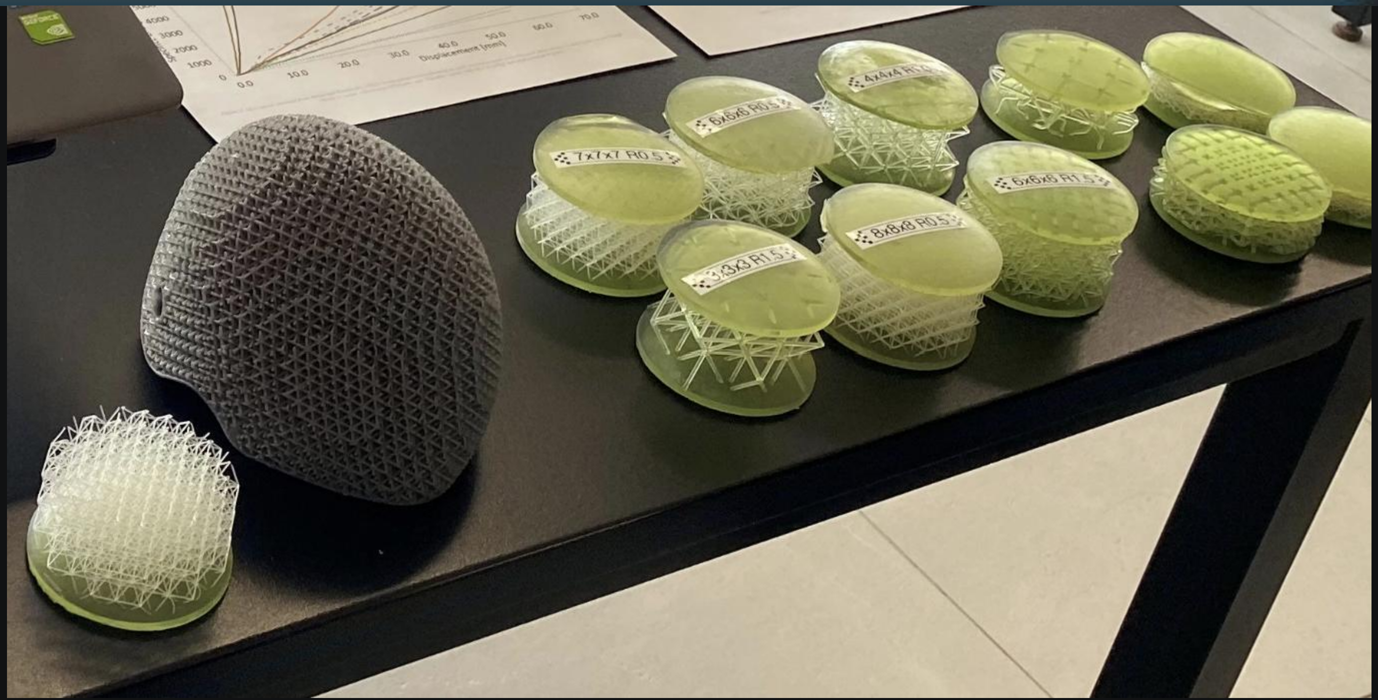


Figure 259: Total Deformation of Impact Test on Cylinder (arm) on a single 3x3x3 Cell Structure w/ 3mm Mesh. Mesh Size varies on Cylinder.



WINNER - Competition Recognition

Visionify: AI Navigation for Visual Accessibility

About

Visually impaired individuals face significant navigation challenges in unfamiliar environments. Existing assistive technologies provided limited real-time environmental awareness, poor object recognition accuracy, and inadequate integration with standard navigation systems, creating barriers to independent mobility. Users asked for a proactive approach that current solutions don’t have.

Task

Create an AI-powered mobile navigation system providing real-time environmental analysis, obstacle detection, path guidance, and audio feedback specifically designed for visually impaired users. The solution needed to work offline, process video input in real-time, and provide accurate spatial awareness information.

Responsibilities

Developed computer vision algorithms using TensorFlow and OpenCV for real-time object detection and depth estimation, implemented spatial audio feedback system with 3D sound positioning, created offline mapping capabilities with GPS integration, optimized mobile app performance for various smartphone hardware configurations, and conducted extensive user testing with visually impaired community members. I also was responsible for hardware integration and 3d printing of the glasses.

Result

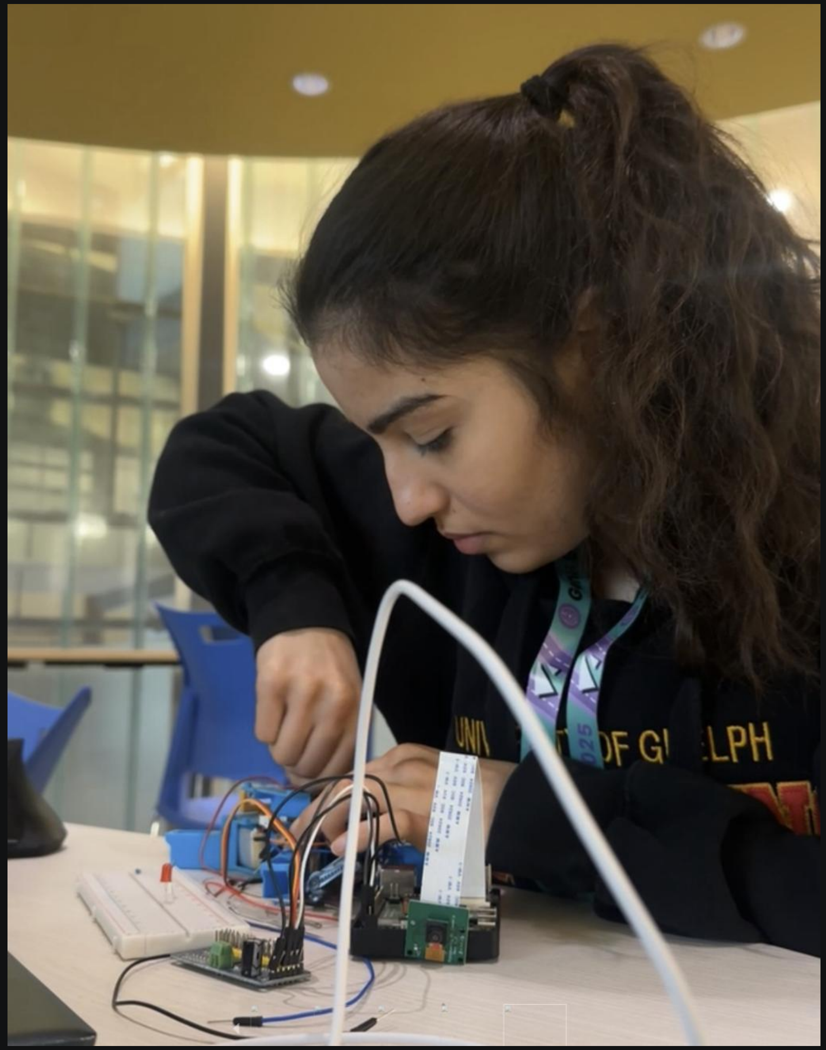
Won first place in accessibility technology competition, achieved 94% accuracy in obstacle detection, reduced navigation time by average 35% during user trials, successfully guided 100+ test routes with zero safety incidents, and secured interest from three assistive technology companies for licensing opportunities. Earned 4000$.

> "Visionify represents the kind of inclusive engineering that transforms lives.
> This project demonstrates exceptional technical skill combined with genuine social impact awareness."
> — Competition Judge Feedback

Skills

- 3D Printing
- Time and Cost Management
- Rapid Prototyping
- Python
- AI Integration
- Sensor Integration
- Teamwork

Devpost Link: https://devpost.com/software/visionify



C-Wrist: Reimagining Human-Tech Interaction

About

Existing wearable devices suffered from limited interaction methods, poor battery life, and disconnect between user intent and device response. Traditional touch interfaces proved inadequate for complex task execution while maintaining device miniaturization requirements.

Task

Develop an advanced wearable interface system incorporating gesture recognition, haptic feedback, and predictive interaction algorithms. The device needed to recognize 20+ distinct gestures with 95% accuracy while maintaining 48-hour battery life.

Responsibilities

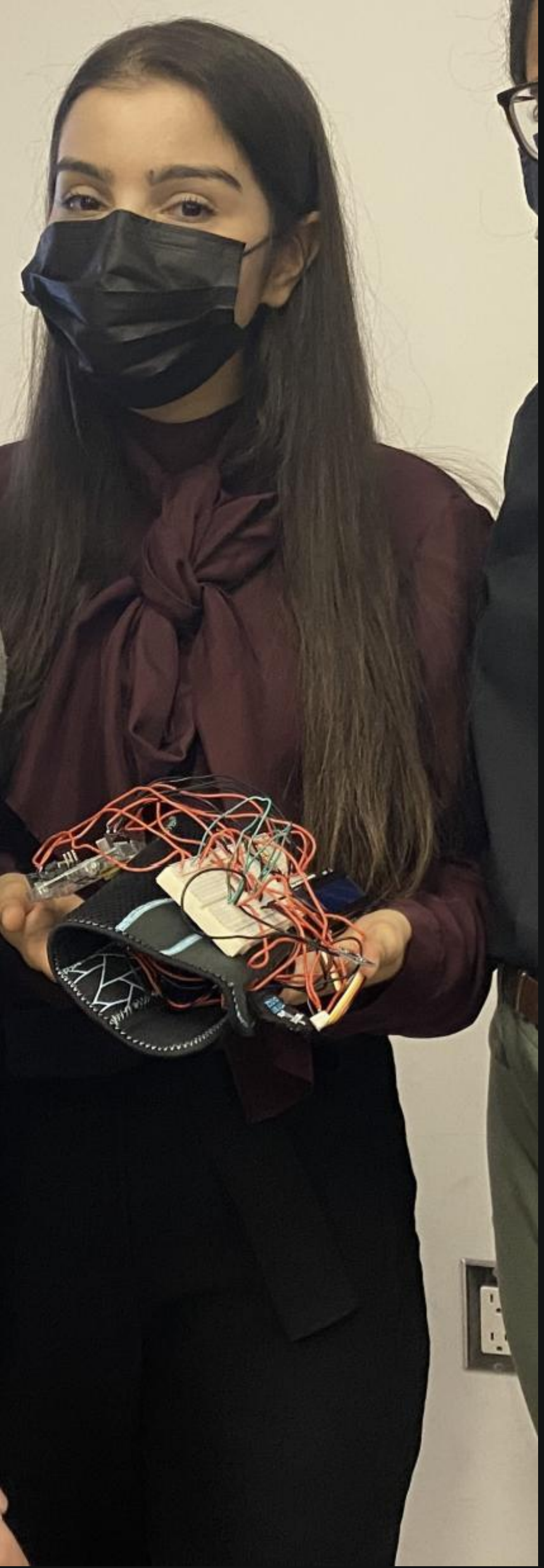
Integrated IMU sensors with machine learning algorithms for gesture classification, designed custom PCB with ultra-low-power microcontroller, implemented haptic feedback using piezoelectric actuators, developed companion mobile application with cloud synchronization, and created adaptive learning algorithms for personalized user experience.

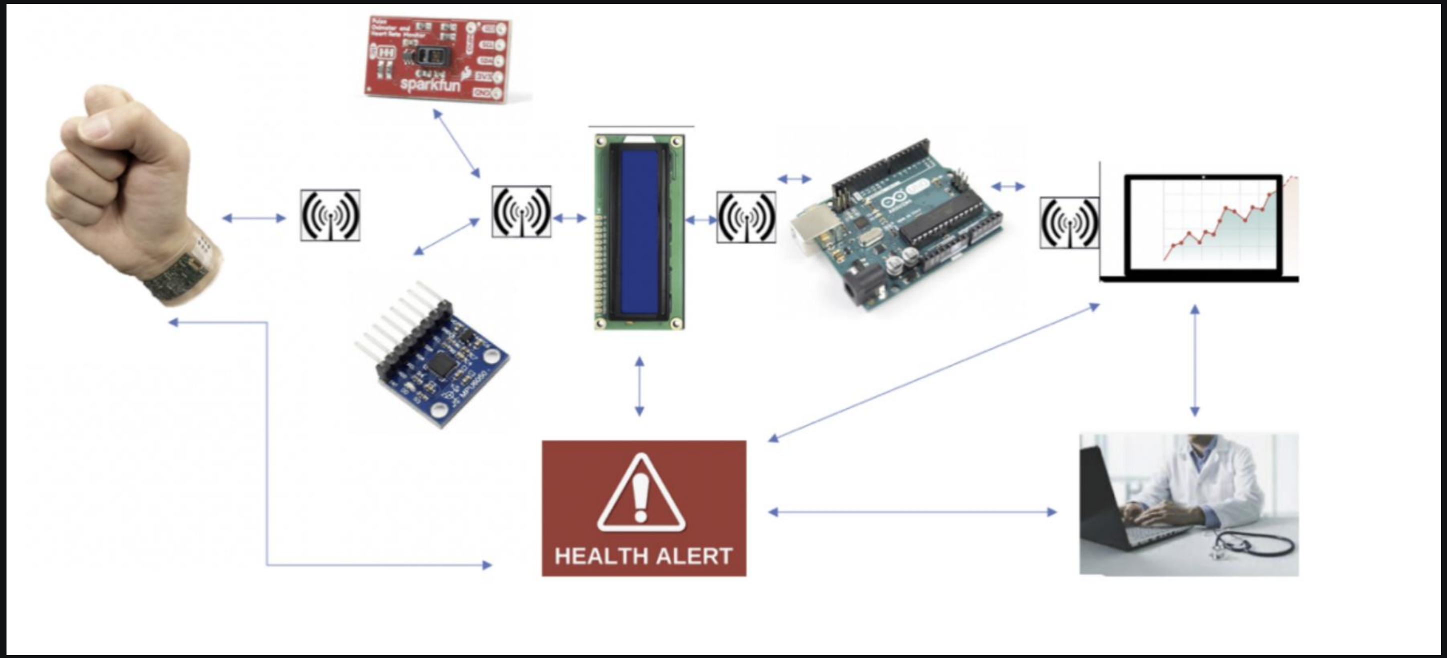
Result

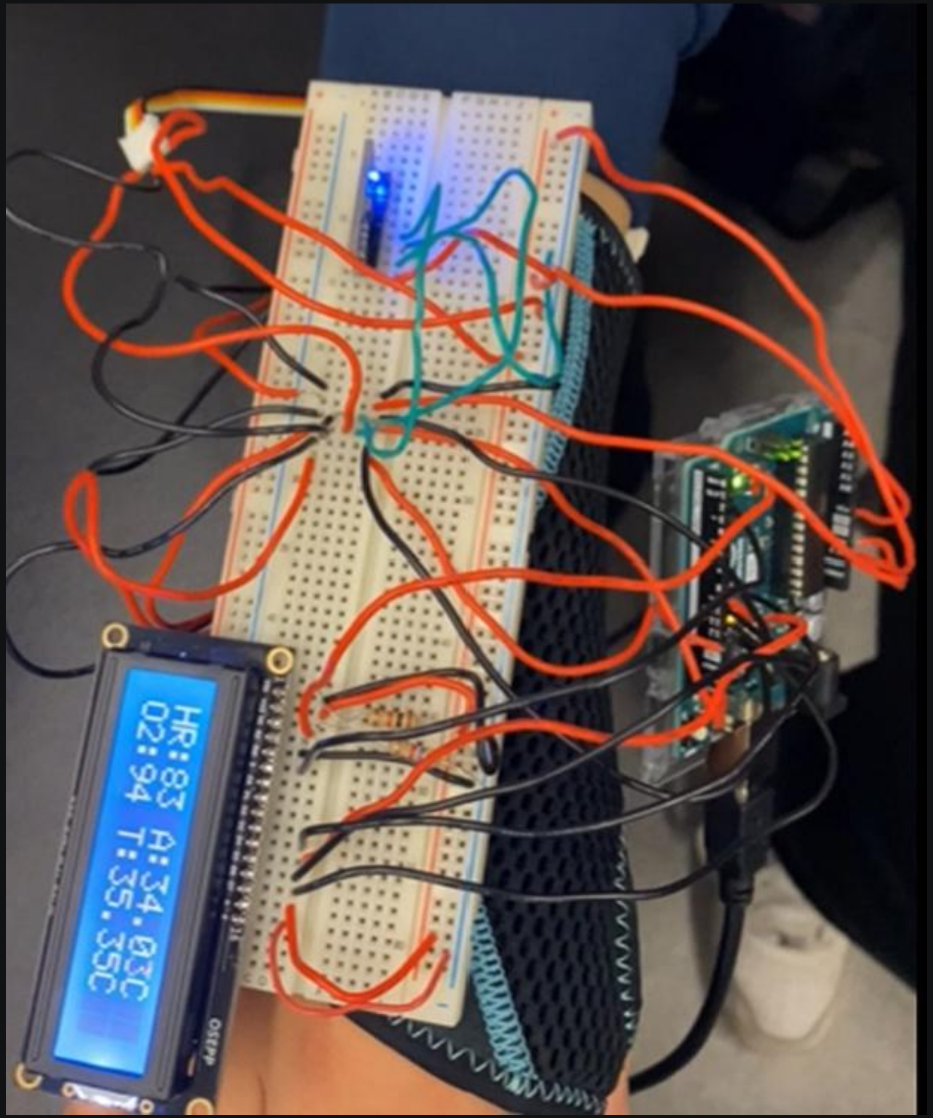
Achieved 97.3% gesture recognition accuracy, 52-hour battery life under normal usage, successful prototype testing with 25 users showing 85% task completion improvement and earned 1000$ for winning the health and wellness category.

Skills

- 3D Printing
- Raspberry Pi
- SolidWorks
- MATLAB
- Rapid Prototyping
- Python
- Sensor Integration




sparkfun
HEALTH ALERT


HR:83 A:34.03C
02:94 T:35.35C

Technical Skills Demonstrated Across Projects

Robotics & Automation

Advanced kinematics algorithms, servo motor control systems, PID feedback loops, motion planning, and real-time control implementation. Demonstrated through Q-Arm project with industrial-grade precision and reliability standards.

Embedded Systems

Custom PCB design, microcontroller programming, sensor integration, power management, and hardware-software interface development. Showcased in C-Wrist project with ultra-low-power optimization and real-time processing capabilities.

Machine Learning & AI

Computer vision algorithms, neural network implementation, gesture recognition, object detection, and adaptive learning systems. Applied in Visionify project with real-time processing and high-accuracy performance requirements.

CAD & Simulation

SolidWorks 3D modeling, finite element analysis, topology optimization, stress simulation, and design validation. Utilized in Octet-Lattice helmet design with complex geometric optimization and safety compliance verification.

Data Acquisition

LabVIEW programming, sensor calibration, measurement systems, statistical analysis, and automated testing protocols. Implemented in Tensile Tester project with precision measurement and standards compliance.

Software Development

Mobile app development, user interface design, cloud integration, API development, and cross-platform compatibility. Demonstrated across multiple projects with focus on user experience and performance optimization.

Each project in this portfolio represents a commitment to pushing boundaries while delivering solutions that make a meaningful difference in people's lives. Thank you for viewing my passionate work!

LinkedIn Profile

Portfolio

mohsenbetool@gmail.com