Engineering Portfolio

Hudson Aibel

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Roar-E – Combat Robot

Summary: Lead the mechanical design and manufacturing for Columbia University Robotics Club's 12 lb combat robot, Roar-E, which qualified for the NHRL September Pro Tour. Own the full loop from design through in-house fabrication and competition readiness. Iterated through three different revisions.

Timeline: September 2024 – Present

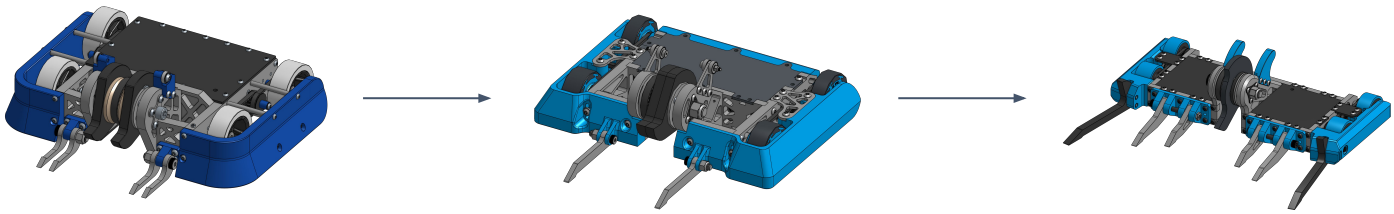
Role(s): Combat Robotics Lead (and Club President)

Contribution:

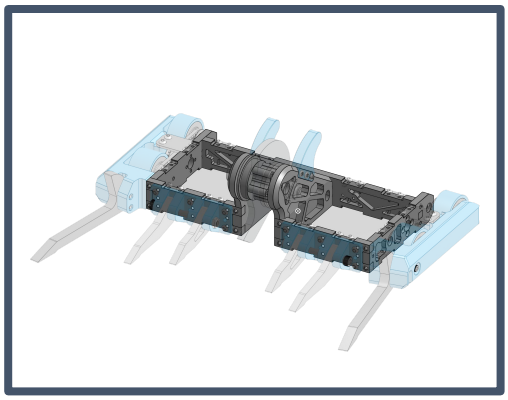
- Own the engineering design process: mechanical design, manufacturing, electrical design, competition
- Designed and manufactured almost all components. 6061 drivetrain rails, custom 7075 weapon hub, titanium and carbon fiber top and bottom plates.
- Applied GD&T and tolerance stack-up analysis to hold press-fit bearing bores and mating-plate alignment.
- Iterated designs through failure analysis, improving durability while reducing weight.

Tools Used: Onshape (CAD), Autodesk Fusion (CAM), HAAS Mini Mill, Ward Waterjet

Skills: GD&T, tolerance stack-up, design for manufacturing, CNC milling, failure analysis

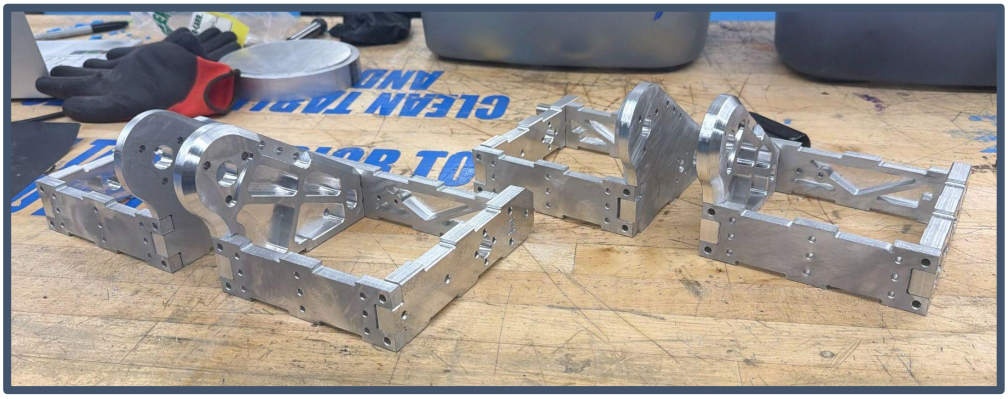


Version 1 Version 2 Version 3

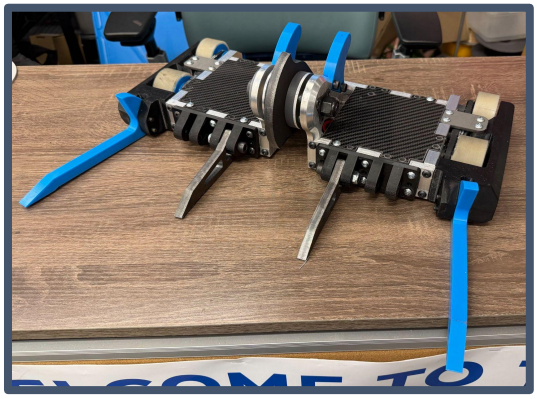


Isolated CAD Of machined aluminum components

Drivetrain plates after Operation one



Finished Machined Components



Completed Robot

Impact Racing Simulator — Neck-Loading Research

Summary: Designing, manufacturing, and programming a racing simulator that applies real-world-equivalent G-forces to a driver's head during simulated driving to measure neck loading. 3-cable robot with a RR linkage and Z axis decoupling. Funded by a competitive Summer@SEAS Fellowship.

Timeline: June 2026 – Present

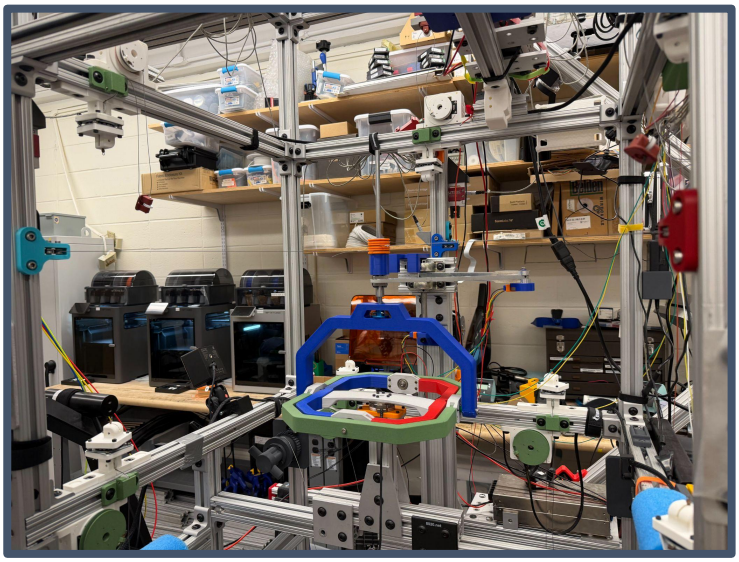
Role(s): Undergraduate Researcher – Robotics and Rehabilitation Lab (Summer@SEAS Fellow)

Contribution:

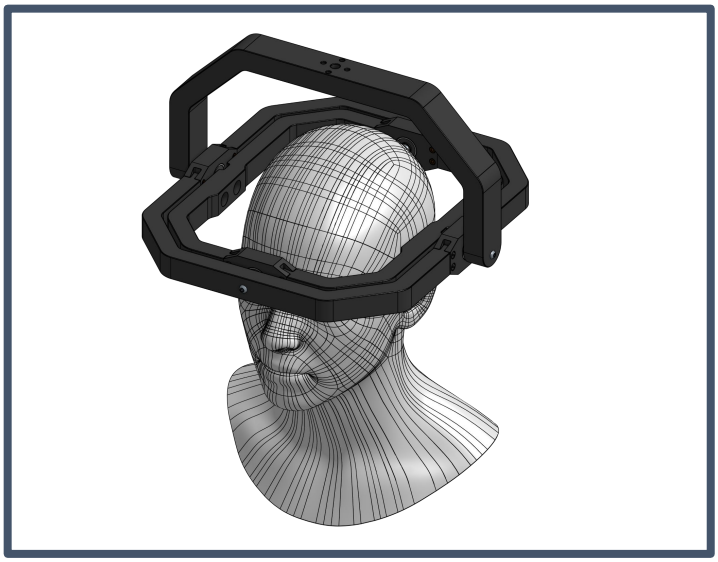
– Designing and building a test rig validated with a six-axis force-torque sensor.
– Taking simulator data and programming the system to apply repeatable, real-world-equivalent G-forces. capture head motion data for validation of system.
– Designed a spherical jig to decouple all but horizontal forces to simulate accelerations to the head.

Tools Used: Onshape (CAD), Solidworks (CAD), six-axis force-torque sensor, Python, Steam VR

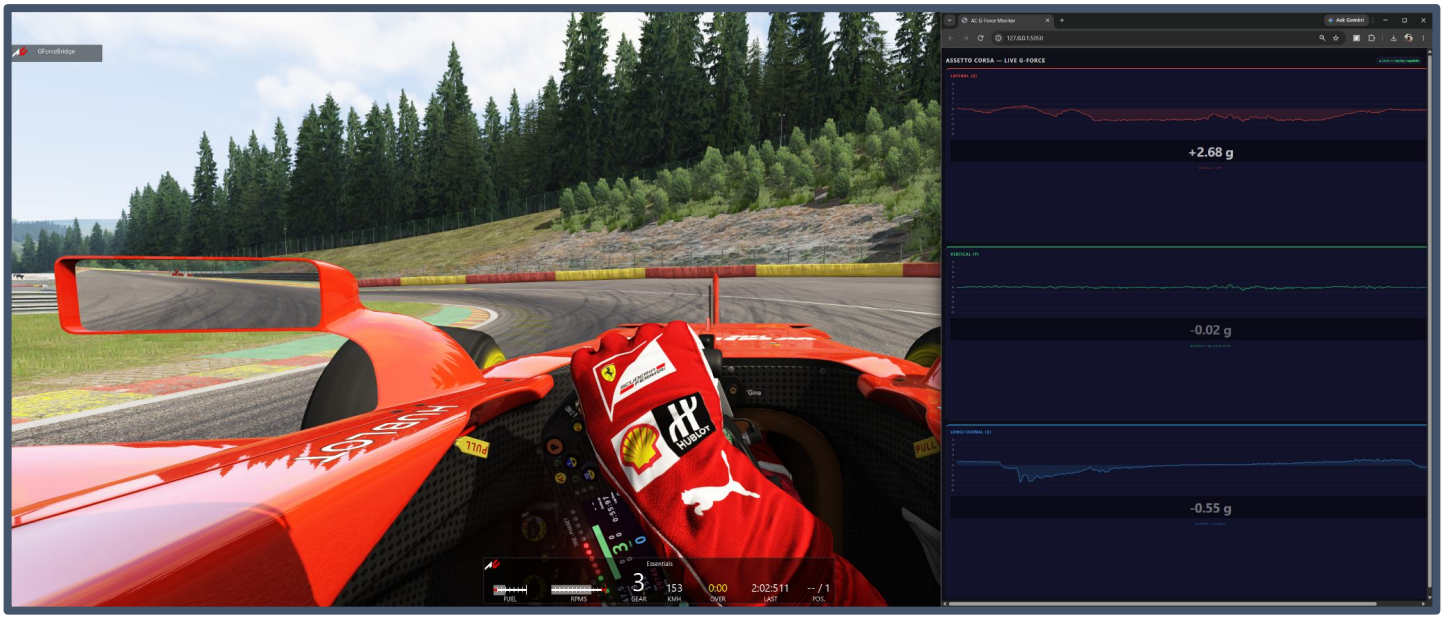
Skills: Test-rig design, instrumentation, biomechanics, data acquisition



Force Test Bench



Spherical decoupling Jig CAD



Custom python script for outputting g-force data

ROAR Lab – Studying Soccer Header Mechanics

Summary: Studying how soccer header mechanics change between professionals and amateurs. Characterizing the results using IMUs, HTC Vive, and RGB cameras. Creating alternative trainings for amateurs using VR and a cable-driven parallel robot.

Timeline: August 2025 – Present

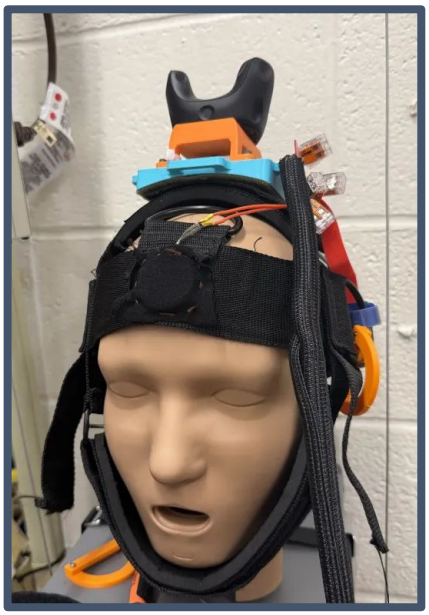
Role(s): Undergraduate Researcher – Robotics and Rehabilitation Lab

Contribution:

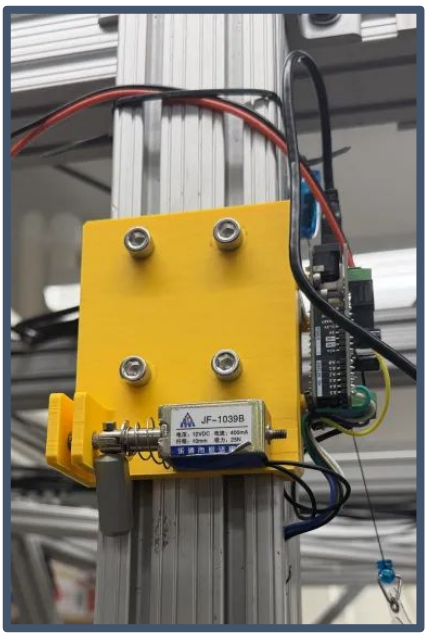
– Characterizing heading forces and motion using HTC Vive trackers, computer vision, and an IMU.
– Designed a repeatable heading drill using a custom solenoid circuit.
– Experimenting with replacing the motors in the cable driven parallel robot with BLDC, improving speed, torque, and reliability.

Tools Used: Onshape (CAD), Solidworks (CAD), Kicad (PCB Design), HTC Vive, OpenCV, Arduino (IMU), Odrive platform

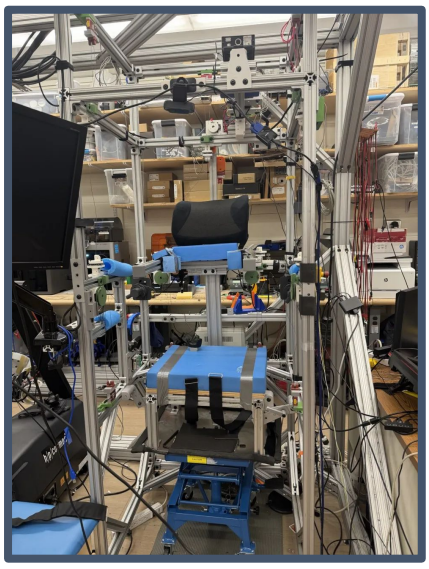
Skills: Sensor integration, experimental design, actuator control



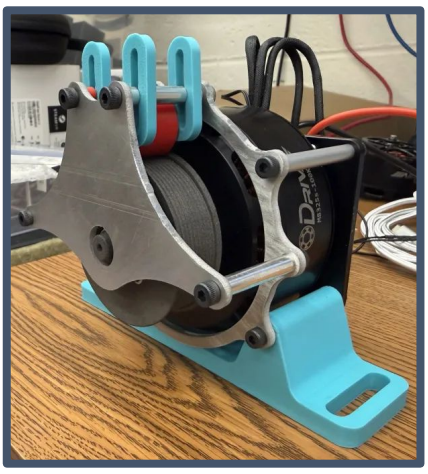
Header sensor rig; including FSR Sensor, IMU, and HTC Vive



Solenoid assembly with custom PCB arduino hat



Cable Driven Parallel Robot



O-Drive Motor on custom mount

Wire EDM Restoration & Custom CAM Post-Processor

Summary: Restored a decommissioned 2002 Mitsubishi RA90 wire EDM to full operational status and built a custom CAM workflow. Machining components out of stainless steel for surgery, redesigning for manufacturability.

Timeline: June 2026 – Present

Role(s): Undergraduate Researcher – Columbia Small Scale Mechanics Laboratory

Contribution:

– Diagnosed and repaired power faults to return the machine to service for lab research.

– Developed a custom Fusion 360 CAM post-processor that takes paths designed for CNC mills, parses the g-code, and implements the required machine code for the wire EDM machine.

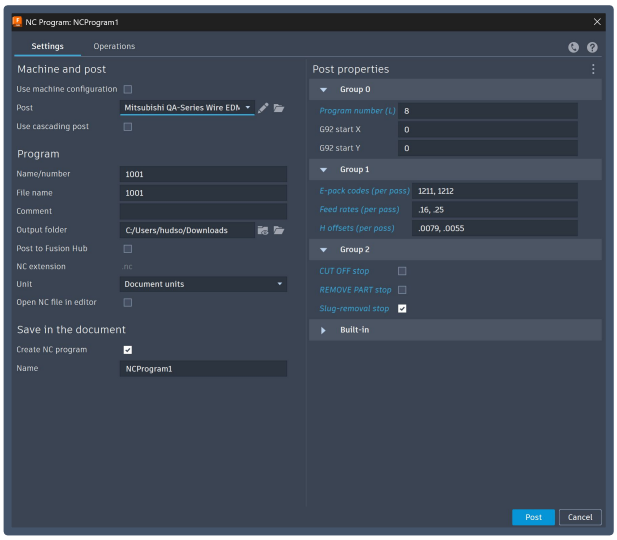
– Replaced the lab's entirely hand-written workflow.

Tools Used: Mitsubishi RA90 Wire EDM, Autodesk Fusion (CAM), Javascript (custom post-processor)

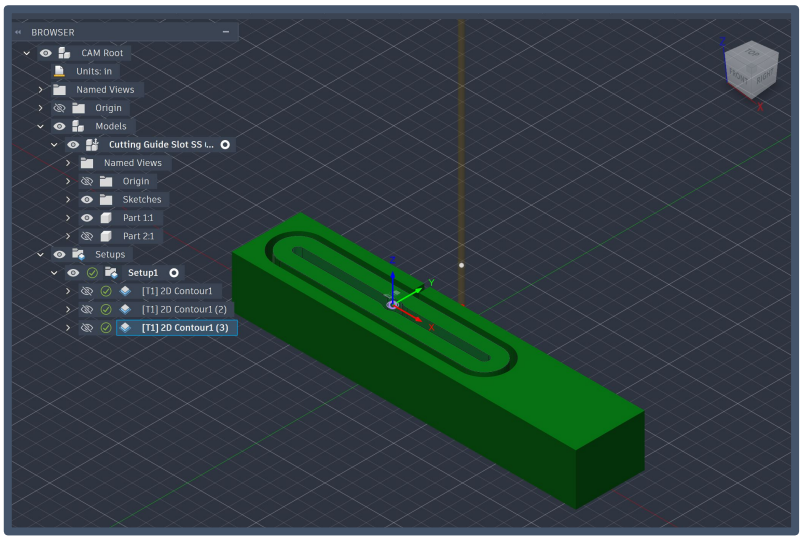
Skills: Machine restoration, electrical troubleshooting, CAM programming, post-processor development

Restored RA90 performing a Cut

Wire-cut part



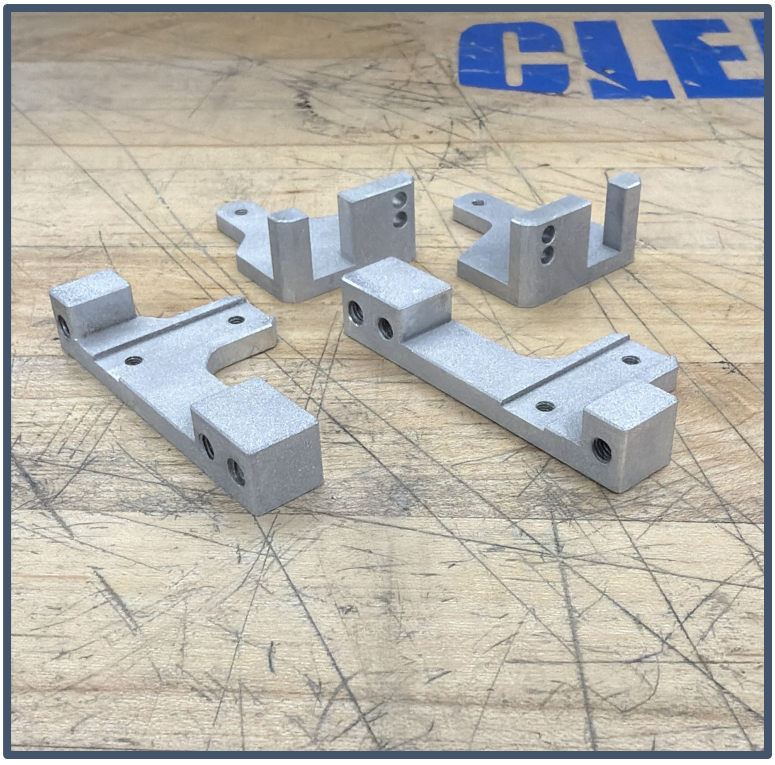
Custom Post Processor



Example part: sagittal saw holder, 0.8mm slot

Additional Projects

Connect 4 Robot



Commissioned Machined Parts

FIRST Tech Challenge Robot

Open Source Projects

More details at hudsonaibel.com