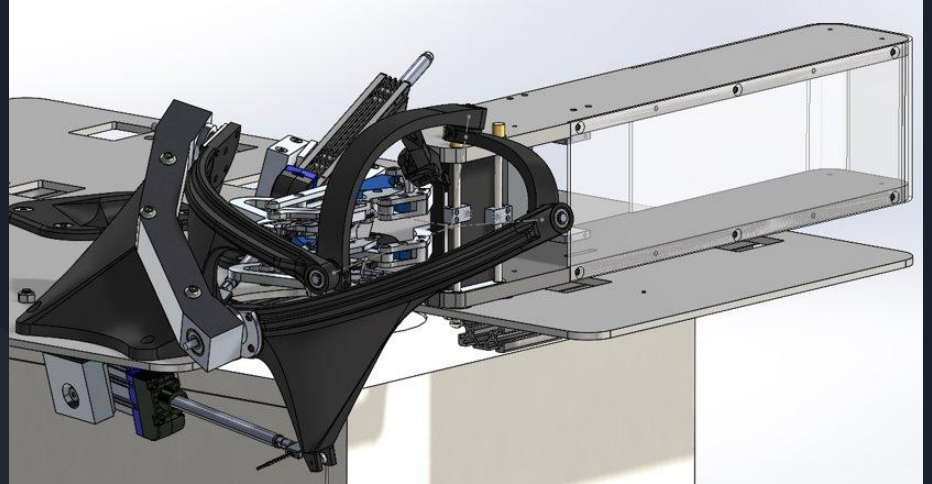
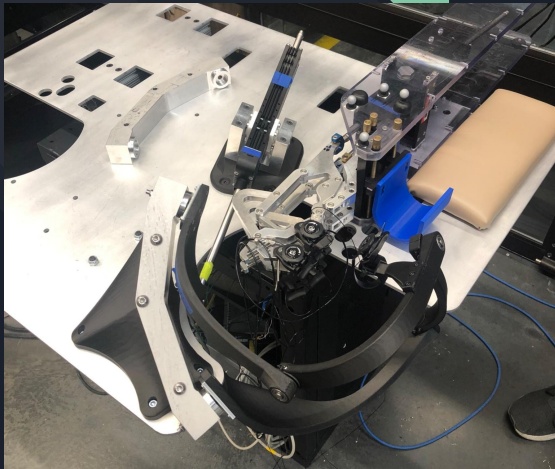


# Design Expo Technical Presentation

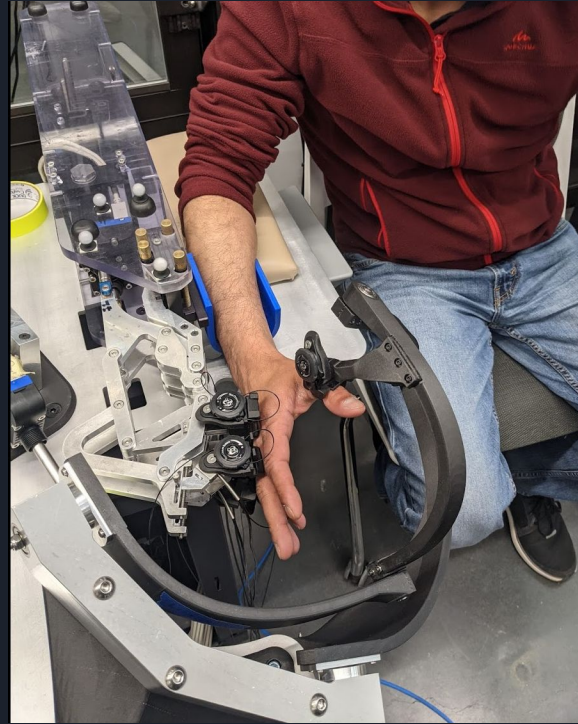
## FINGER 2.0 Thumb Exoskeleton

By: Ryan Burr, Avery Frazier and Royal Elder



# Presentation Content

- Acknowledgments
- Objective
- Value Proposition
- Background
- Final Designs
- Design Validation
- Recommendations
- Questions



# Client and Faculty Support

## Client:

- Dr. Eric Wolbrecht: University of Idaho Mechanical Engineering Dept.

## Faculty Advisor:

- Dr. Joel Perry: University of Idaho Mechanical Engineering Dept.

## Mentors:

- Jacob-Cobi Brower
- Vishwanath Ketkar

Funded by The National Center for Medical Rehabilitation Research at the National Institute of Child Health and Human Development



# Objective

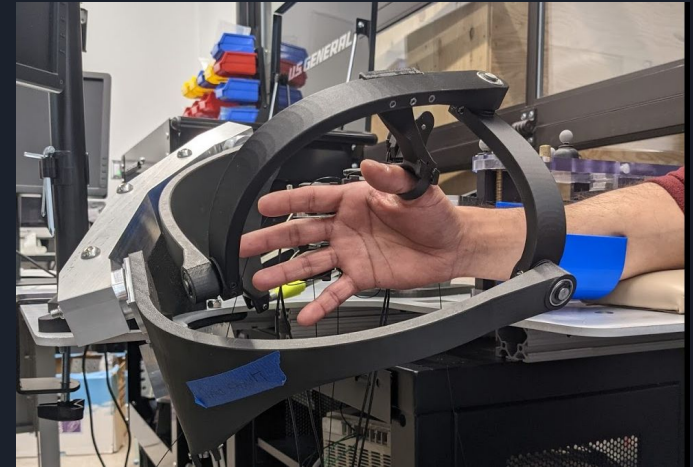
Create a robot that will aid in the rehabilitation of the hand for stroke victims

## FINGER 1.0

- Robotic finger training device (index and middle finger)
- Tests the hypothesis that proprioceptive integrity is a gateway for robotic assistance.

## FINGER 2.0

- Goal: Add a thumb module to FINGER 1.0
  - Regain connections between the thumb and other fingers.



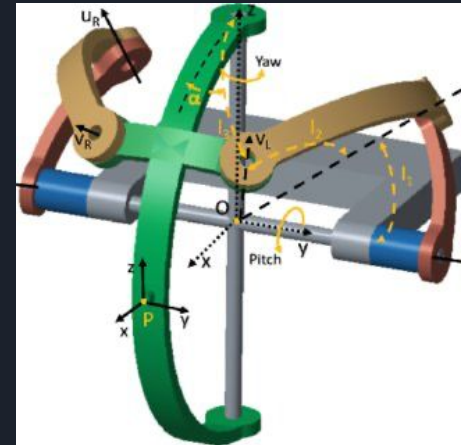
# Background

- 800,000 people per year suffer from a stroke in the United States
  - $\frac{2}{3}$  of survivors experience long-term impairment
- Robotics can automate many aspects of conventional physical therapy
- Robots can serve as scientific instruments
  - Quantification of the recovery process



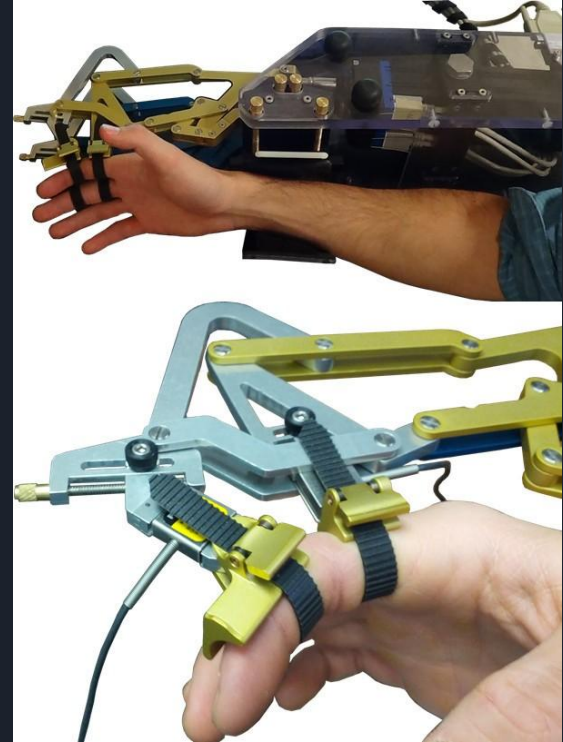
# Background

- Finger 1.0 was previously completed
  - Joint effort between the University of Idaho and the University of California Irvine.
- Finger 2.0 is a previously designed spherical 5-bar system
  - Allows for 3 dimensional movement of the thumb
- Assigned Tasks
  - Refine previous link designs
  - Decrease joint slop
  - Quick switching from left to right



# FINGER 1.0

- Sought to maximize controller fidelity and minimize the mechanical impedance
  - 1 degree of freedom
  - High control fidelity
  - Low friction
- Assists both the middle and pointer finger through the natural grasping motion
  - 8-bar mechanism
- Controls the orientation and position of the middle phalanx of the finger





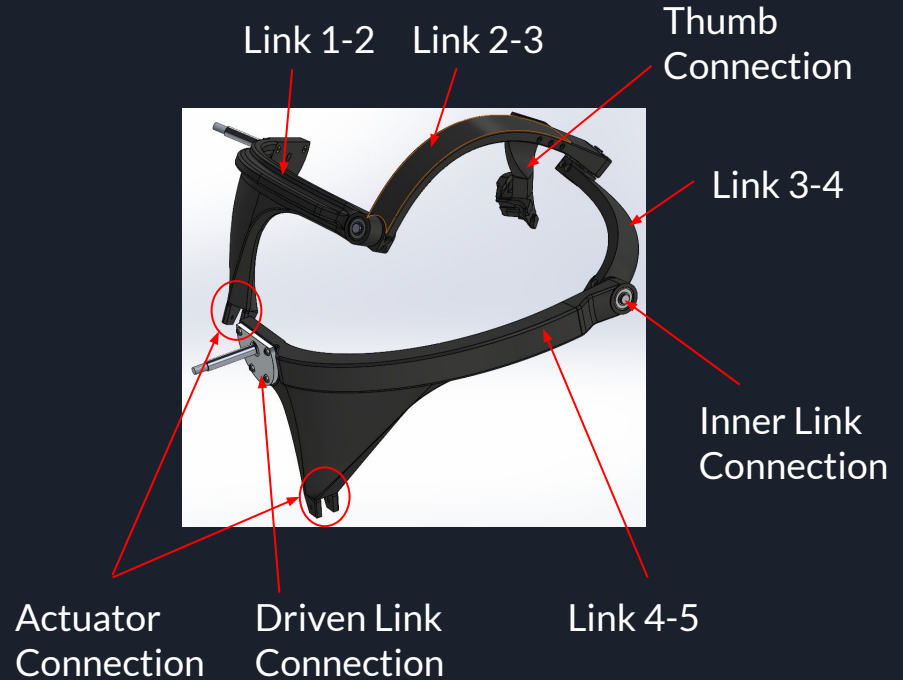
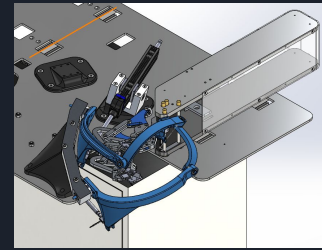
# Value Proposition

- Problem: The correct amount of assistance for a stroke patient is highly variable
  - Depends on multitude of factors, including time spent in therapy
- Solution Benefit: The robot uses sensors to determine the user input, and provides the necessary amount of assistance
  - Automatically calculates necessary assistance to aid the user without providing too much help
- Sensors and measurement allow for quantification of assistance

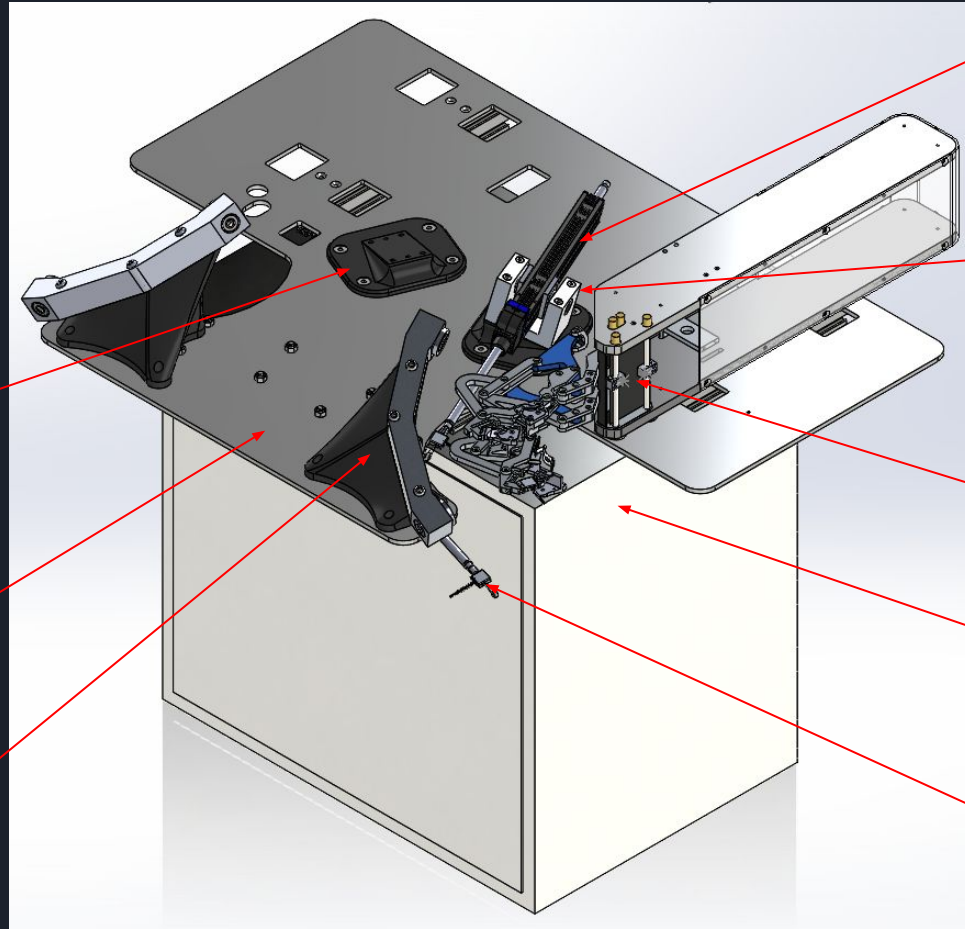


# FINGER 2.0

- Assists thumb through grasping motion
  - Spherical 5-bar mechanism
- Similar to FINGER 1.0, aim is maximum controller fidelity
  - High control fidelity
  - Low friction
- Controls position of the thumb distal phalanx



# Finger 2.0



Actuator Mount Base

Baseplate

Fixed Link and Base

Top Linear Actuator

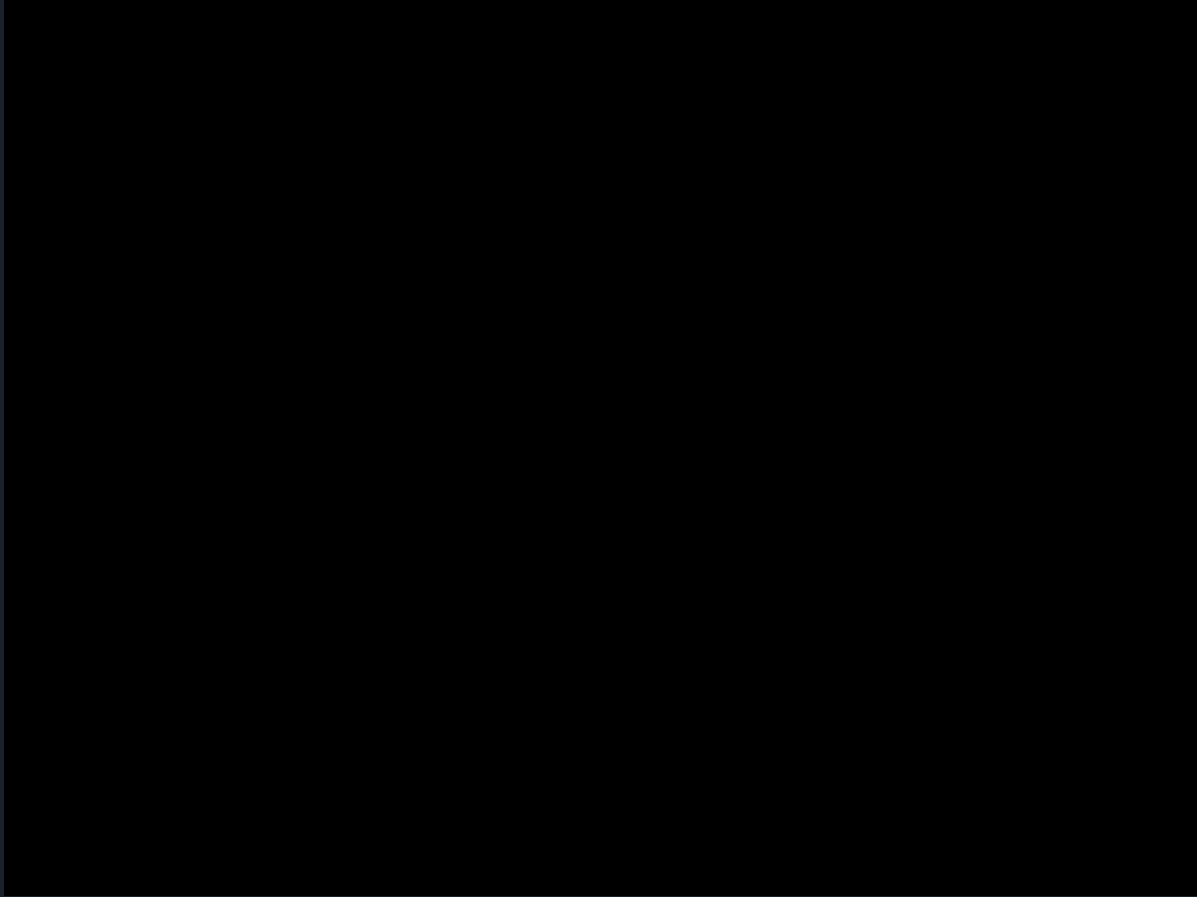
Actuator Mount

FINGER 1.0

Server Rack

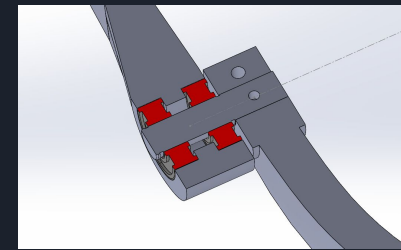
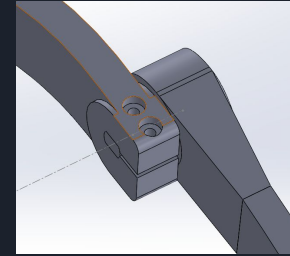
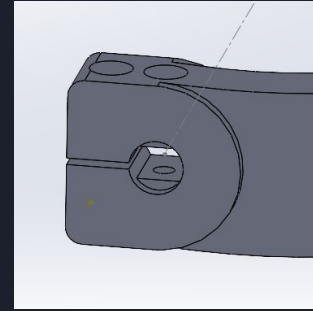
Bottom Linear Actuator (under baseplate)

# Working FINGER 2.0



# Key Attribute Design: Inner Link Connection

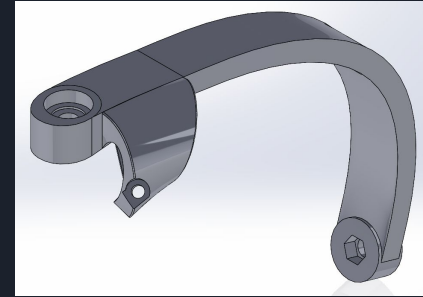
- Original design uses shoulder bolt through two bearings
- Issues: High Friction and play in joint connection
- Needs:
  - More rigid connection between bolt and links.
  - Higher tolerance between shaft and bearing to minimize play in the joint.
- Approach: Redesign link ends and design custom shaft
- Link Ends: utilize a clamping mechanic for rigid connection
- Custom Shaft: Uses retaining rings and shims on both sides of the bearings for a complete connection



# Key Attribute Design: Thumb Cuff and Link Connection

## Original Design

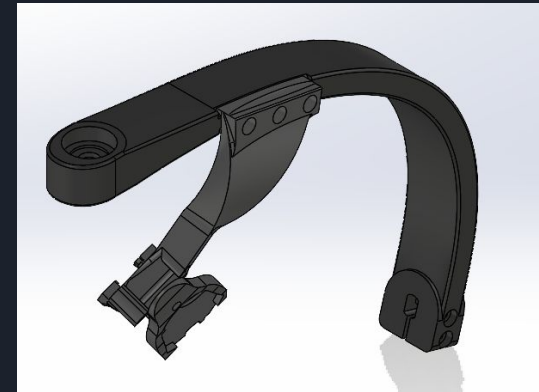
- Single bolt to connect thumb piece and the link
- The link was blocking the user's view of their thumb



Original Link

## Redesigned Connection

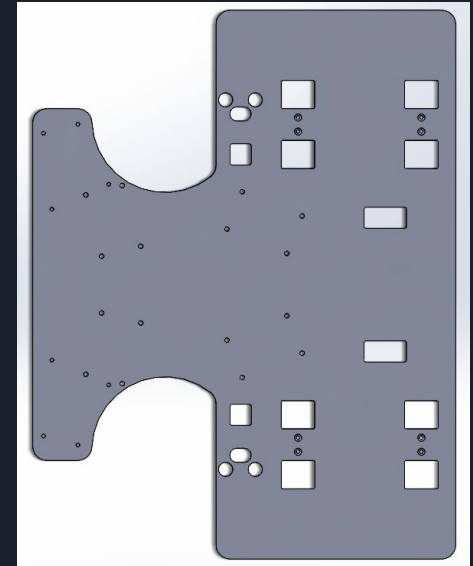
- Three bolts connecting thumb piece to link
- Slimmer design of connection material
- Size can be easily changed for different hand sizes



Redesigned Link and  
Thumb Connector

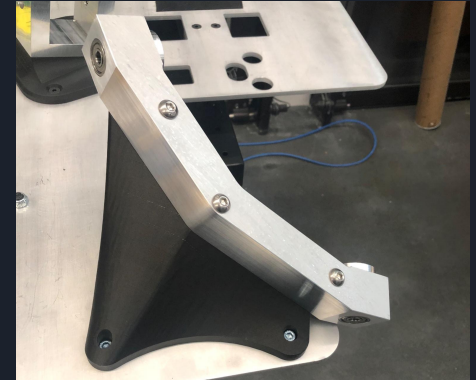
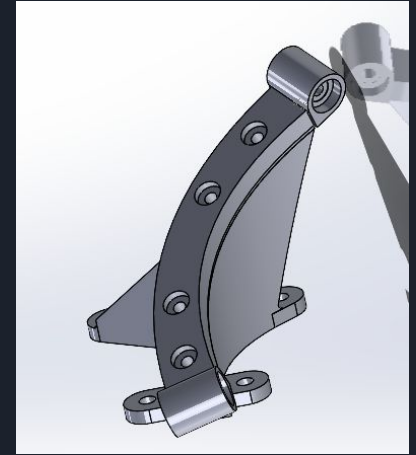
# Key Attribute Design: Baseplate

- Mirrored for use with both hands and new holes added for wire routing
- ¼ inch 7075 aluminum that was water jetted by Gateway Materials in Lewiston
- Mounted on 80/20 bar which is then mounted to the server rack
- Contains all actuators, Finger 1.0, and solid mounted link



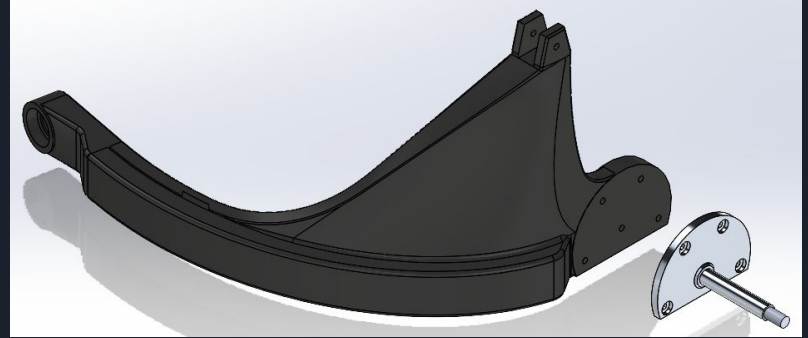
# Key Attribute Design: Fixed Link

- 3D printed base holds link in position relative to base plate. Uses threaded inserts to attach.
- Top is CNC'd 1.5 inch 7075 aluminum plate
- Houses shaft side of driven link connections
- Link is now symmetric and can be used for both left and right side (e.g. if one becomes damaged)



# Key Attribute Design: Fixed Link Connection

- Printed ONYX link
  - Nylon with carbon fiber
  - Hanging end accommodates bearings for inner joint
- Machined joint connection on mounted end
  - 6061 Alloy
  - Identical for all mounted joint connections

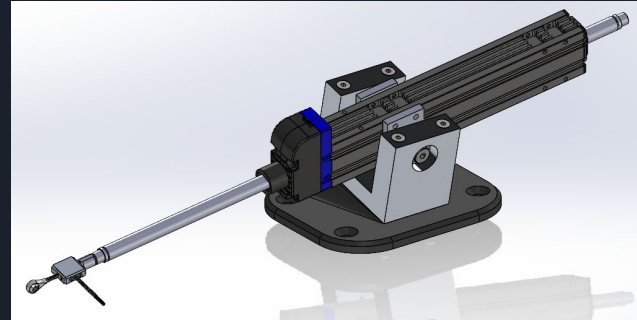




# Key Attribute Design: Actuator Mounts

## Original Design

- Solid mount 3D printed out of ABS
- Actuator side swap achieved by removing axle screws



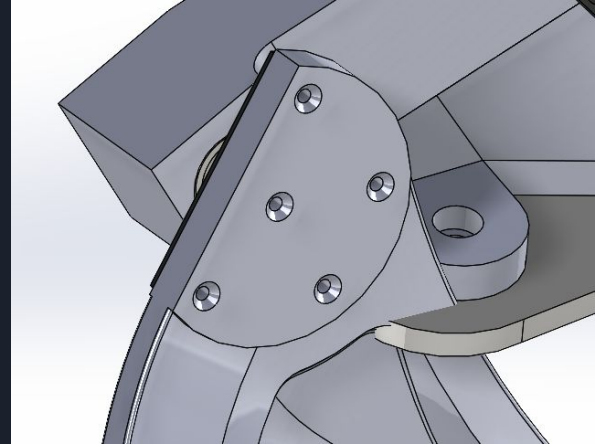
## Redesigned Connection

- Machined mount bolted onto ONYX angled base
- Side swap by unbolting mount from the base
- Mounting fasteners are easier to access and rethread than previous design
- More robust design



# Design Validation

- Baseplate Validation
  - Leaning and resting on the plate while a person is attached to the robot
  - No interference with left and right thumb modules
- Link manipulation and deflection tests
  - FEA Analysis
  - Hand “Squish” test
- 3D Assembly
  - Use interference detection to validate that parts are not going to run into each other



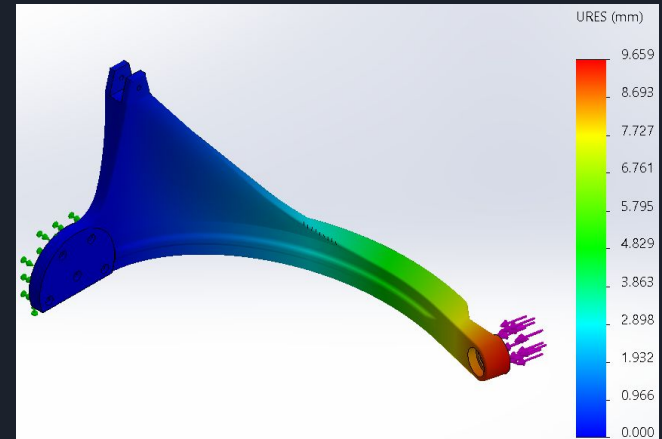
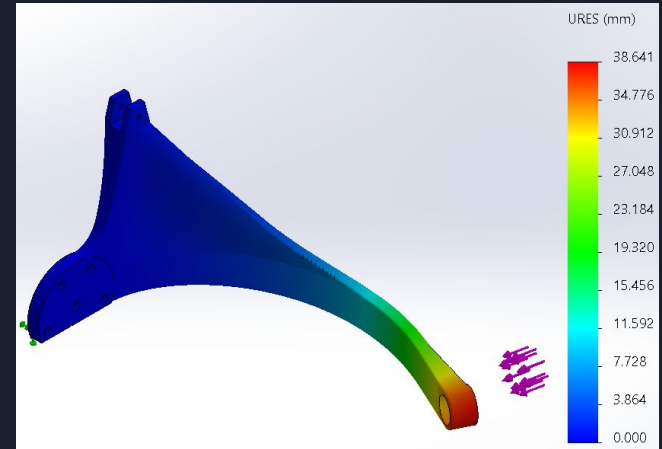
# Design Validation (cont.)

## Parameters

- Material: ABS PC
- Applied load: 10 lbf
- Component: Link 4-5 with rib and without

## Results

- Due to lack of correct material, deflections considered as dimensionless scalars
- Maximum deflection without rib: 38.641
- Maximum deflection with current rib: 9.659
- Percent reduction in deflection: 75%

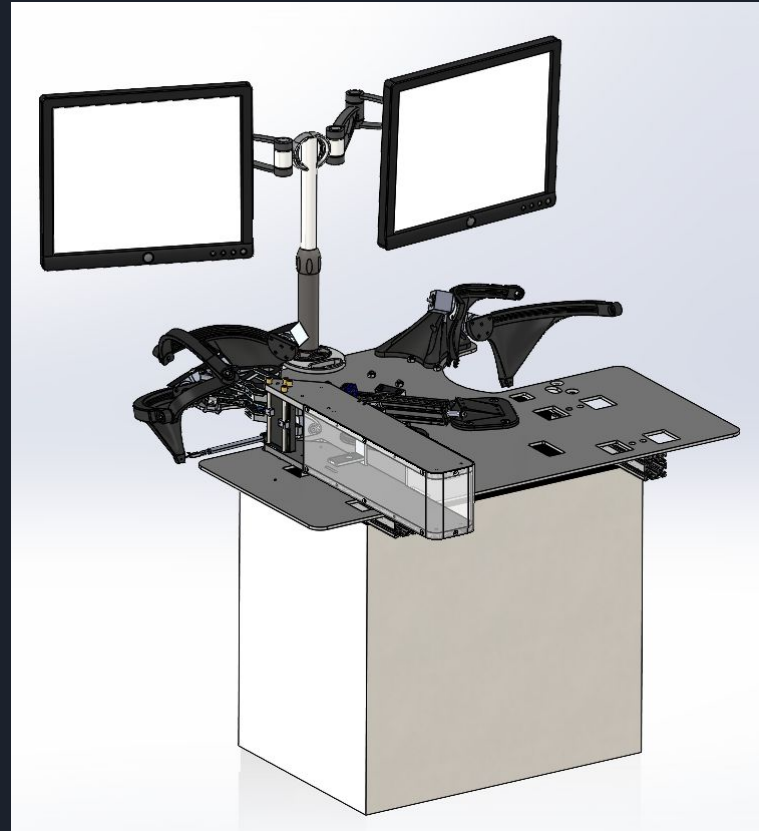


# Bill of Materials and Manufacturing Plans

Capstone Design									
Combined BOM and Manufacturing Plan									
Part No. or Assy. No.	Description	Quantity	Make or Buy?	Source	Fabrication Technique	Drawing Available	Material Available	Unit Cost (\$)	Extended Cost (\$)
<b>Full Assy. 1</b>									
Subassembly 1	FINGER 1.0	1							
Subassembly 2	Baseplate	1							
Subassembly 3	5-Bar Mechanism	2							
<b>Subassembly 1</b>	FINGER 1.0	1							
<b>Subassembly 2</b>	Baseplate								0
Baseplate		1	Make	Lewiston	Waterjet Cut	yes	yes	300	300
80/20 Bar		1	Buy	McMaster Carr	N/A	no	yes	35	35
Rolling Server Rack		1	Buy			no	yes	150	150
M6 Bolts		32	Buy	McMaster Carr	N/A	no	yes	0.5	16
									0
<b>Subassembly 3</b>									0
Links	Custom Links	8	Make	GJ-125	3D Print	no	yes	65	520
Fixed link		2	Make	ME Shop	N/A	yes	no	291.5	583
Fixed link Mount		2	Make	GJ-125	3D Print	no	no	277	554
Actuator U-Channel		4	Make	ME Shop	N/A	yes	no	124	496
Actuator angled Plate		4	Make	GJ-125	3D Print	no	no	45	180
C698ZZ	small bearing	12	Buy	Misumi	N/A	no	yes	5	60
C628ZZ	Large Bearings	8	Buy	Misumi	N/A		yes	5	40
5972K910	Ball Bearing	4	Buy	McMaster Carr	N/A		yes	5	20
Actuator	Dunkermotoren ST Linear actuators	2	Buy	Dunkermotoren	N/A	N/A	yes	1000	2000
Thumb Cuff	Connects thumb to links	2	Make	GJ-125	3D Print	no	yes	35	70
Linkage Shaft	Shafts to connect inner links	6	Make	ME Shop	N/A	yes	yes	30	180
Face Mount Shaft	Connects inner links to fixed link	4	Make	ME Shop	N/A	yes	yes	120	480
Fasteners	Various bolts, nuts and retaining rings	50	Buy	McMaster Carr	N/A	no	yes	0.8	40
Monitor Stand	Clamp Stand for user Monitor	1	Buy	ME Shop	N/A	yes	yes	30	30
Monitors	21.5" monitors	2	Make	ME Shop	N/A	yes	yes	120	240
								<b>TOTAL (\$)</b>	5994

# Moving Forward

- Further refine the driven links to decrease deflection
- Assemble left side using new designs for comparison to right side
- Finish FINGER 2.0 Prototype 1 and send to California
- Begin implementing new designs to second prototype for use at U of I





Thank you for your time!  
Questions?