Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

TechARM

TECHTOUCH

MTOA-2: AI Prosthetic Arm

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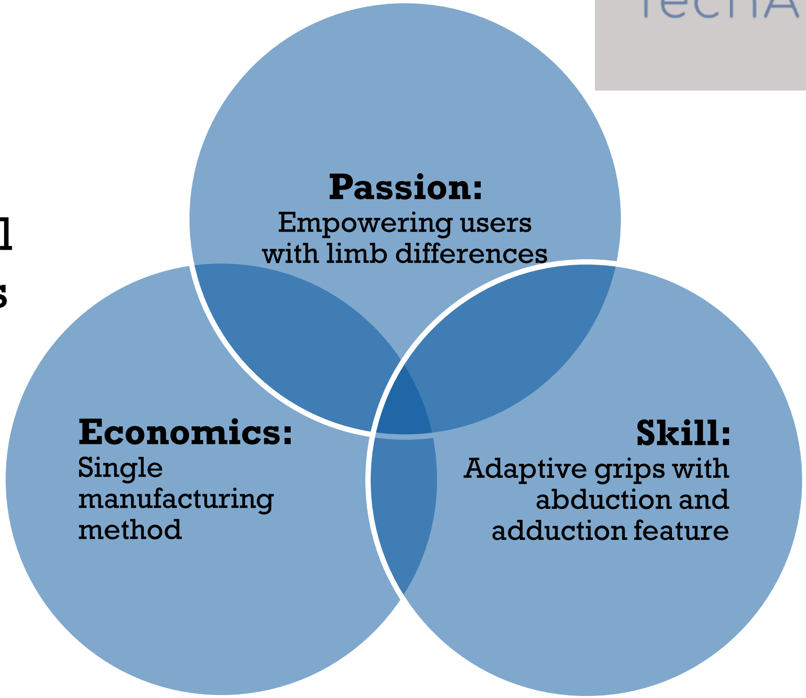
POWERING THE NEW ENGINEER TO TRANSFORM THE FUTURE

Overview

- Hedgehog Concept
- Product Specifications/Key Dimensions
- Design Highlights
- Evolution of Design
- Electrical Schematic
- Code
- Testing
- Cost Summary
- Future Improvements

Hedgehog Concept

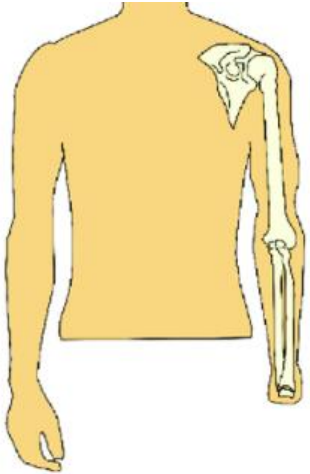
Our Goal: Develop an affordable prosthetic for those with trans-radial amputations allowing multiple grips to support the self-sufficiency of users.



Product Specifications

Customer Needs

- The prosthetic must achieve as many hand grasps as possible; grasps can be found in Spiers et al (2021).
- Prototype R&D artifact as-built and as-tested must not consume more than $1500 worth of raw material and individual test components.
- The user attachment interface is for a trans-radial amputation and must accommodate a range of trans-radial arm amputation shape profiles.
- A sustainable profit margin must exist between the total projected product cost to produce and the final commercialization price of no more than $4000.
- The user attachment interface must comfortably accommodate sizes ranging from child to adult.
- The user is able to form and release grasps via physical controls on the arm.



Product Specifications

Customer Needs Continued

- The color of the device is user customizable.
- Exposed device features cannot catch on any moving part of the device.
- The object grasping interface must release any grasped object once a task has been deemed completed by the user.
- In the event of an emergency, a manual override safety feature must be easily accessible to the user to immediately power-down the prosthetic.
- The device must be cordless while in operation.
- Heavy operational use between recharges must exceed 3 hours.
- The device must be easily and rapidly rechargeable by a single-handed user using power sources found in the typical U.S. home environment.

Product Specifications

Customer Needs Continued

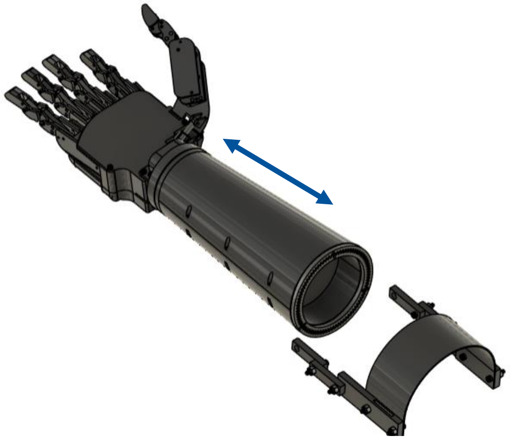
- The device must be easily repaired using basic shop tools and fabrication services available in developing countries.
- Device must be resistant to dust and water.
- Device must be resistant to reoccurring impact.
- Access to, and maintenance of, inner components must be made easy for a single-handed user.
- The device must fulfill U.S. Food & Drug Administration (FDA) requirements to be categorized as a "Class II (special controls)" device [2].
- The end-user must be able to easily attach and remove the prosthetic by themselves.
- Operating noise must not exceed 70db.

Product Specifications

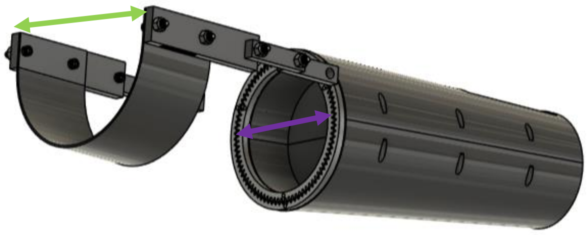
Customer Needs To Be Met in Future

- Weight of any complete arm attached assembly must not exceed 2 lbs.
- While holding an object, the object grasping interface must apply only a reasonable level of force required to perform the intended action
- The prosthetic must include a "smart" feature that allows the user to form and release grips without using the physical controls on the arm.

Key Dimensions



- Forearm length: 7.75”
  - Average forearm length: 9.5”
- Cinching mechanism diameter: 3.75”
  - Measured the largest forearm diameter
- Palm width: 4.25”
  - Average palm width: 3.1”
- Bicep attachment diameter: 4.75”
  - Tested on all members

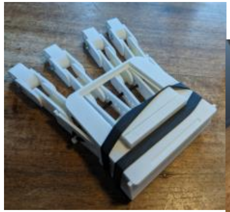


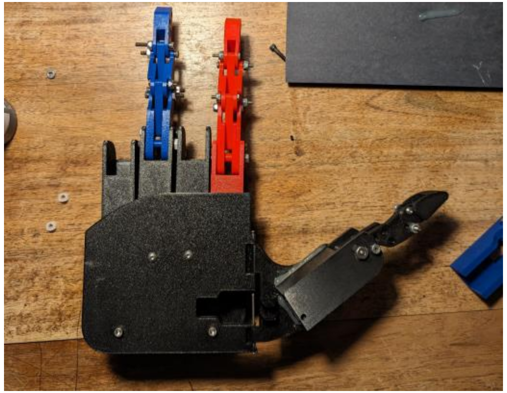
Design Highlights

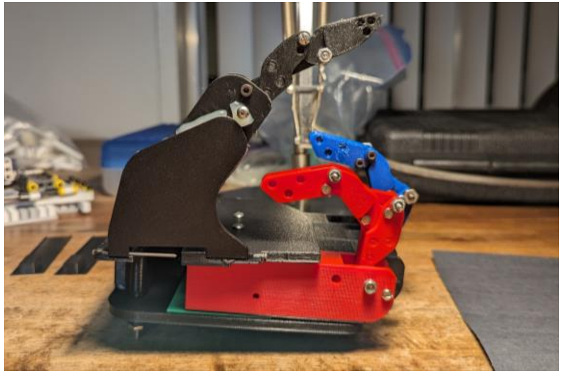
- Adduction and Abduction
- Manual wrist rotation →
- Adjustable forearm cinching mechanism

Evolution of Design: Preliminary Grasping Mechanism

- Prototype 1 proof of concept
- Prototype 1 and 2 durability
- Prototype grip effectiveness
- Preliminary calculations

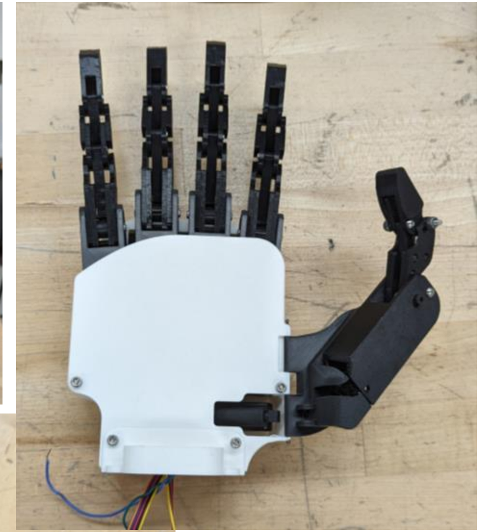
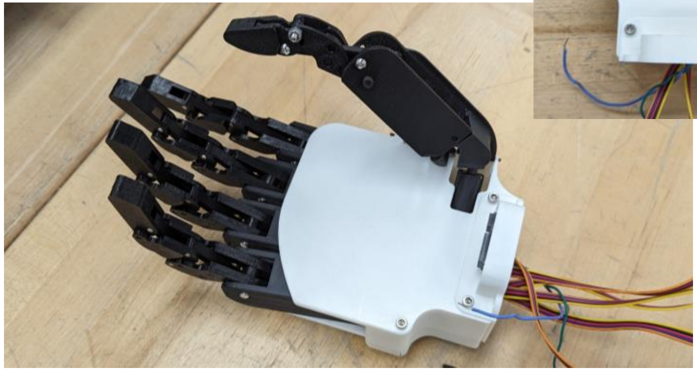






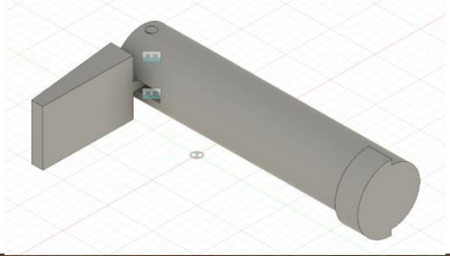
Evolution of Design: Final Grasping Mechanism

- Improved shape
- Increased durability
- Water resistance features
- Dowel pins connect finger links

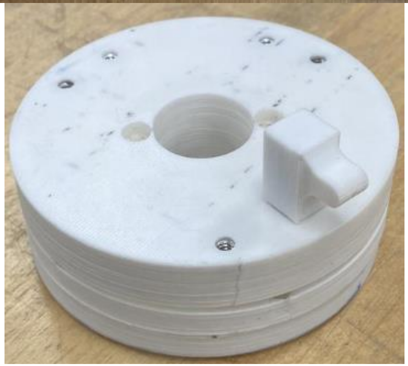





Evolution of Design: Preliminary Wrist

- Originally motorized
- 4 major parts
- Pin pulled radially
- Relatively complex pin geometry
- Assembly issues
- Smooth sliding faces



Evolution of Design: Final Wrist



- Pin pulled axially
- Simpler overall geometry
- Countersink holes and spring-loaded pin
- Improved grip, and rotation restrictors

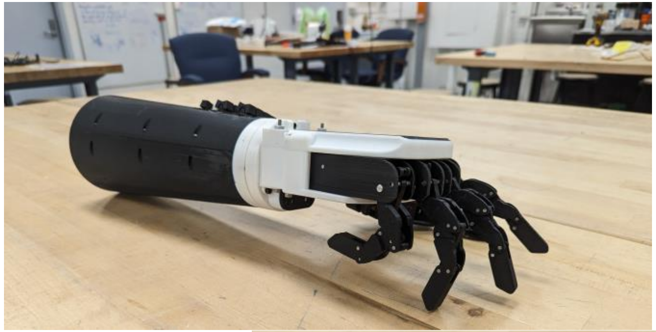
Evolution of Design: Residual Limb Attachment

- Large diameter
- Simple geometry
- Bolt fasteners
- Attach to the forearm

Evolution of Design: Final Residual Limb Attachment

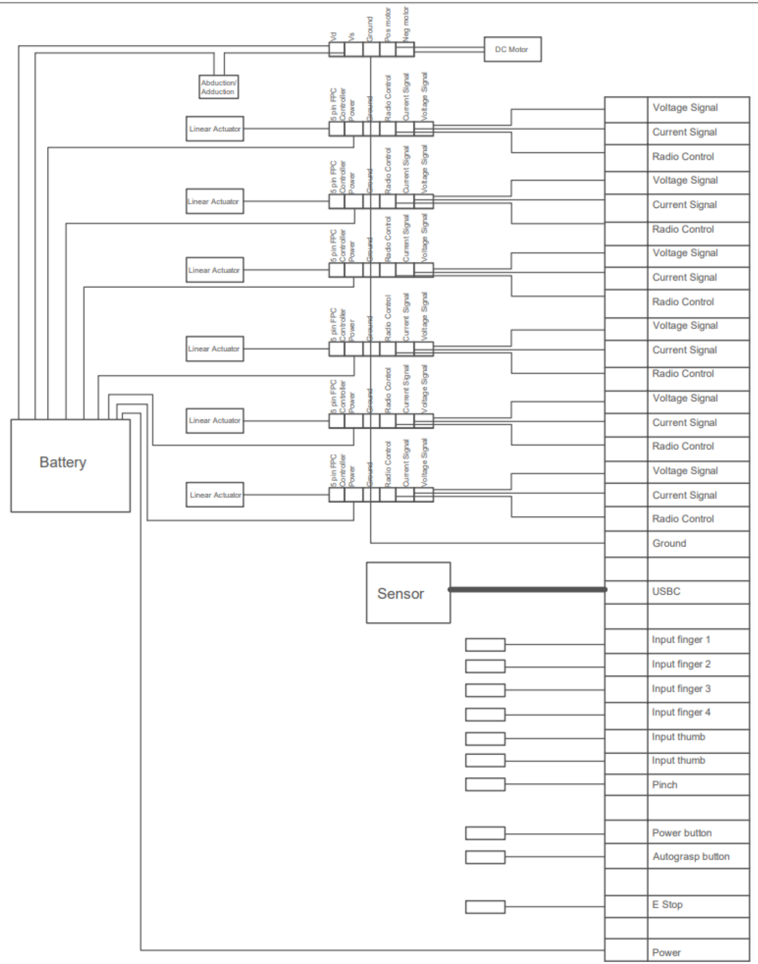
- Smaller diameter
- Geometry change
- Rivets
- Cinching mechanism
  - Tapered teeth

Evolution of Design: Final Assembly



Electrical Schematic

- Battery
- Raspberry Pi
- Sensor/Smart feature
- Motor controllers
- 6 linear actuators
- DC motor
- Inputs



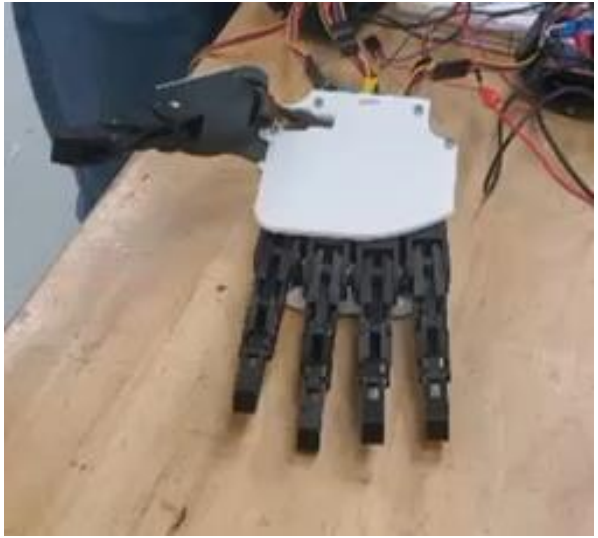
Code

6 Actuators

- 2 input pin switch states
- 3.3 V, 1kHz PWM output signal
- Motor driver PWM voltage control

DC motor

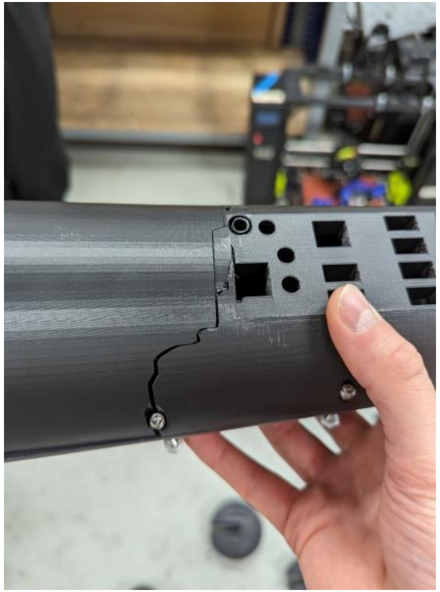
- 2 input pin switch states
- 2 output pin high/low states
- 3.3 V, 1kHz PWM signal speed control



Performance Evaluation #1

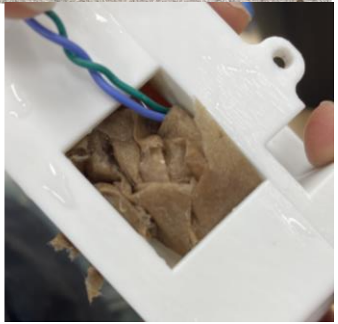
Impact Test – Post testing imagery

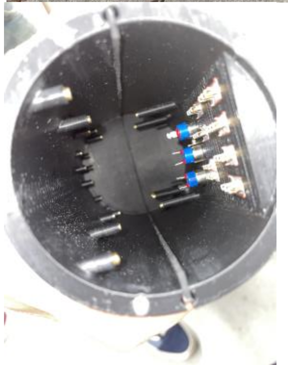


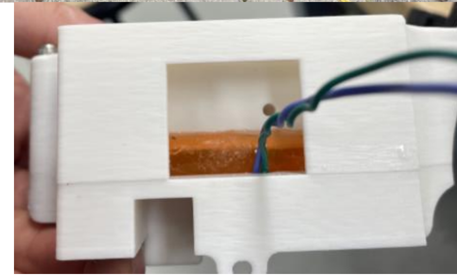



Performance Evaluation #2

Water/Dust Testing







Cost Summary

Cost Table: Prototype

	Material/Process	Cost ($)
Material	ASA Filament	38.46
	PETG Filament	37.98
	OTS Parts	1,193.75
Manufacturing	Adjustments- Misc.	400
	Sewing	0.96
	Cure, Room Temperature	0.01
Assembly	Assemblers and Fabricators	12.47
Total		1,683.63

Cost Summary

Cost Table: Batch Production of 100

- Several OTS parts ordered in bulk would have excess units that would be added to the company inventory to be used in next mass production.
- Dividing the total cost by 100, it can be determined that the COGS decreases when mass producing the product.
    - Prototype COGS ($1,683.63) > Mass Production COGS ($835.03)

	Material/Process	Cost ($)
Material	OTS Parts	82,352.58
Manufacturing	Injection Mold by Xometry®	-
	Sewing	96
	Cure, Room Temperature	0.60
Assembly	Assemblers and Fabricators	1,052.97
Total		-

Cost Summary

Gross Margin Percentage (GM%) of Batch Manufacturing

- COGS= $835.03 (+ manufacturing cost by Xometry)
- Selling Price= $3,500
- Gross Margin= $2,664.97
- GM%= 76.1%
  - Note: This calculation does not consider manufacturing and assembly cost because we outsourced production manufacturing with Xometry and are still awaiting a quote.

A GM% of greater than approximately 45% is acceptable for the industry our product would fall under.

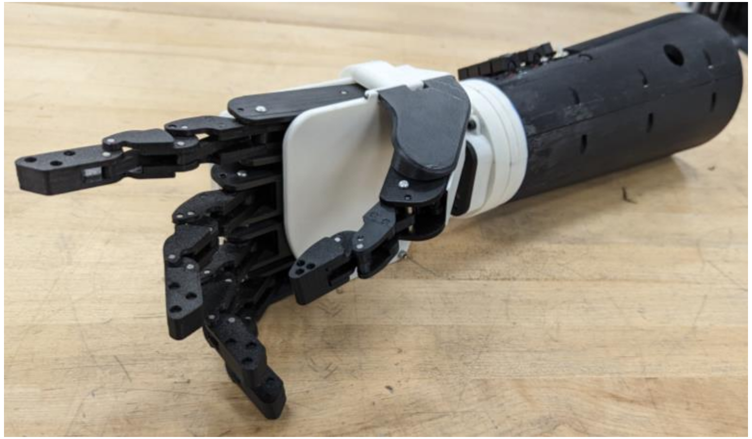
Future Improvements

- Scaling down the entire device
- AI object identifier feature
- Force sensor and grip material on fingers
- Custom PCB
- Universal bolt driver size
- Overall aesthetics

Why TechARM™?

- Novel abduction/adduction feature
- Adjustability
- Low cost

QUESTIONS?



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