Fall 2021 ME 571: Medical Robotics

3D Printed Prosthetic Robotic Grasper

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Significance

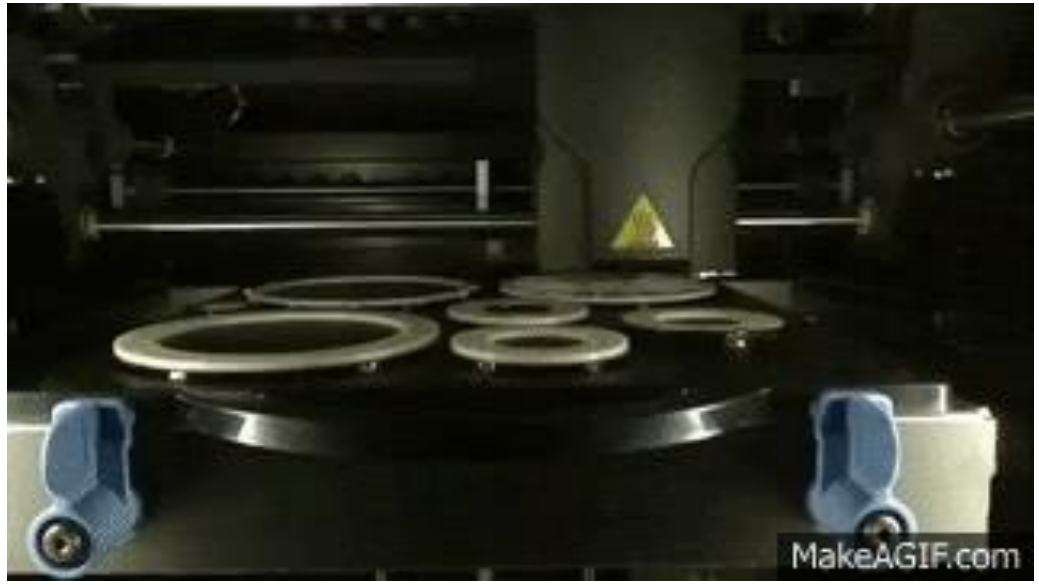
- Hand motor capabilities are important in daily life
  - There are estimated that 1.7 million people in the United States living with limb loss, and 50,000 to 100,000 new amputations occur per year.[7]
  - Seventy percent of patients with upper limb loss undergo amputation below the elbow, with 10% of those occurring at hand or wrist [7]
  - the total number of amputations are estimated to increase from 1.6 million in 2005 to 3.6 million individuals by 2050 in the United States [6]
- Amputation, trauma, malignancy, vascular disease, congenital deformities, and Carpal tunnel syndrome may lose independence
- Current bionic hand technologies are costly [1]
- Economically scarce countries or demographics have very few option, if any at all

Bionic Hand	Price Category (USD)	Current Availability
Ability Hand	$20,000 to $30,000	USA
Adam's Hand	$30,000 to $40,000[1]	Italy Q1 2022, USA, Germany, France, and Spain later in 2022
Atom Touch	More than $50,000[2]	USA (launch date 2024)
Bebionic Hand	$30,000 to $40,000	Global
BrainRobotics Hand	$20,000 to $30,000	USA (launch date 2021/2022)
Hero Arm	$10,000 to $20,000	USA, UK, Europe, Australia, New Zealand
i-Limb Access	$40,000 to $50,000	Global
i-Limb Ultra & Quantum	More than $50,000	Global
LUKE Arm	More than $50,000[2]	USA
MeHandA	$30,000 to $40,000	Russia, Germany, Commonwealth of Independent (CIS) countries

Bionic hand prosthetic cost

Innovation

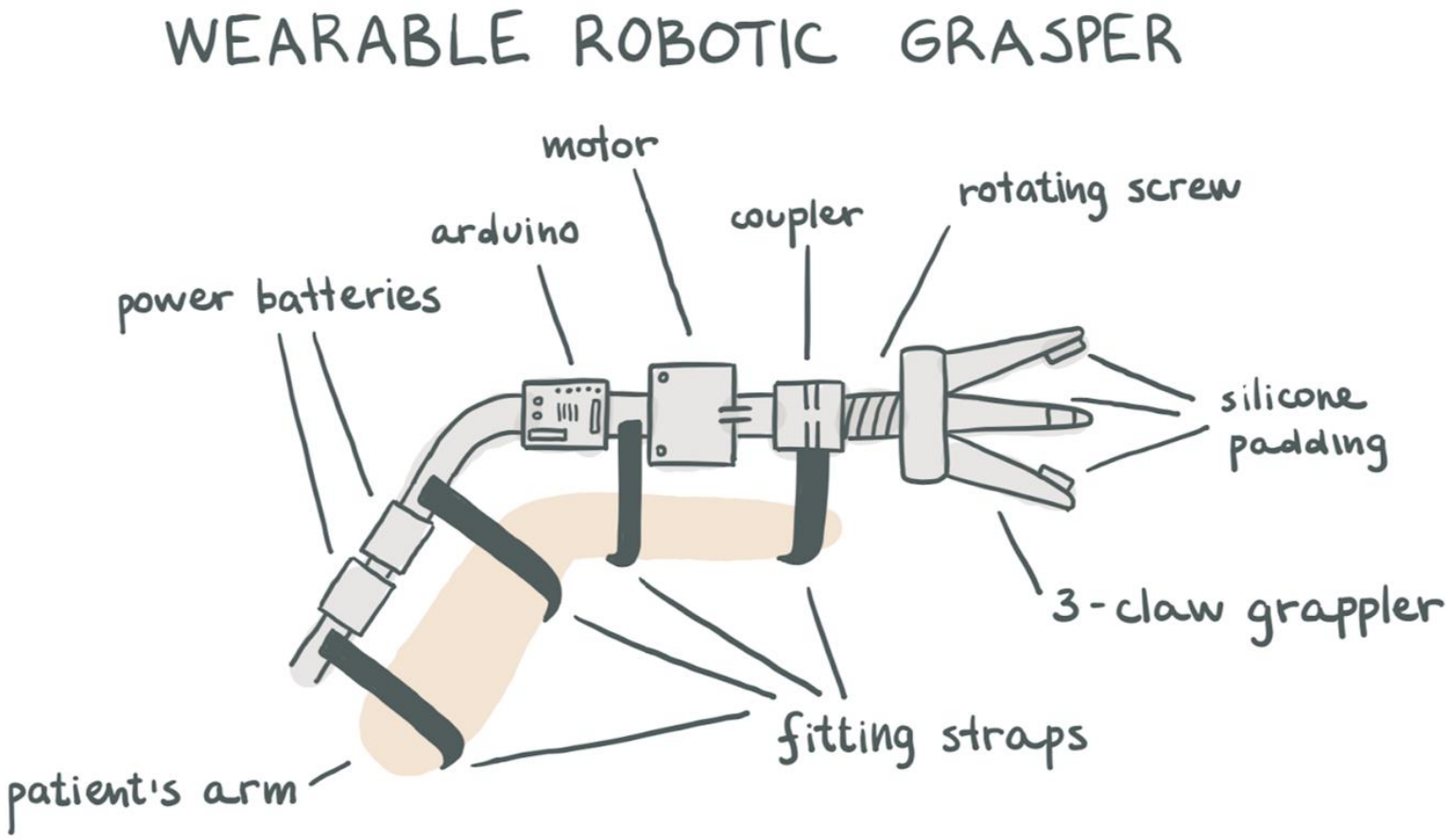
- Low-cost/High Accessibility
  - Simple 3D Prints
  - Inexpensive electronics
- Usability/Mobility
  - Light plastic materials
  - Simple mounting
  - Basic user controls
- Basic user feedback
  - Force sensing tip
  - Vibration haptic feedback



3D Printing on Stratasys FDM system

Approach

- End Effector
  - Soft tips
  - FSR Sensor
  - Interchangeable
- Mechanism
  - Stepper motor
  - Coupler
  - Lead Screw/Nut
- Electronics
  - Arduino UNO
  - 2 x 9V Batteries
  - EMG Sensor
  - Vibration Motor



Approach

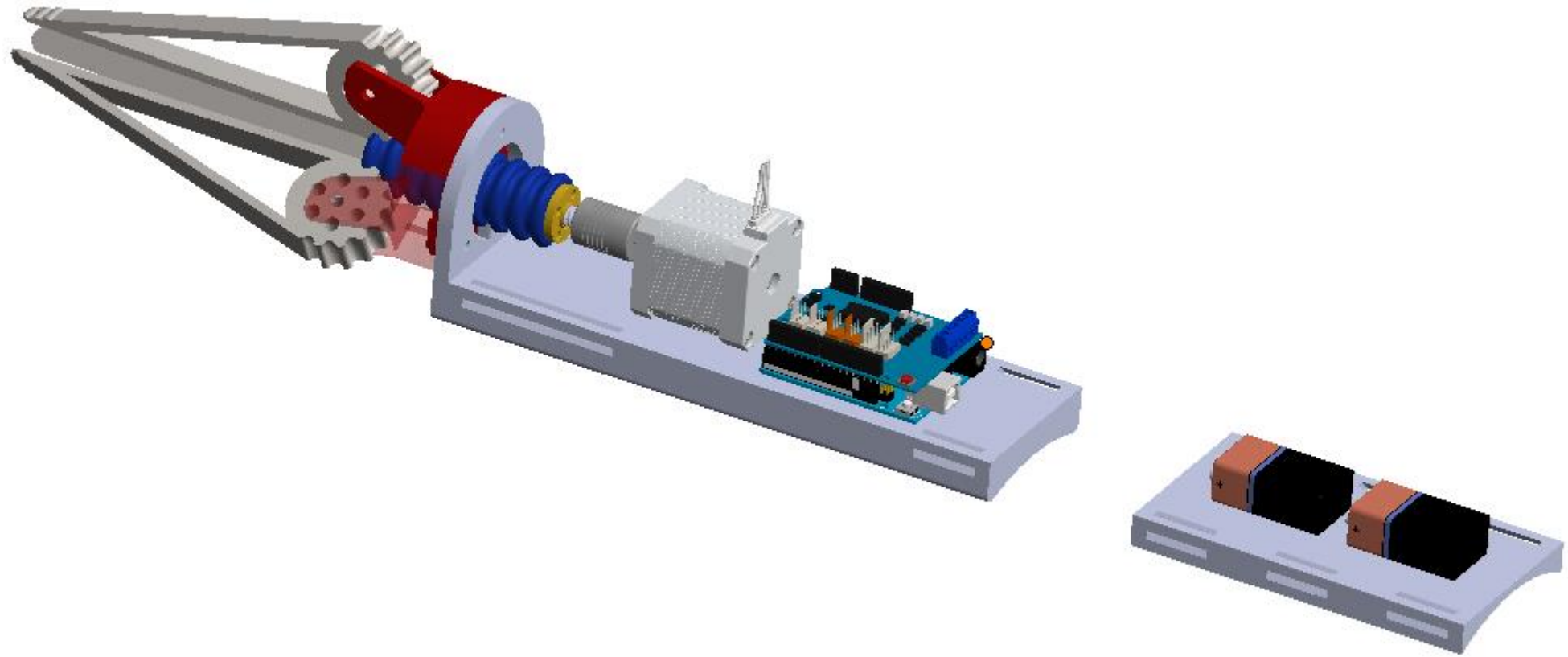
- Manufacturing
  - Stratasys FDM PC-ABS
  - Fabric/Velcro Straps
  - Linear stage components
  - Mechanical fastening
- Controls
  - EMG Sensor for activation
- Haptic Feedback
  - Vibration Motor for force feedback
- End Effector Interchangeability
  - Base design can be modified and easily swapped

3V Vibration Motor

Arduino EMG Sensor

Stratasys SE Plus FDM 3D printer

Prototype 3D Model



Finished Prototype

Prototype Demo

Future developments

Design Weaknesses

- Some components are heavier than I'd like
- Limited functionality
- Limited ergonomics
- Mostly solid materials
- Low power storage capacity
- Still quite bulky

Improvements

- Switch metal components for plastic
- Add shrouds/covers
- Redesign end effector for more "hand-like" functionality
- Add cushioning or less rigid materials for ergonomics
- More comprehensive/intuitive feedback

References

[1] https://bionicsforeveryone.com/bionic-hand-price-list/

[2] https://makeagif.com/gif/3d-printing-with-stratasys-y3xUfx

[3] https://techzeero.com/arduino-tutorials/vibration-motor-with-arduino/

[4] https://www.sparkfun.com/products/13723

[5] https://www.cati.com/3d-printing/stratasys-3d-printers/uprint-se-plus/

[6] https://onlinelibrary.wiley.com/doi/full/10.1016/j.pmrj.2018.06.015

[7] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6173827/