e-NABLE: Lateral Wrist Movement to 3D-Printed Prosthetic

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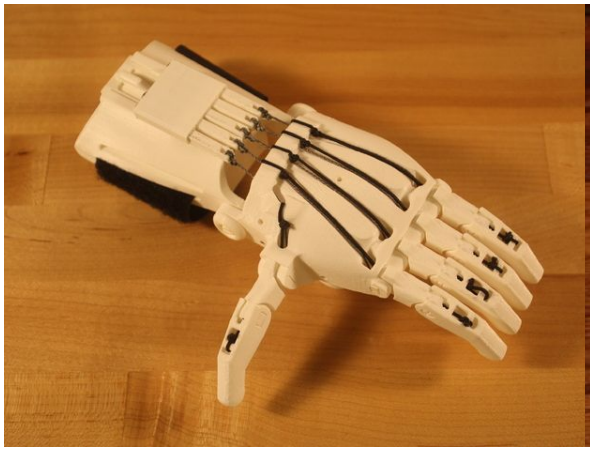
eNABLE: Badger Hands

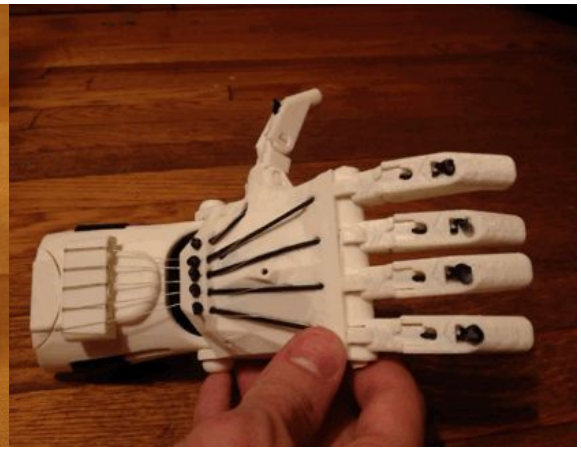
Problem Statement

- e-NABLE international community 3D prints inexpensive upper limb prosthesis for children and adults in need
- Current designs only allow for one degree of freedom
- Proposed by e-NABLE to modify the design of the *Raptor Reloaded* hand prosthetic to add a second degree of motion (lateral motion)

Current Design: Raptor Reloaded

- Used for individual with a palm, but no fingers
- One degree of freedom: wrist flexion closes fingers
- Fingers close in the same motion
- Ideally, thumb and pointer finger can be used to pinch
- 3D printed with PLA

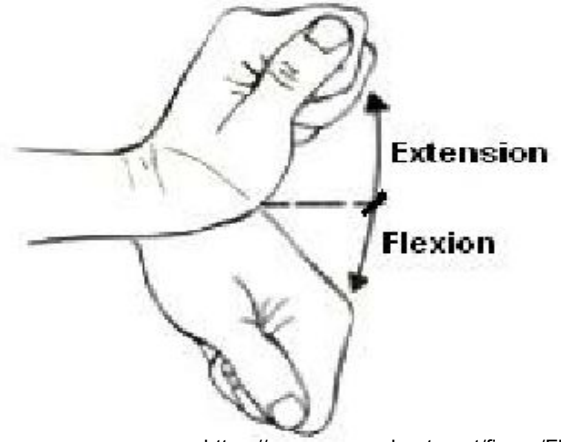




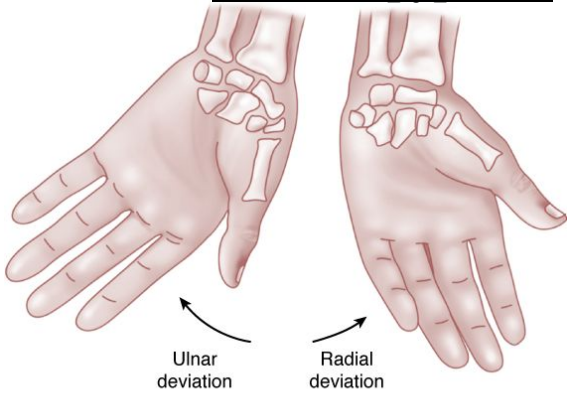
https://www.thingiverse.com/thing:596966 http://sinkhacks.com/building-the-e-nable-prosthetic-raptor-hand/

Important Aspects of the Wrist

- Current Application: Flexion
- Typical ranges of motion:
  - Abduction: 17°
  - Adduction range of motion: 40°
- Rotation occurs at the elbow
- Two degrees of freedom



https://www.researchgate.net/figure/Flexion-extension-of-the-wrist_fig3_279493096



Product Design Specifications

- Cannot lose any of the functions already implemented with the first degree of freedom
- Must be 3D printed
  - Besides the strings and bands
- Withstand everyday use (span of 1-2 years)
- The lateral motion must not cause excess strain on the person’s wrist
- No significant weight increase

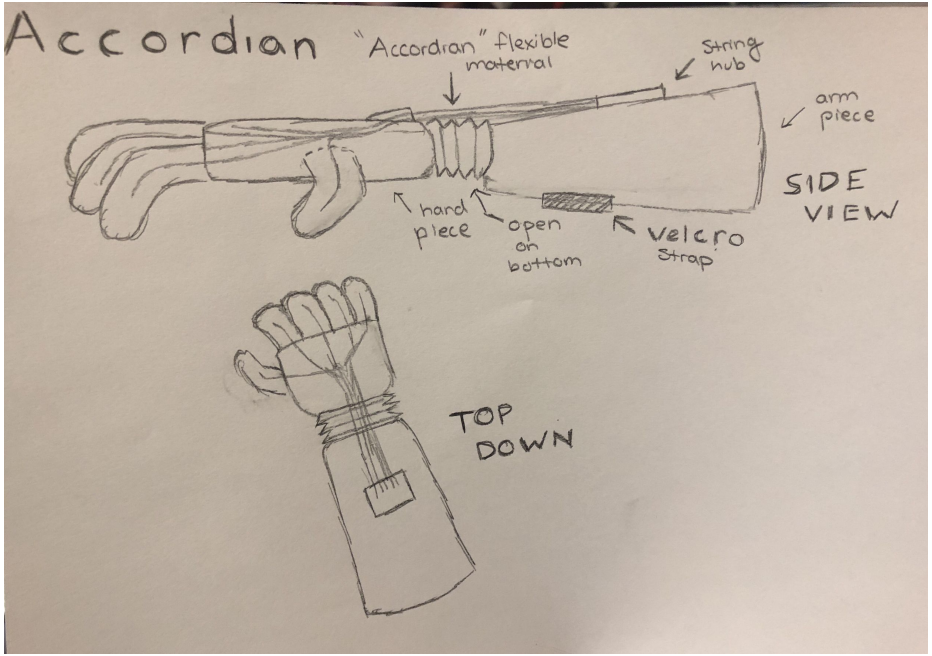
Design 1: The Accordion Wrist

Pros:

- 2 degrees of freedom
- Little maintenance
- Comfortable for user
- Compact design

Cons:

- Use of multiple materials
- Can it reach full range of motion
- Material could be less durable



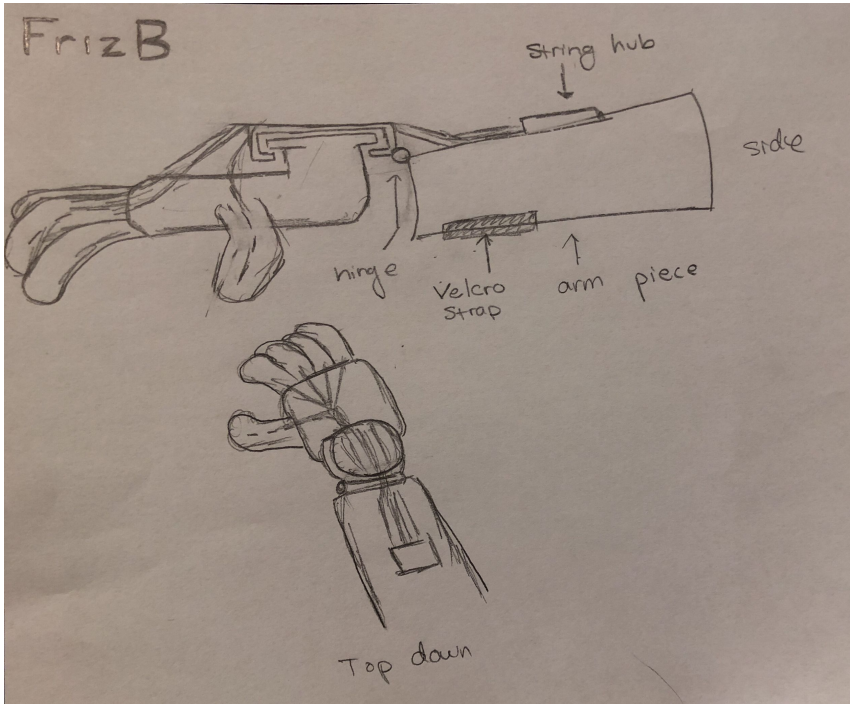
Design 2: The FrizB

Pros:

- Maintains current range of motion
- Easy to use
- Low user strain

Cons:

- Location of string hosing would have to be moved
- Disc must not interfere with strings
- Disc would create friction
- Contact point under additional stress
- Assembly is more difficult



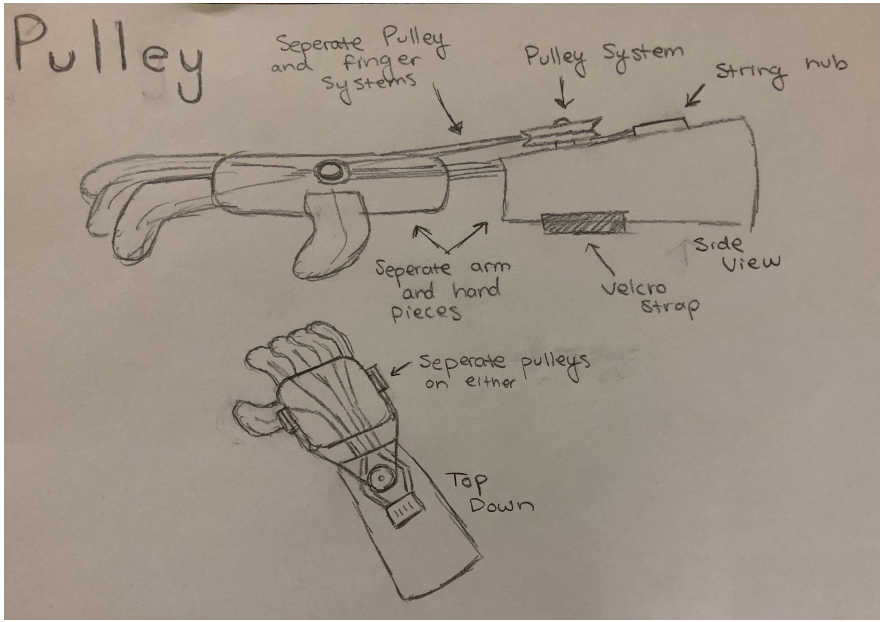
Design 3: The Pulley

Pros:

- Creates less tension on patient
- Allows for effective lateral movement
- Allows for easy take on and take off
- Maintains the current capability

Cons:

- Pulley activation would be difficult
- Movement of pulley would interfere with the current strings/bands
- Easily breakable
- Not easily reproducible



Design Matrix

Criteria	Weight	The Accordion		The FrizB		The Pulley	
Maintain Current Capabilities	25	(4/5)	20	(4/5)	20	**(5/5)**	**25**
Range of Motion	20	(3/5)	12	(3/5)	12	**(4/5)**	**16**
Patient Comfort	15	**(5/5)**	**15**	(2/5)	6	(3/5)	9
Functionality/Ease of Use	15	(3/5)	9	**(4/5)**	**12**	(2/5)	6
Durability	10	**(4/5)**	**8**	(3/5)	6	(2/5)	4
Reproducibility	10	**(3/5)**	**6**	(2/5)	4	(2/5)	4
Cost	5	**(5/5)**	**5**	**(5/5)**	**5**	**(5/5)**	**5**
Total	100		**75**		65		69

Future Work

- Material consideration: PLA v. ABS
- Assembly consideration
  - 360 or 180 degree sleeve
- Range of motion testing
- Create CAD drawings
- Fabrication

References

“badgerhands.org,” *badgerhandsorg*. [Online]. Available: http://badgerhands.org/. [Accessed: 28-Sep-2018].

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J. Ryu, A. K. Palmer, and W. P. Cooney, “Wrist Joint Motion,” *Biomechanics of the Wrist Joint*, pp. 37–60, 1991.