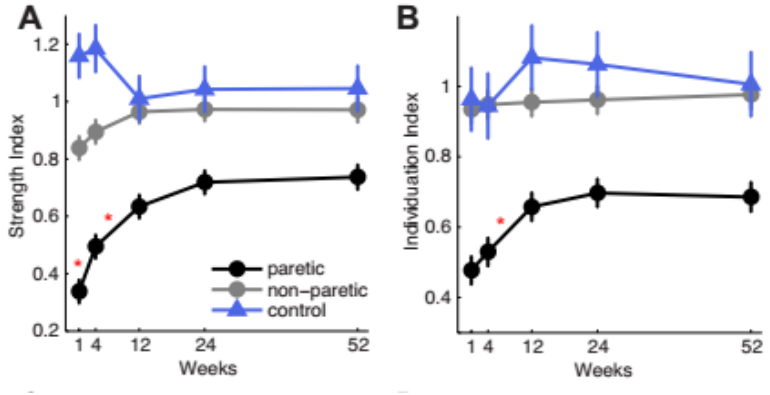
Stroke Rehabilitation Hand Device

TEAM #15
MEMBERS: JAKE CARDUCCI, KEVIN OLDS (MENTOR)

Clinical Motivation

- Issues experienced by upper-limb stroke patients:
  - Exerting sufficient force
  - Moving over sufficient range
  - Stabilizing arm while moving fingers
  - Feeling sense of touch or finger/hand position
- Patient recovery
  - Quantifiable as strength, individuation, Fugl-Meyer impairment, ARAT activity, etc.
  - “Most improvement in both strength and individuation occurred over the first 12 weeks” [1]



Group recovery curves for the Strength and Individuation Indices for patients and controls. Asterisks indicate significant week-to-week change for the paretic hand. [1]

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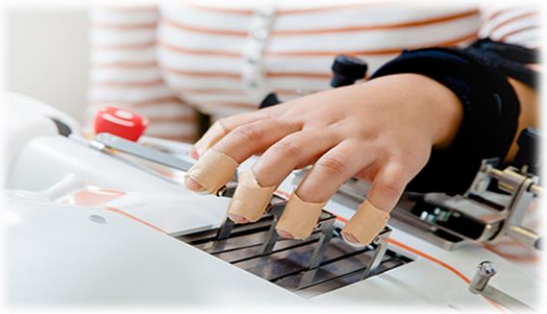
Prior Art / Previous Devices

- Amadeo Rehab System (Tyromotion)
  - Linear force sensor/actuators
  - Rehab software with games
  - Not easily portable
  - Long setup time
  - High friction for weak patients



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Prior Art / Previous Devices

- Rapael Smart Glove (Neofect)
  - Flexible, wearable frame with bend sensors
  - Bends in one direction only
  - Too stiff for weak patients

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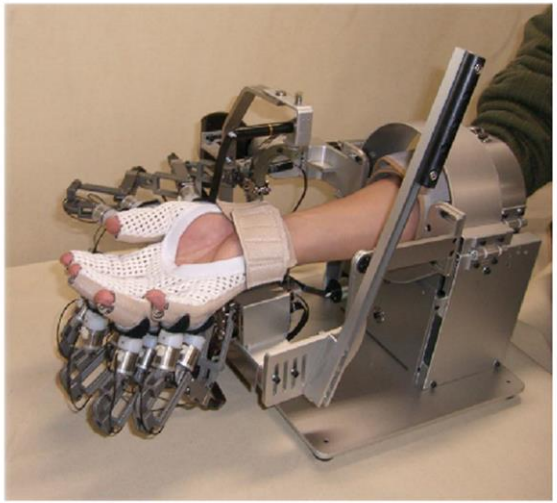
Prior Art / Previous Devices

- Hand Rehab Robot (Kawasaki et al.)
  - Not portable
  - Complex
  - High-cost
- Finger Evaluation Device (Xu et al.) [1]
  - Lacks multiple-axis force detecting
  - Minimal finger securing



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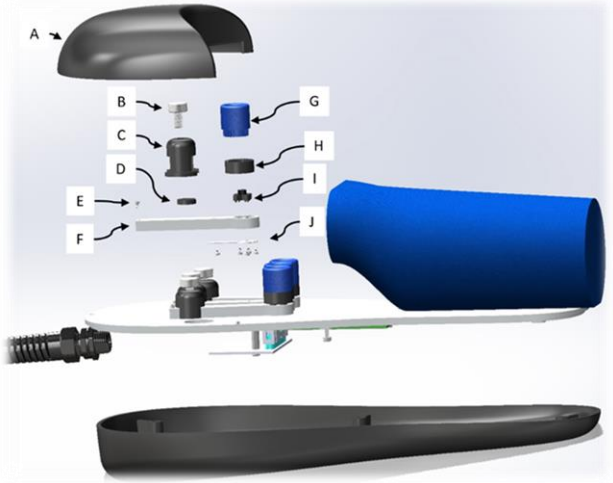
Goal

To get clinical engineering approval and an IRB-approved clinical study for a hand rehabilitation device, to design and fabricate an improved version of the device based on study feedback, and to get preliminary study feedback for the revised version.

Technical Summary (Current)

- Hand fits in adjustable brace, secures to base
- Finger fits in silicon cup(s), force detected at base
- Force signals sent to computer and processed into usable information



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Technical Approach (Planned)

- Increase signal channel count from two to five
- Modified mechanisms for easier component attachment and removal (brace, retention cups, etc.)
- Properly calibrated force sensors with high sensitivity
- Modified adjustable force beam designs for each finger

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Tasks and Deliverables

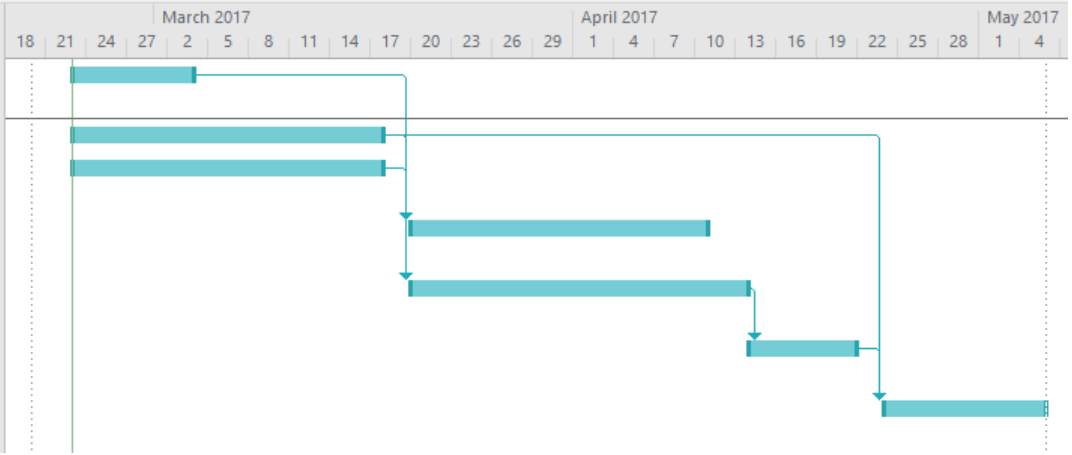
Minimum Tasks	Expected Date	Associated Deliverable
Send the existing prototype to clinical engineering team at JH Hospital; get approval stamp	03/03/2017	Correspondence and approval documents
Get IRB approval for a clinical study	03/17/2017	Correspondence and approval documents
Design a revised prototype on paper and in CAD • Easily removable arm brace • Appropriate design for thumb force sensor • Snap-on mechanism for finger retention cup adapter • PCBs for microcontroller and signal processing to support 5 fingers	03/17/2017	Schematics and diagrams associated with each subsystem
Get feedback from at least 5 individuals affected by stroke of various degrees	04/07/2017	Force test results

Tasks and Deliverables

Expected Deliverables and Tasks	Expected Date	Associated Deliverable
Fabricate the revised prototype to implement features developed from patient feedback and other considerations • All designed components from revision design • Breadboard testing of components / soldering PCB parts	04/14/2017	Assembled and functional revised prototype
Maximum Deliverables and Tasks	**Expected Date**	
Send the revised prototype to clinical engineering, get approval stamp	04/21/2017	Correspondence and approval documents
Get feedback again from at least 5 stroke-affected patients	05/05/2017	Force test results

Schedule

Task Name	Duration	Start	Finish	Predecesso
CES Approval Stamp for Original Prototype	7 days	Thu 2/23/17	Fri 3/3/17	
IRB Approval	17 days	Thu 2/23/17	Fri 3/17/17	
Design Revisional Prototype	17 days	Thu 2/23/17	Fri 3/17/17	
Get Patient Feedback for Original Prototype	16 days	Mon 3/20/17	Mon 4/10/17	2,1
Fabricate Revisional Prototype	19 days	Mon 3/20/17	Thu 4/13/17	3
CES Approval Stamp for Revisional Prototype	6 days	Fri 4/14/17	Fri 4/21/17	5
Get Patient Feedback for Revisional Prototype	10 days	Mon 4/24/17	Fri 5/5/17	6,2



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Dependencies

Dependency	Status	Plan of Resolve
Hardware from outside vendors (PCBs, printed/machined parts)	Unresolved (Estimated Resolve Date: 03/20/2017)	None of these parts require a specific vendor, and the vendor can be changed if there are any issues.
CES and IRB approval	Unresolved (Estimated Resolve Date: 03/17/2017)	If intractable delays in CES and IRB approval come up (unlikely since similar projects and devices from the same group have been approved in the past), the project will shift to focus more on technical development of the new prototype.
Patient recruiting	Unresolved (Estimated Resolve Date: 04/07/2017)	Even with CES and IRB approval, there can be delays in recruiting patients to participate in the study. If this occurs, many aspects of the design can be tested with healthy subjects, which are much easier to recruit.

Management Plan & Responsibilities

- Regular meetings every week
- Jacob Carducci
  - Documentation for submission to clinical engineering and IRB
  - Patient data collection
  - Design / fabrication of revised prototype
- Kevin Olds (mentor)
  - Providing School of Medicine resources
  - Documentation and design supervision
  - Fabrication facility access

Seminar Reading List

[1] K. Nagata, "Fingertip-mounted six-axis force sensor". US Patent 6622575 B1, 7 July 1999.

[2] J. Xu, A. Haith, J. Krakauer, "Motor control of the hand before and after stroke," *Clinical Systems Neuroscience,* Ed. K. Kansaku et al. Springer Japan, 2015.

[3] J. Xu, N. Ejaz, B. Hertler, M. Branscheildt, M. Widmer, A. Faria, M. Harran, J. Cortes, N. Kim, P. Celnik, T. Kitago, A. Luft, J. Krakauer and J. Diedrichsen, "Recovery of hand function after stroke: separable systems for finger strength and control," *bioRxiv,* 2016.

[4] R. Pozos and J. Agraz, "Force measuring device and method". US Patent 6673026 B2, 27 March 2000.

[5] S. Ito, H. Kawasaki, Y. Ishigure, Y. Nishimoto, T. Aoki, T. Mouri, H. Sakaeda and M. Abe, "Development of a Hand Motion Assist Robot for Rehabilitation Therapy by Patient Self-Motion Control," in *Proceedings of the 2007 IEEE 10th International Conference on Rehabilitation Robotics*, Noordwijk, Netherlands, 2007.

References

[1] J. Xu, N. Ejaz, B. Hertler, M. Branscheildt, M. Widmer, A. Faria, M. Harran, J. Cortes, N. Kim, P. Celnik, T. Kitago, A. Luft, J. Krakauer and J. Diedrichsen, "Recovery of hand function after stroke: separable systems for finger strength and control," *bioRxiv,* 2016.

[2] Olds, K. (n.d.). “System for Hand Rehabilitation” [Disclosure document]. Retrieved February 20, 2017.

[3] Olds, K. (2017, February 6th). [Interview by J. Carducci].

[4] Olds, K. (2017, February 20th). [Interview by J. Carducci].

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Q&A

Thank you for your time and attention!

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